

# NSF Awards Analysis Report

Tier 2 (High) Matches:

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Total Funding: \$1,604,375,625.00

Number of Awards: 1275

Title: Graduate Research Fellowship Program (GRFP)

Awardee: Stanford University

Amount: \$76,809,648.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **diversity** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Massachusetts Institute of Technology

Amount: \$75,486,624.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a

highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of California-Berkeley

Amount: \$61,326,220.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Washington

Amount: \$32,949,888.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award

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Matched Words: diversity

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Title: SII-Center: SpectrumX ? An NSF Spectrum Innovation Center

Awardee: University of Notre Dame

Amount: \$24,174,664.00

Abstract: the worldwide growth of wireless communication, navigation, and telemetry has provided immense societal benefits including mobile broadband data, internet of things, mobile healthcare, and intelligent transportation systems. this award is a grant to establish a spectrum innovation initiative: national center for wireless spectrum research (sii-center) to ensure united states

leadership in future wireless technologies, systems, and applications in science and engineering through the efficient use and sharing of the radio spectrum. an sii-center will promote transformative use and management of the electromagnetic spectrum, charting a trajectory to ensure united states leadership in future wireless technologies, systems, and applications in science and engineering through the efficient use and sharing of the radio spectrum. an sii-center will also educate and develop an agile workforce needed to support industries of the future which rely heavily on wireless technologies. this award funds the establishment of the first national center for wireless spectrum research, spectrumx. the vision for spectrumx is to be an inclusive multidisciplinary and increasingly interdisciplinary center that applies convergence research and team science to promote coexistence among disparate use cases in the radio spectrum, particularly including ?public good? use cases for science and defense. in particular, spectrumx will pursue its initial research strategy in scientific receiver hardware with interference measurement and mitigation capabilities; instrumentation of the radio spectrum in terms of advanced sensing networks; collecting and sharing accurate regulatory, usage, and economic data; flexible use rights that align incentives with efficient outcomes; and distributed, data-rich, and cloud-ready system designs for more efficient spectrum management and utilization. the project team is led by the university of notre dame, bringing together broad and synergistic research capabilities from a team of 41 founding researchers and staff from 27 universities, including 14 minority-serving or majority non-white institutions, and partnerships across industry, government, and academia. the center will be an information and innovation hub connecting stakeholders. spectrumx has a broadening participation plan aimed to increase awareness of cultural competence for all center participants to ensure that **\*\*diversity\*\***, equity, and inclusion are woven into the core of the center?s values and culture. spectrumx will develop spectrum-related curriculum for grade 6 through master?s students and has an education and workforce development plan to offer flexible pathways for researchers and students from diverse backgrounds, disciplines, and levels of maturity to engage in spectrum innovation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the

foundation's intellectual merit and broader impacts review criteria.

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Yale University

Amount: \$22,414,976.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Texas at Austin

Amount: \$21,664,088.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: California Institute of Technology

Amount: \$21,318,746.00

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Wisconsin-Madison

Amount: \$21,256,534.00

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Title: STC: Center for Research On Programmable Plant Systems

Awardee: Cornell University

Amount: \$19,750,000.00

Abstract: this nsf science and technology center aims to devise a two-way communication system between humans and plants that will dramatically enhance the ability to predict, design, and mediate biological behavior in crop-based agriculture. this transdisciplinary effort brings together plant sciences, engineering, computer science, and science and technology studies to establish an

enabling framework for the systematic discovery of the rules that govern biological behavior of plant systems in field environments. the team's approach couples genetic, biochemical, cellular, organismal and ecological principles with environmental and socio-economic considerations. in parallel, the center's research drives innovation in systems and synthetic biology, biotechnology, nanotechnology, automation, robotics, computing, and communication. the center educates students through new curriculum and research engagements that integrate computer science, engineering, and public engagement with knowledge in biology and the life sciences for undergraduate, master's, and ph.d. students. the center integrates public engagement throughout all activities to drive continuous, iterative dialogue between the center's researchers, stakeholders in the agricultural sector, and the general public. the center strives to engage the full **\*\*diversity\*\*** of our society and broaden participation in its mission by creating pipelines into stem fields and sustained mentoring for students and young professionals from rural and underrepresented minority communities.

in pursuit of its scientific and technological goals and its aim for broader impacts, the center organizes research across an innovation engine with four technological thrusts and a discovery engine with four research themes called living laboratories. these interlinked teams engage in continuous cycles of design-build-test-learn across disciplines, technical challenges, and scientific and social goals. the innovation engine focuses on building and integrating the elements of an internet-of-living-things (iolt) through the following thrusts: (1) biotransducers give rise to programmable plants through synthetic biological gene circuits that enable bidirectional communications between molecular processes in plants and digital sensors. (2) nanotransducers improve and complement molecular biological transducers to enable communication between plants and digital systems. (3) digital interfaces develop agile and cooperative robots, communications technologies, and edge-computing capabilities to mediate efficient communication between programmable plants and cloud-hosted models. (4) digital systems develop integrated multi-scale models of plant systems that integrate data and orchestrate actuation across the iolt with hybrid mechanistic and data-driven strategies. furthermore, the living laboratories of the discovery engine

interact with all thrusts in pursuit of the following research themes: (1) resource use and growth optimization deploy programmable plants to dissect the pathways that define water and nitrogen use and plant development, and modulate these processes for improved outcomes in productivity and sustainability. (2) predictive modeling and germplasm improvement use the iolt, programmable plants, and integrative multi-scale models to predict emergent phenotypes in complex environments and accelerate the process of breeding crops with improved performance. (3) plant-microbe interactions apply technologies from the innovation engine to access the physical, chemical, and microbial dynamics of the near-root zone or rhizosphere and integrate plant-microbiome characteristics into systems biology models, breeding strategies, and crop management. (4) public engagement permeates all center activities to facilitate and study productive interactions among researchers, stakeholders, and general publics around the development, understanding, and communication of scientific and technological goals. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Mid-scale RI-1 (M1:IP): A Deep Soil Ecotron facility to explore belowground communities and ecosystem processes

Awardee: Regents of the University of Idaho

Amount: \$18,950,956.00

Abstract: an award is made to the university of idaho to implement a deep soil ecotron facility that will lead to an improved understanding of deep soils, further illuminating the variety of life on the planet, its role in ecosystem processes, and its response to global change. the deep soil ecotron will provide research infrastructure that the us currently lacks, accelerate research on deep soils and the role these soils play in the broader biosphere, and lead to the development of novel technologies aimed at assessing belowground structure and function. additionally, the deep soil ecotron will serve as the central hub for a network of epscor researchers focused on questions related to deep soils. this national network currently has representatives from nine epscor jurisdictions. graduate students will be involved in all aspects of the deep soil ecotron. these students, recruited from

underrepresented groups, will receive unprecedented training in project management. the project management program, which will include workshops, classes, and hands-on-experience, will generate the future leaders and innovators of infrastructure development in the environmental sciences. finally, the groundwork for future generations of soil researchers will be laid by expanding an established middle school curriculum development program, where middle school students will design and conduct mini-ecotron experiments. the understanding gained from this facility can help mitigate the degradation of the nation's soil resources and help address future challenges, thus ensuring soil bio\*\*diversity\*\*, food security, and climate mitigation capacities for future generations.

not unlike the deep ocean, little is known about deep soils. currently, research on deep soils is limited to excavating soil pits, which limits research and experiments that directly manipulate the deep soil environment are currently non-existent. the deep soil ecotron will give researchers the unparalleled ability to investigate deep soils. this facility, composed of twenty-four, highly instrumented ecounits, will allow for soil profiles up to three meters in depth to be repeatedly sampled and continuously monitored. the deep soil ecotron will enable researchers to address the following four broad research needs using approaches and instrumentation which have been unattainable under more common field and laboratory experiments. first, the deep soil ecotron will reveal how deep soil communities and processes affect and interact with surface soils to influence whole ecosystems. second, the deep soil ecotron will allow researchers to determine how deep soils respond to global and land-use change, such as increasing soil temperature and agricultural management practices. third, information gained from the deep soil ecotron will be integrated into earth system models to improve model representation. fourth, the deep soil ecotron will provide a testbed for the development of sensors for the in-situ monitoring of deep soils. ultimately the deep soil ecotron will be the first of its kind in the world, shedding light on a largely unknown and unexplored environment, and accelerating research on belowground systems. this project is jointly funded by the mid-scale ri-1 program, the established program to stimulate competitive research (epscor), and infrastructure innovation for biological research (iibr) program. this award reflects

nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Johns Hopkins University

Amount: \$17,767,750.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Chicago

Amount: \$17,249,424.00

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scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: NSF ZEUS Multi-Petawatt Laser Facility: Operations

Awardee: Regents of the University of Michigan - Ann Arbor

Amount: \$16,500,000.00

Abstract: the g rard mourou center for ultrafast optical science at the university of michigan will operate a new laser user facility to be called nsf zettawatt-equivalent ultrashort pulse laser system (zeus) facility. the nsf zeus facility will operate the most powerful laser in the us and will provide unique and world-leading capabilities for scientific research. the nsf zeus facility will have an open and transparent review process for facility access with at least 30 weeks per year dedicated to external user experiments. the facility will have local and national economic and societal impact through training of students and post-doctoral researchers at universities throughout the us, with specific outreach efforts focused on increasing demographic **\*\*diversity\*\*** of the zeus user community. the facility will also foster innovation in the field of laser technology, potentially enabling formation of new high tech companies. the new nsf zeus user facility will include a multi-beam 3 petawatt (pw) laser system that will have three radiation-shielded experimental target areas to accommodate differing experimental configurations for users. the zeus laser system will have three modes of operation, either for experiments using a single 3 pw beamline, dual beam 2.5 pw/500



terawatt (tw) or up to 300 tw at higher repetition rate. a nanosecond-duration 75 j shock driver beamline for generating high-energy-density states of matter will also be available. the repetition rate of zeus at full power will be one shot per minute but will also have a higher repetition rate mode at 5 hz for powers up to 300 tw. this additional operational mode will enable a significant amount of data to be taken, which is particularly important for x-ray (up to 50 kev) and neutron (up to 20 mev) imaging applications. these bursts of x-rays and neutrons produced by zeus will have ultra-short pulse duration and can also be used for probing dynamic events at picosecond or femtosecond temporal resolution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: iDigBio: Sustaining the digitization, mobilization, accessibility, and use of biodiversity specimen data in U.S. museum and academic collections

Awardee: University of Florida

Amount: \$15,917,274.00

Abstract: integrated digitized biocollections (idigbio.org) at the university of florida (uf), florida state university (fsu), and arizona state university (asu) is the national coordinating body for the sustained effort to digitize, and make available online, the vast amount of information in the nation's bio\*\*diversity\*\* collections, which may contain up to 1 billion specimens. for biological specimens, information digitized include names of species, localities and dates of collection, digital photographs, sound, video, and 3-d models created from a variety of sources. this community digitization effort was catalyzed by nsf's advancing digitization of bio\*\*diversity\*\* collections (adbc) program via thematic collections networks (tcns), groups of institutions that digitize specimens to address a

major research topic such as the relationship between agricultural crops and insects or the impacts of invasive species on natural ecosystems. idigbio assists in coordinating activities of the tcns by facilitating development of standards and workflows for digitization of specimens and related information, providing cyberinfrastructure resources to enable long-term preservation of digital data, promoting novel and traditional uses of collections data in research and outreach, and working with the collections community to plan for the long-term sustainability of the national effort and the resources it has produced. the availability of digitized information about specimens greatly enhances the ability to conduct research on biological **diversity** and to address some of the most fundamental questions in biology. over the past ten years, the national effort to digitize information in the nation's bio**diversity** collections has been significantly advanced by the activities of idigbio. collaborations with data providers and users have been developed, goals and priorities defined, best practices related to digitization identified, and global collaborations with bio**diversity** data aggregators established. cyberinfrastructure resources, including a national search portal, have been provided. these community-driven activities have led to improved digitization practices, increased involvement in digitization and training, and adoption of instruments and informatics tools that improve the efficiency and scalability of digitization and research workflows in all types of bio**diversity** collections. idigbio works with staff in more than 926 collections in 317 institutions distributed across all 50 states. communication among stakeholders to increase access to collections data has been established through workshops, webinars, and the use of social media. since 2011, idigbio has sponsored attendance of 16,768 participants from 1,034 institutions to 430 workshops, webinars, symposia, and events that targeted digitization-related topics. idigbio has ingested 1,651 record sets containing 128 million specimen records and 41 million media records. all data ingested are indexed to enable queries and other types of index-based access. searches for data can be done through a web-based graphical interface or through programmatic apis. search and analytical tools enable users to mine diverse data such as taxonomy, location, images, traits, and vocalizations. during this award period, idigbio to continue its successful strategies with an

increasing emphasis on data improvement and use in research and outreach and to incorporate such rapidly developing technologies as artificial intelligence and machine learning in bio\*\*diversity\*\* data integration. idigbio is recognized as an essential resource for information on bio\*\*diversity\*\* and digitization. as the scientific and societal benefits of validated collections data are realized, digitization will become a common and sustained practice in natural history collections. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: AI Institute for Engaged Learning

Awardee: North Carolina State University

Amount: \$15,678,072.00

Abstract: emerging breakthroughs in ai create significant and timely opportunities for accelerating innovation relevant to pressing national challenges in stem education. advances in ai are enabling new levels of interactivity, engagement, and inclusion. driven by a vision in which ai supports and extends the intelligence of teachers and learners, the nsf ai institute for engaged learning will design, develop, and investigate ai-driven narrative learning environments that create engaging story-based, collaborative problem-solving experiences. the institute will conduct foundational ai research in natural language processing, computer vision, and machine learning, as well as in ai ethics. building on these foundational advances, the institute will conduct use-inspired ai research on narrative learning environments with rich ai-driven virtual agents and powerful multimodal sensing capabilities to understand how students learn and collaborate in rich story-based problem scenarios. the institute will provide a robust infrastructure to support at-scale implementations of ai-driven narrative learning environments. it will create a nexus for distinctive innovations in in-school and out-of-school stem education. its research vision will be to empower diverse learners to become the next-generation stem workforce by creating generative, collaborative ai-driven

narrative learning environments that deeply engage learners in schools, at museums, and within their own communities. this vision will be informed by connections with diverse stakeholders to ensure that the institute's learning environments are ethically designed and promote **\*\*diversity\*\***, equity, and inclusion. the nsf ai institute for engaged learning will produce transformative advances in stem teaching and learning by bringing together a team of diverse researchers from four universities (north carolina state university; indiana university, university of north carolina at chapel hill; vanderbilt university), as well as an educational non-profit organization (digital promise) which will bring educational practitioners, policy makers, and product developers into the work. the institute's partners include a national network of k-12 schools, museums, and non-profit organizations. the institute will create narrative learning environments that generate interactive stories dynamically tailored to the needs and interests of individual students and small groups and in multiple settings (classrooms, after-school programs, and museums). the institute's research has three complementary thrusts, to create: (1) narrative learning environments that generate engaging interactive story-based problem scenarios that elicit rich communication, require coordination, and spark collaborative creativity; (2) embodied conversational agent technologies with multiple modalities for communication (speech, facial expression, gesture, gaze, and posture) to support engaging learning interactions. embodied conversational agents will be driven by advances in natural language understanding, natural language generation, and computer vision; and, (3) an innovative multimodal learning analytics framework that analyzes parallel streams of multimodal data derived from students' conversations, gaze, facial expressions, gesture, and posture as they interact with each other, with teachers, and with embodied conversational agents. woven throughout the institute's activities will be a strong focus on ethics, with an emphasis on creating ai-augmented learning that is deeply informed by considerations of fairness, accountability, transparency, trust, and privacy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Duke University

Amount: \$15,580,622.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Illinois at Urbana-Champaign

Amount: \$12,804,599.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: I-Corps Hub: Mid-Atlantic Region

Awardee: University of Maryland, College Park

Amount: \$12,725,124.00

Abstract: the broader impact/commercial potential of this i-corps hubs project is to catalyze an inclusive mid-atlantic innovation network to spur the development of deep technology startups that will have much-needed economic and societal impacts regionally, nationally, and globally. research universities are positioned to support commercialization of scientific discoveries, and nsf i-corps accelerates the growth and impact of university-launched deep technology ventures. the uniquely-experienced mid-atlantic region i-corps hub team will build on the initial success of i-corps nodes to continue the cultural transformation at several of the country's top research universities to embed innovative practices into the conceptualization and conduct of research; to solve critical societal problems; and to create jobs, opportunities, and economic value. this hub project directly aligns with the goals of the american innovation and competitiveness act, which is critically important



for previously industrialized regions such as the mid-atlantic region as it is experiencing significant economic turmoil due to shifts in american manufacturing industries, compounded by disruptions due to the pandemic. also, the hub vision and strategy prioritizes **diversity**, equity, and inclusion, particularly among underrepresented groups and underserved minorities and minority institutions like historically black colleges and universities (hbcus). the i-corps program curriculum is built on scientific methods that incorporate hypothesis testing, the build-measure-learn cycle, and continuous iteration. multiple outcomes result from the program, teams: change research directions, get funding from grants or private investors, or form start-up companies and grow through revenue. equally important, the impact of the program accrues over many years. the hub model enables alignment of a systematic and comprehensive analysis of regional impacts, as well as the programmatic, environmental, and individual factors that mediate the efficacy of the program itself. understanding for whom and under what conditions i-corps programs are most effective, and what factors contribute to or detract from this effectiveness is critical to inform the continued growth and scaling of i-corps. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF I-Corps Hub: West Region

Awardee: University of Southern California

Amount: \$12,550,000.00

Abstract: the broader impact of this i-corps hubs project is the development of a model technology innovation hub in the western united states that cultivates the creation of deep technology ventures and builds a robust innovation ecosystem that is diverse, inclusive, and representative of its population. this goal will be achieved through education, training, outreach, and the engagement of a diverse community of innovators, with robust linkages to regional and national entrepreneurial

ecosystems, leading to a strong commercial impact. trainers and trained teams are key hub outputs. proactive outreach is expected to result in the recruitment of diverse groups of teams, trainees, mentors, and instructors. in addition, i-corps training may help increase the flow and impact of commercializable technologies, the growth and **\*\*diversity\*\*** of the innovation ecosystem, and the supply of mentors and experts for the training of future teams. the hub plans to engage in research and education in lean startup-based programming, the financing of innovation, and the broader ethics of technology innovation and entrepreneurship. through education, training, networking, community building, and research outcomes related to deep technology ventures, the hub seeks to deliver economic, technology, and social impact for the benefit of the region and the nation. this i-corps hubs project is based on the development of a comprehensive and inclusive education and training program for innovation and entrepreneurship in deep technology ventures in the western united states. the hub will engage deep technology researchers in lean-startup and customer discovery methodologies to produce teams that advance to the national i-corps program further enhancing the national innovation network. the project will use a framework for team generation and training pipelines based on best practices developed by the hub members, further modified to leverage the hub regional characteristics, in particular, its distinct, diverse demographic signature. the hub plans to incorporate inclusivity in its standardized and integrated approach as well as ethical considerations in team training. the hub will also explore new approaches that may lead to a creative, enabling, human-centric, and socially-relevant innovation ecosystem in the region. in parallel, research is planned to analyze programs for possible additional refinements in hub practices as well as to enrich the broader scholarship and public policy on innovation and entrepreneurship, including a better understanding of innovation financing. specifically, the project will assess differences in programming and funding success for underrepresented groups and the career paths of scientists and engineers in the general entrepreneurial ecosystem. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: NSF I-Corps Hub: Northeast Region

Awardee: Princeton University

Amount: \$12,550,000.00

Abstract: the broader impact of this i-corps hubs project is the development of a regional network of academic, industrial and government partnerships that will grow the nation's capacity to transform scientific discoveries into tangible societal benefits. the hub, located in the heart of the northeast region of the u.s., will leverage its proximity to deep technology industries including pharmaceuticals, nanotechnology, chemistry, energy, and photonics. serving as a catalyst to democratize access to opportunities through educational and training programs, the hub will translate laboratory discoveries generated at the principal, partner, and affiliate institutions to spur formation of new commercial ventures, leveraging the significant volume of federal research dollars already invested in this region. built on robust industrial and government partnerships, the hub has a proven track record of successful collaborations and entrepreneurial activities including previous nsf i-corps sites and industry-funded research collaborations. through a demonstrated commitment to inclusivity and

**\*\*diversity\*\***, the hub will contribute to america?s future prosperity and global competitiveness by training the next generation of innovators from diverse backgrounds. ultimately, the hub will contribute to the growth of america?s technology-driven economy by accelerating the translation of academic discoveries into the marketplace. this i-corps hub project is based on the development of a northeast regional network that will educate, guide, mentor, and support innovators across all participating institutions, and promote the translation of fundamental scientific and engineering discoveries into tangible products through the creation of new commercial ventures. this vision will be realized by leveraging the training techniques from the i-corps program to create a comprehensive ecosystem that supports innovators through the entire ideation and technology venture lifecycle. training and mentoring will focus on empowering academic researchers via i-corps programming geared towards developing critical thinking around deep-tech commercialization, customer discovery, and impact creation. additional programming, specifically geared toward faculty members, will seek to create lasting impact by continuing to leverage academic discoveries to benefit society through entrepreneurial ventures. this approach emphasizes the holistic programming necessary for long-cycle, deep-tech startups and the sharing of best practices from different institutions, enabling synergistic learnings and motivation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: BII: Uncovering mechanisms of amphibian resilience to global change from molecules to landscapes

Awardee: University of Pittsburgh

Amount: \$10,338,698.00

Abstract: paramount to predicting the future of bio**\*\*diversity\*\*** is knowing when and how living systems are resilient to (i.e., can recover from) anthropogenic disturbances. the focus of this biology

integration institute is on understanding resilience to a key global threat: emerging infectious diseases. the team will develop a new framework to measure resilience across multiple scales, stressors, and systems, and apply it to a case study involving a fungal disease linked to global amphibian declines. building on past research in four complementary systems, the team will address four questions: (1) how does the history of disturbance differ across systems? (2) how have changes at different levels of biological organization shaped overall system responses? (3) what are the mechanisms contributing to resilience and are they shared across systems? (4) how is resilience modulated by multiple interacting stressors? the framework and findings will be applicable to hundreds of amphibian species facing disease-related stressors and, more broadly, for understanding the resilience of biological systems to myriad global change threats. the institute's training activities will reach and connect high school through postdoctoral scholars using authentic biology research experiences that foster cross-disciplinary understanding, serve large numbers of students with a focus on underrepresented groups, and promote persistence in stem. outreach activities will reach students, teachers, members of the public, and wildlife managers with messages about bio\*\*diversity\*\*, resilience, and global change. together, the institute's activities will showcase the power of an integrative, team science approach for addressing some of the biggest and most challenging questions in biology.

the focus of this biology integration institute (bii) is on understanding resilience in the context of global change. resilience, or the ability to recover after a perturbation, is an emergent property of living systems. progress toward a mechanistic understanding has been stymied by the lack of a common currency and framework that is applicable across scales, among systems, and in response to different stressors. the team's activities will address these knowledge gaps by developing a flexible resilience framework and applying it to a detailed case study involving a key global change threat to bio\*\*diversity\*\*: emerging infectious diseases (eids). leveraging past research, the team aims to uncover mechanisms of resilience to chytridiomycosis, an eid of amphibians caused by a fungal pathogen, in four complementary systems by answering four key questions: (1) how does the history of disturbance differ across

systems? (2) how have changes at different levels of biological organization shaped overall system responses? (3) what are the mechanisms contributing to resilience and are they shared across systems? (4) how is resilience modulated by multiple interacting stressors? the institute's training and outreach programs will feed back into the research. training activities will reach and connect high school through postdoctoral scholars from across the country through authentic biology research experiences that foster cross-disciplinary understanding, serve large numbers of students with a focus on underrepresented groups, and promote persistence in stem. outreach activities will reach students and teachers, members of the public, and wildlife managers with messages about global change and resilience. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Pennsylvania State Univ University Park

Amount: \$10,157,244.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Center for Advanced Radio Sciences and Engineering

Awardee: University of Puerto Rico Mayaguez

Amount: \$9,437,465.00

Abstract: the center for advanced radio sciences and engineering established in this award will enable the development of integrated tools to resolve spectrum sharing and coexistence issues, and improve performance on radio science observations through an innovation and collaboration ecosystem designed to elevate the science and engineering capacity at university of puerto rico at mayagüez (uprm), arecibo observatory (ao), and puerto rico in general. the center will explore new concepts in radio astronomy, atmospheric sciences, spectrum monitoring and radio frequency interference mitigation, with a focus on scientific observations. the center will improve the research competitiveness of the puerto rico engineering and academic communities, training a new generation of students via hands-on experience with leading-edge research infrastructure and internships. the creation of this center will foster new collaborations between ao, the national radio astronomy observatory (nrao), industry, and the puerto rico academic community, which will both enrich radio sciences and engineering and position puerto rico students and scientists to participate strongly in future radio sciences projects. this project is jointly funded by the division of astronomical

sciences, the established program to stimulate competitive research (epscor), and the office of multidisciplinary activities in the directorate for mathematical and physical sciences. uprm formed a collaboration with industry and with ao via its managing organization, the university of central florida (ucf), to create the center for advanced radio sciences and engineering. this center provides support to maintain and grow the local scientific and engineering capacity. the center will enable the development of integrated tools to resolve spectrum sharing and coexistence issues, and improve performance on radio science observations. the center's specific goals include the development of enabling technologies in radio frequencies, microwave, and millimeter-wave antennas and systems, electronics and embedded systems, and digital signal processing algorithms, together with crosscutting applied sciences research activities in atmospheric sciences and radio astronomy. tools envisioned for development consist of spectrum monitoring and radio frequency interference (rfi) mitigation systems; interference robust scientific receivers; small size, low weight, low power and low-cost scientific receivers and monitoring systems; and adaptable transmitters with reduced out-of-band emissions. the center includes industry partnerships to develop rfi mitigation solutions. a primary focus is to create new partnerships between academia and industry for the development of the diverse, globally competitive stem workforce required to plan, design, prototype, construct, commission and operate the next generation of radio astronomy instruments. center activities will enhance engineering, radio astronomy, atmospheric science and high-throughput computing research infrastructure at uprm and at puerto rico institutions more broadly, including new faculty lines, support for postdoctoral fellows and graduate students, and cross-institutional research support. education, outreach, workforce, and **\*\*diversity\*\***, equity and inclusion activities will be developed in partnership with the uprm centro universitario para el acceso, and the nrao radio astronomy data imaging and analysis lab project. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: NSF INCLUDES Alliance: Engineering PLUS (Partnerships Launching Underrepresented Students)

Awardee: Northeastern University

Amount: \$8,950,000.00

Abstract: the broader impact of this nsf includes alliance project is nationwide growth in the number of underrepresented minorities and women obtaining undergraduate and graduate engineering degrees. specifically, the project aims to achieve a national target of 100,000/30,000 (bs/ms-phd) degrees for underrepresented minorities and women by 2026 and establish a future growth rate that

can substantially close the gap. engineering depends on team collaboration, and research shows that diverse groups are typically more effective than homogeneous teams when complex problem solving is a critical goal. the u.s. must therefore educate a diverse engineering workforce to encompass the complex technological challenges faced by society. this nsf includes project directly addresses this critical challenge. this alliance will have a broad reach, expanding to 150 higher education institutions in five major regions of the country. the work of the alliance is designed to learn what is most effective at broadening participation in engineering education, particularly at the critical transition points for students. its work will enable wider adoption of best practices through the training of change agents that can work effectively both regionally and nationally. the proposed project has the overarching goal to achieve transformative, systemic and sustainable change that will dramatically increase the number of underrepresented minorities and women obtaining undergraduate and graduate engineering degrees. the alliance will leverage the wealth of best practices for broadening participation in engineering that has emerged from research over the last several decades to provide the collaborative infrastructure needed to support sustainability and scale-up of successful strategies. the intellectual merit of the alliance mission is tied to the research which is aimed at answering the question: how does regional scaling occur across the alliance? three levels of investigation will be pursued; q1) what role does evidence play in scaling the most promising engagement activities across a given region and the alliance overall? q2) how do the social interactions and the resultant networks affect scaling? and q3) what are the historic and operative frameworks of how gender, race and ethnicity, pathway opportunities and goal attainment are addressed? the research results will create new knowledge and help others work toward achieving inclusive participation in engineering. this nsf includes alliance award is funded by: - nsf inclusion across the nation of communities of learners of underrepresented discoverers in engineering and science (nsf includes), a comprehensive national initiative to enhance u.s. leadership in discoveries and innovations by focusing on **\*\*diversity\*\***, inclusion and broadening participation in stem at scale. - broadening participation in engineering (bpe). - louis stokes alliance

for minority participation (Isamp). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF INCLUDES Alliance: ALRISE - Accelerate Latinx Representation In STEM Education with Institutional Intentionality and Capacity Building for Experiential Learning

Awardee: Arizona State University

Amount: \$7,976,632.00

Abstract: the alrise alliance is developing a network of faculty, staff, administrators, and students at 2-yr and 4-yr hispanic serving institutions (hsis) and emerging hsis (ehsis) to accelerate latinx representation in science, technology, engineering, and math (stem) education. challenges such as (1) campus environments that are not intentionally culturally-responsive to latinx stem students; (2) deficit mindsets of stem educators that devalue latinx students? strength and resilience; (3) latinx stem retention and graduation rates that are significantly lower than enrollment; and (4) the underrepresentation of latinx professionals in stem job clusters compound broadening participation efforts. these factors place a necessity for change on institutions, educators, and employers to intentionally harness latinx students? assets and create a more welcoming environment that fosters reproducible success. the alrise alliance provides professional development for faculty, staff and industry to serve latinx students with intentionality through culturally-responsive undergraduate research and work-based experiential learning. uniquely focused on the intersectionality of latinx stem students and experiential learning, alrise fills an important gap in ongoing broadening participation efforts, with its focus on culturally-responsive experiential learning in an action-oriented and data-driven environment of continuous improvement and collaboration. the networked improvement community (nic) collaborative infrastructure of the alrise alliance will mobilize large-scale change through shared vision, partnerships, common goals and metrics, leadership and

communication, and potential for expansion, sustainability, and scale. the alrise backbone organization, science foundation arizona center for stem at arizona state university, provides leadership and communications structures to connect and collaborate amongst four regional hubs that coordinate a total of 26 hsi/ehsi institutional members and their stem planning educator teams. partner subgroups defined by professional expertise in experiential learning and intentionality, undergraduate research, work-based experiences and advocacy and policy will provide services for assessing and developing intentionality across the alliance. a continuous improvement cycle will be used to effect change locally while also improving the alrise alliance and processes. quantitative and qualitative data will be collected and analyzed at the student, institutional, and experiential learning program levels to provide evidence for practices supported and disseminated by alrise. triangulated findings from multi-level mixed methods research, and outcomes from formative and summative evaluation, will advance knowledge on culturally responsive practices, hsi intentionality, and as-yet undiscovered common challenges and synergies within and across alliance members. instilling intentionality to serve latinx students at the institutional level, and through asset-oriented educator professional development and coaching, will build capacity to effect change at each member institution. this capacity-building approach will not only serve the latinx students actively engaged in experiential learning programs but also retain the knowledge and programs to impact a far greater number of students in the future. the alrise alliance is funded by nsf inclusion across the nation of communities of learners of underrepresented discoverers in engineering and science (nsf includes), a comprehensive national initiative to enhance u.s. leadership in discoveries and innovations by focusing on **\*\*diversity\*\***, inclusion and broadening participation in stem at scale and the improving undergraduate stem education (nsf iuse): hispanic serving institutions (hsi) program, which supports efforts to enhance the quality of undergraduate stem education and to increase the recruitment, retention, and graduation rates of students pursuing associate's or baccalaureate degrees in stem. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.



Matched Words: diversity

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Title: National Cybersecurity Training & Education (NCyTE) Center

Awardee: Whatcom Community College

Amount: \$7,499,995.00

Abstract: keeping computers and information systems secure is a major challenge. business, industry, and government need well-prepared technicians who can prevent, detect, and investigate cybersecurity breaches. the growth of cyber-threats has created a need for many additional workers who have cybersecurity knowledge and skills. as the advanced technological education (ate) program's national center in the area of security technologies, the national cybersecurity training & education (ncyte) center will leverage previous nsf grants, projects funded by the national security agency (nsa), and the expertise of partners to provide leadership for cybersecurity education in community and technical colleges and related secondary school programs that build america's skilled technical workforce in cybersecurity. the center will pursue four strategic goals: (1) expand educational pathways and the **\*\*diversity\*\*** of cybersecurity programs to meet the nation's workforce needs. (2) develop and deploy leading-edge cybersecurity curricula. (3) cultivate engagement with employers (business, industry, government) and career opportunities for students. (4) disseminate resources to improve current and future directions of cybersecurity education. in addition to whatcom community college, major partners in the center include california state university, san bernardino; embry-riddle aeronautical university (daytona beach, fl); eastern new mexico university - ruidoso; the center for systems security and information assurance (cssia; based at moraine valley community college); and the national cyberwatch center (ncc; based at prince george's community college). to advance cybersecurity education and build the nation's cybersecurity workforce, the ncyte center will expand, standardize, and disseminate cutting-edge resources for teaching and learning (including online learning) and best practices aligned with industry standards. the center will develop cybersecurity content targeting new industry sectors, integrate new and updated

cybersecurity concepts into existing fields, conduct associated professional development for college and k-12 educators, and coordinate the work of other ate grantees in cybersecurity. a projected 1,500 faculty will receive training and an estimated 2,300 faculty will engage in annual leadership development workshops and forums to update their knowledge and skills and to learn about needs in industry. academies and boot camps will address the shortage of cybersecurity faculty. through forums and career fairs, an estimated 10,000 students will learn about cybersecurity careers and make connections with employers. these activities, as well as targeted outreach and mentoring activities (with a special focus on women, veterans, and native americans), will attempt to broaden participation in the field. using the materials, methods, experiences, and guidance that the center provides, community colleges around the nation will be able to launch, grow, and maintain cybersecurity programs, ultimately expanding and diversifying the pool of graduates who pursue cybersecurity careers. this project is funded by the advanced technological education (ate) program, which focuses on the education of technicians for the advanced-technology fields that drive the nation's economy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: North Carolina State University

Amount: \$7,072,520.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Phase II CREST Center for Interface Design and Engineered Assembly of Low-dimensional Systems (IDEALS II)

Awardee: CUNY City College

Amount: \$5,100,000.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). the centers of research excellence in science and technology (crest) program supports the enhancement of research capabilities of minority-serving institutions through the establishment of centers that effectively integrate education and research. crest promotes the development of new knowledge, enhancements of the research productivity of individual faculty, and an expanded presence of students historically underrepresented in science, technology, engineering, and mathematics disciplines. with national science foundation support, cuny city college will continue development of its phase ii center for interface design and engineered assembly of low-dimensional systems (ideals ii). building upon the salient accomplishments of phase i ideals (ideals i), ideals ii research intends to address the need to strengthen the nation's leadership in materials capabilities in the frontier areas of quantum materials, bioinspired reconfigurable materials, and photonic materials and technologies that address critical national needs, elevating ccny as a premier research institution in these fields. phase ii center investigators and students will pursue frontier research and education transformative goals through extending collaborations, created a multifaced cutting-edge materials research program, fully integrate research and education to enhance student experience and train tomorrow's leaders, and introduce the city college new york presidential postdoctoral fellowship program to enhance faculty **\*\*diversity\*\***. the research thrusts of the nsf phase ii crest center for interface design and engineered assembly of low-dimensional systems (ideals ii) at the city college of new york (ccny), encompass the frontier areas of quantum materials, bioinspired reconfigurable materials and photonic phenomena to address energy, health, and environmental needs. the multi-disciplinary, collaborative research activities are organized into three thematic subprojects. subproject 1, entitled, emergent quantum materials and functions, will focus on materials science and engineering of two-dimensional systems, such as, surfaces and interfaces where band topology and strong electron correlations lead to new functions and quantum phenomena for the next-generation quantum technologies. zero-dimensional systems, such as,

quantum dots and rare-earth ions in host matrices will be utilized as platforms for implementing spin qubits that circumvent the limitations of current schemes of quantum computation. subproject 2, bio-inspired, re-configurable materials to scale, focuses on scalability of reconfigurable materials (materials that change their properties by adapting to an external stimulus) developed in phase i and further explores their specific applications in light harvesting, medical diagnostics and cancer therapy as well as sustainability and environmental rehabilitation. subproject 3, frontiers of photonic materials, phenomena and devices will explore emerging basic ideas, synthesize new materials (such as, hybrid semiconductor heterostructures, topological nanostructures) with unprecedented functionalities, investigate salient properties of the engineered materials, design and test devices (light sources, detectors and quantum sensors) based on promising materials, and provide feedback for materials and device design criteria. the seed project approach will be used as a mechanism for the nucleation of new ideas and exploration of areas of opportunity and growth. an integrated research and education thrust, will continue to apply the proven interventions developed and implemented in ideals i, and introduce new ones, to help produce a talented, inclusive and diverse work force capable of leading the materials research and development endeavors in the 21st century. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Pittsburgh

Amount: \$5,091,699.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award



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Matched Words: diversity

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Title: NSF Convergence Accelerator- Track C: QuSTEAM: Convergent undergraduate education in Quantum Science, Technology, Engineering, Arts, and Mathematics

Awardee: Ohio State University

Amount: \$4,989,414.00

Abstract: the nsf convergence accelerator program supports use-inspired, team-based, multidisciplinary efforts that address challenges of national importance and will produce deliverables of value to society in the near future. the goal of this project is to develop qusteam (quantum information science, technology, engineering, arts and mathematics), a transformational undergraduate curriculum that will provide a national educational model for the emerging field of quantum information science and engineering (qise). the intellectual merit of this project is in development of a qusteam curricular structure using evidenced-based research to determine the scientific and engineering practices that will be required of the future quantum smart workforce. our curriculum will serve as a national standard for qise education. this new curricular structure will be designed from the ground up to address structural barriers that have to date limited the **\*\*diversity\*\*** and inclusiveness of stem training and will include concurrent training in the societal impact of qise technologies by incorporating content beyond traditional stem disciplines. the key outputs of our research will be: (i) a schematic of interdisciplinary modules that details how the building blocks of qise-competency can be organized for different educational targets (module, class, minor, and certificate). (ii) a map of steps taken to actively promote equity and inclusivity in the curriculum that will serve as a model for future curricular development. (iii) individual course curricula that demonstrate the implementation of qusteam. the broader impacts of this project will be in creation of a quantum smart workforce will have a transformative effect on the us economy and

society. the qusteam curriculum, and the methodology used in developing it, will be made publicly available to serve as a template for the development of convergent curricula in other subjects. "" this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Engineering for US All-E4USA: A National Pilot High School Engineering Course and Database

Awardee: University of Maryland, College Park

Amount: \$4,961,444.00

Abstract: the aim of the engineering for us all (e4usa): a national pilot program for high school engineering course and database project is to demystify and democratize engineering through a program targeting high school students and teachers that will by nature benefit society and advance the desire for a more diverse future engineering workforce. the program expands the pool of teachers capable of teaching engineering and the number of students considering further education and/or a career in engineering. the knowledge taught by empowered teachers will provide a broader understanding of engineering intended to excite an interest in pursuing additional engineering education. specific efforts to collaborate with a diverse group of schools (urban, suburban, rural, private, public, parochial, single gender, etc.) will ensure that this program reaches those who have previously been unable to offer engineering and/or traditionally underrepresented in engineering. partnerships with post-secondary institutions will also create and facilitate pathways for students to explore possible engineering careers. scaling and sustaining e4usa will allow the project to address the desired societal outcome of a more educated citizenry and increased numbers and **\*\*diversity\*\*** of students joining the future engineering workforce. continued support for e4usa will establish the program as major contributor in the field of engineering and technological literacy, while bringing engineering truly to all.      engineering for us all (e4usa): a national pilot program for high school

engineering course and database's primary goal is to demystify and democratize the learning and practice of engineering by engaging high school students and teachers in a project-based engineering curriculum. e4usa will increase engineering literacy for all and expand opportunities for those traditionally underserved and underrepresented in engineering to pursue careers as engineers. current nsf funding has led to the creation of the e4usa curriculum, teacher professional learning (e.g., professional development workshops and community of practice), and additional supporting resources (e.g., mydesign®). this first of its kind program presents the engineering field using four big ideas: 1) discover engineering, 2) engineering in society, 3) engineering professional skills, and 4) engineering design. this design and development grant is intended to support efforts to scale, study, and sustain e4usa over the next three years. school settings will be broadened by expanding the reach of e4usa to 50 teachers and approximately 5,000 students nationwide. design-based implementation research (dbir) capturing participating student and teacher data will continue and expand to include five in-depth case studies. knowledge gained will inform central components of e4usa intended to improve developed resources, expand partnerships, garner insights into the impacts of e4usa, and increase pathways for credit and placement these insights, in conjunction with the creation of an oversight and advocacy agency, will provide the foundation for e4usa becoming a self-sustaining, independent entity supported by key partners like teachengineering. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Community College Presidents Initiative - STEM (CCPI STEM)

Awardee: Prince George's Community College

Amount: \$4,638,192.00

Abstract: according to the national science board, by 2022 the u.s. will experience a workforce shortage gap of approximately 3.4 million skilled technical jobs. this and other similar statistics are a call to action for community colleges to address the impending shortage and existing need for stem education and workforce development. this project, the community college presidents initiative in stem (ccpi-stem), serves the national interest through its efforts to galvanize, enlighten, and inspire community college leadership including college presidents, board members, and vice presidents to promulgate and support local, state, and regional stem education, nsf ate funding, and workforce development on their campuses. the project has two major emphases: (a) the important leadership role of administrators and boards of trustees in community college external funding for stem education, and (b) the institutional infrastructure and capacity necessary for effective grant development and implementation, overcoming challenges to success. four objectives will guide

the execution of this project. first is to catalyze the engagement of community college presidents, boards of trustees, and other senior administrators in developing stem action items for their colleges and communities. second is to identify and analyze the needs and issues of interest and importance to community college leaders by region. third is to develop and pilot test instructional curricular materials for existing and future community college presidents and leaders that will strengthen their understanding of stem education issues. fourth is to strengthen collaborations with the business community that investigate and promote the economic impact of the ate program. seven regional networks (rns), each led by a community college president in close collaboration with national organizations including aacc, acct, and the league of innovation, as well as with representatives of business and industry will be developed. each rn will formulate its own list of initiatives with input from member community colleges, businesses and its community at large. ccpi-stem will also work with external organizations, such as economic modeling specialists intl. (emsi) and burning glass, to assess the economic impact of ate awards in select colleges. curricular materials on ate funding and program implementation will be developed and tested in collaboration with leaders of community college graduate programs. **\*\*diversity\*\***, equity, and inclusion in stem education will be addressed in the initiatives of the rns and through the prism of external funding and institutional infrastructure. ccpi-stem results will be broadly disseminated through the rns, a website, and national, regional and local conferences and venues. specific guides and publications, including "models that work," will be developed and broadly disseminated. the ccpi-stem annual summit, to be held in conjunction with the aacc national convention, will provide a forum for interaction and dissemination on a national level. this project is funded by the advanced technological education program that focuses on the education of technicians for the advanced-technology fields that drive the nation's economy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RESEARCH-PGR/NSF-BSF: Identification and Functional Dissection of Shared Cis-Regulatory Elements Controlling Quantitative Trait Variation Across Angiosperms

Awardee: Cold Spring Harbor Laboratory

Amount: \$4,046,050.00

Abstract: crop plants provide food, feed for livestock, and other essential materials. breeders are continuously improving our crops; however, there is an urgent need to accelerate crop improvement in the face of climate change and limited resources. natural genetic variation in the form of dna mutations is widespread in crops, and is the starting material for their improvement, but such variation is often not useful or is unpredictable in its effect on plant growth. genes that control important yield traits are expressed at specific levels, locations and times during plant growth, and tuning these expression programs may enhance crop productivity. gene expression is controlled by regions of dna surrounding genes known as cis-regulatory elements. despite their fundamental biological significance, the identification of such elements and their use in agriculture has been challenging. this research project, a collaborative effort between scientists at cold spring harbor laboratory, the university of massachusetts-amherst, and the hebrew university of jerusalem, will predict regulatory elements using a newly developed computational algorithm, conservatory, combined with existing genome sequences from many plant families. these elements will then be modified using crispr genome editing tools. these new variants will be tested for changes in phenotype that lead to improvements in yield and other important agronomic traits. the project will train young scientists at various levels, as well as promote outreach and education in plant genomics in partnership with genspace, a community biology lab in brooklyn, ny. the project will develop a new curriculum for high school students from under-resourced title i schools and demographic groups historically excluded from the life sciences to explore applications of crispr in agriculture, including hands-on labs in plant transformation and crispr editing. this project will test the hypothesis that genes with conserved functions are regulated by deeply conserved cis-regulatory elements (cres) across angiosperms, and that characterizing these cres will provide a

new level of understanding in linking genotype to phenotype. the project will exploit the recent explosion in high-quality sequenced genomes to identify conserved regulatory elements across angiosperm **\*\*diversity\*\*** using the conservatory algorithm. the functions of the elements identified by conservatory will be tested by precise genome editing, with a focus on developmental regulators and architectural traits. functional dissections will be performed in two species in each of three diverse plant families, spanning eudicots and monocots, which will allow the assessment of cre functional evolution over shallow and deep timescales. the catalog of conserved regulatory elements identified, and the editing strategies developed to test their functions, will reveal fundamental principles governing gene expression control and will accelerate innovative approaches to fine-tune crop productivity traits. critically, the tools, techniques and fundamental principles emerging from this multi-disciplinary project will comprise a valuable community resource, enabling the engineering of diverse systems and phenotypes, such as biotic and abiotic stress tolerance, nutritional quality, and symbiosis. all project outcomes will be widely accessible through long-term public data and genetic repositories. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: RII Track-2 FEC - Advanced Manufacturing of Renewable and Recyclable Polymers

Awardee: University of Kansas Center for Research Inc

Amount: \$4,000,000.00

Abstract: millions of tons of plastic waste pollute the environment with adverse ecological and health impacts. new technologies are urgently needed to facilitate plastic recycling and enable the growth of a circular and sustainable economy. such a transition requires technological innovation and public policies that enable the reuse of used polymers in new products, as well as renewable raw materials such as grasses and crop leftovers. in this project, researchers from the university of kansas (ku), university of delaware (ud), and pittsburg state university (psu) will use their complementary expertise to develop the knowledge to foster this transition. the team aims to develop novel catalysts and processes to (a) transform biomass feedstocks into commercially relevant plastic materials, and (b) deconstruct recycled plastics efficiently into precursors for reuse. simulations, data science, techno-economic analyses and life cycle assessments will guide the research. concurrently, public policies will be formulated and evaluated to drive rural economic growth and the market penetration of the new materials. such activities will spawn an agro-based, renewable materials manufacturing industry in kansas, delaware and beyond, providing a major economic boost in these two epscor jurisdictions. the program will mentor junior faculty and establish a postdoctoral program for faculty **\*\*diversity\*\*** to support women and underrepresented minorities in

this career path. additionally, we will recruit and educate a diverse workforce equipped with the skills needed to use advanced manufacturing concepts to drive our economy towards sustainability.

specifically, the project will develop novel synthesis routes for a broad slate of renewable polyesters and polymer recycling strategies, signaling a new benign by design paradigm for the advanced manufacturing of sustainable materials. the program will focus on three renewable monomers: 4,4'-biphenyl-dicarboxylic acid, 5,5'-bifurandicarboxylic acid, and sebacic acid. these were selected because they can be synthesized from biomass-derived furfural. since recycling will involve renewable and fossil-based plastics for the foreseeable future, the project will evaluate and optimize copolymers of these renewable monomers with the existing poly(ethylene terephthalate) (pet) plastic. the convergent research expertise of our team of investigators will enable integration of catalysis and kinetics fundamentals with separations and process intensification strategies to develop scalable manufacturing and recycling concepts. novel catalytic materials including biocatalysts, intensified spray and microwave reactors, and new fundamental knowledge underlying the synthesis and recycling of polymers will emerge. a framework for analyzing cradle-to-cradle process systems blended with sustainability principles, economics and public policy considerations will be developed. we will deploy and advance state-of-the-art data science methods and multiscale modeling to expedite discovery and innovation of renewable and recyclable biobased polymers. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity  
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Title: RII Track-2 FEC - Advanced Manufacturing of Renewable and Recyclable Polymers

Awardee: University of Kansas Center for Research Inc

Amount: \$4,000,000.00

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Matched Words: diversity

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Title: RII Track-2 FEC: Genome Engineering to Sustain Crop Improvement (GETSCI)

Awardee: University of Hawaii

Amount: \$3,993,756.00

Abstract: improved and practical crop breeding tools are required to meet the increasing demands of a growing global population and to overcome the sudden and variable stresses, made worse, by climate change. this project brings together researchers from the university of hawaii at manoa and iowa state university to develop an efficient, robust genome engineering toolkit that can be used to speed the generation of resilient crops adapted to a changing environment. reproductive barriers are a major bottleneck that limits the genetic **diversity** available for crop improvement. tropical maize germplasm is a rich source of genetic **diversity** but its flowering behavior in temperate regions precludes its broad use for maize improvement. to access this **diversity**, our two institutions formed a collaboration that integrates our strengths in tropical plant biology and transformation (hawaii) with maize transformation, genome engineering, and breeding (iowa). our goals are to establish a rapid and efficient genetic transformation platform and to develop improved genome editing tools to reprogram the flowering behavior of high-yielding tropical maize lines allowing their incorporation into any maize breeding program. both hawaii and iowa will gain a valuable new capability in genetic transformation and genome engineering which will transform the types of crop research possible at both institutions. expected impacts from this project will help address food

security and economic weaknesses in hawaii, by allowing for the development of new tropical crop breeding industries. in iowa, access to gene-edited temperate-adapted tropical germplasm will move maize improvement into the next era of genome-optimized breeding. workforce capacity will be increased by engaging underrepresented students, particularly native hawaiians and pacific islanders, in diverse aspects of genome engineering research, by the exchange of undergraduates between partner institutions to prepare a globally competitive, multiculturally, and socially responsible workforce, and by creating opportunities for improved science communication skills through training sessions, workshops, and engagement with the community to communicate the value and safety of these new tools. critical to our future is maintaining the rate of genetic improvement of the crops that feed us and sustain our economy. but the sudden and increasingly severe stresses caused by climate change limit the pace of improvement. advances in genome engineering offer rapid solutions by enabling precise and targeted reprogramming of molecular networks to improve crop performance. the rich genetic **\*\*diversity\*\*** in tropical maize is largely underutilized for maize improvement because tropical lines are photoperiod sensitive and flower late in the long-days of temperate growing regions. to access this **\*\*diversity\*\***, we formed a collaboration between the university of hawaii at manoa (uh manoa) and iowa state university (isu), which integrates strengths in tropical plant system biology and transformation (uh manoa) with maize transformation, genome engineering, and breeding (isu). our goal is to use gene editing to suppress the photoperiod response in elite, high-yielding tropical maize to promote earlier flowering. these edited tropical lines can then be used to enhance any maize breeding program. our objectives are to (1) establish an efficient, germplasm-independent maize transformation platform, (2) develop a facile, tractable genome editing toolkit to suppress the photoperiod response in six tropical inbreds, (3) analyze photoperiod network function in genome edited tropical lines, and (4) improve skills in communicating the value and safety of these new genome engineering tools. the outcomes from this project include new tropical maize transformation capabilities at both jurisdictions, genome editing reagents for modulating flowering in maize, six elite tropical inbreds adapted to temperate

breeding programs, a mechanistic understanding of the response to reprogramming the flowering network, and improved skills to communicate the value of this technology in professional and public contexts. broader impacts expected from this project include opening this technology to academic labs, that can build research capacity by allowing genome engineering of diverse crops. democratizing these tools are expected to speed breeding advancements, sustain crop improvement efforts, and spur economic growth. both hawaii and iowa will gain a valuable new capability in maize transformation and genome engineering, and will transform the types of crop research possible at both institutions. in hawaii, this project will help address food security and economic weaknesses revealed by the pandemic, by allowing for development of new tropical crop breeding industries. in iowa, access to gene-edited temperate-adapted tropical germplasm moves maize improvement into the next era of genome-optimized breeding. workforce capacity will be increased by engaging underrepresented students, particularly native hawaiians and pacific islanders, in diverse aspects of genome engineering research, by the exchange of undergraduates between partner institutions to prepare a globally competitive, multiculturally, and socially responsible workforce, and by creating opportunities for improved science communication skills through training sessions, workshops, and engagement with the community to communicate the value and safety of these new tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CyberCorps Scholarship for Service (Renewal): Secure Computing Initiative

Awardee: New Jersey Institute of Technology

Amount: \$3,825,496.00

Abstract: this new jersey institute of technology (njit) project will continue and expand the secure computing initiative (sci) as part of the cybercorps®: scholarship for service (sfs) program. sci is

designed to prepare the next generation of cybersecurity professionals to fulfill the national need for cybersecurity experts, while promoting **\*\*diversity\*\***, learning, and discovery. sci has been successful in recruiting, training, and placing highly qualified cybersecurity experts in government positions since 2016. the sci project recruits students in their junior or senior undergraduate year and supports them through the completion of one of two cybersecurity master's degrees offered at njit: ms in cyber security and privacy or ms in information technology administration and security. the project also includes several activities to recruit a diverse student body, such as working with the njit's murray center for women in technology to enhance gender **\*\*diversity\*\***, collaborating with the njit chapters of hispanic and african american professional societies to enhance racial/ethnic **\*\*diversity\*\***, and cooperating with the njit's educational opportunity program office to recruit students from disadvantaged socio-economic backgrounds. the sci cybersecurity education model is characterized by seven features: flexible cybersecurity curricula, experiential learning, research-supported education, nurturing students' creativity, a cybersecurity technology watch activity, fostering students' abilities to work under stress, and multi-tier mentoring. njit has a strong commitment to cybersecurity education, demonstrated by more than 40 courses that focus on this area. as a result, njit's undergraduate and graduate programs allow the sci students flexibility in choosing their area of cybersecurity specialization. in addition, sci incorporates experiential learning projects that map to the national initiative for cybersecurity education (nice) cybersecurity workforce framework. sci scholars are required to participate in a research project with a mentor drawn from a pool of research-active faculty who teach and conduct research in cybersecurity. creativity is stimulated through training in design-thinking approaches for research projects and working in interdisciplinary teams. to keep the students abreast of evolving cybersecurity threats, sci organizes a cybersecurity technology watch, which consists of investigating recent cybersecurity breaches, analyzing them, and drawing lessons from them. to develop appropriate skills for work under stress, the sci students participate in cybersecurity competitions, in which they typically have to solve practical problems in a limited amount of time. finally, sci is structured for a multi-tier mentoring



approach that includes guidance/feedback both from the pis and peers serving as mentors. in addition to training the next generation cybersecurity workforce, sci also produces scientific results and publicly available software that helps advance the discipline of cybersecurity. many of the sci activities involve contact with the general public and are likely to sensitize society at large to the importance of cybersecurity. the outreach activities also include enrichment programs that focus on cybersecurity education for high school students. this project is supported by the cybercorps® scholarship for service (sfs) program, which funds proposals establishing or continuing scholarship programs in cybersecurity and aligns with the u.s. national cyber strategy to develop a superior cybersecurity workforce. following graduation, scholarship recipients are required to work in cybersecurity for a federal, state, local, or tribal government organization for the same duration as their scholarship support. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: BPC-AE: Equity in Computing Education Policies, Pathways, and Practices (ECEP 3)

Awardee: University of Texas at Austin

Amount: \$3,599,041.00

Abstract: we live in an increasingly technology-dependent world where computational literacy and an understanding of computing's implications on individuals and society are vital to personal success, healthy and engaged communities, and to our nation's economic competitiveness and security. the lack of **\*\*diversity\*\*** in k-12 computer science education, limits our nation's ability to leverage the full range of expertise and creativity present in our classrooms and communities. the equity in computing education policies, pathways, and practices (ecep 3) alliance will address the persistent problem of the lack of **\*\*diversity\*\*** in k-12 computer science education and computing pathways. as a result of ecep support, state leaders will untangle the complex web of factors that produce inequitable outcomes for marginalized students, interrogate their own state data to identify specific student populations that have been excluded from computing pathways, investigate their state's educational ecosystems and policies to determine the root causes of disparities in access and participation in computer science education, and promote equity-explicit policy changes to address systemic barriers to broadening participation in computing. ecep will help our nation to transform the exclusionary systems that lead to disparities in cs education for k-12 students, thus leading to a

more diverse computing workforce and computationally literate citizenry. the ecep team is led by the university of texas at austin, the massachusetts green high performance computing center, indiana university bloomington, and university of california irvine. ecep builds state-level capacity for systemic change, thus laying the foundation for improvements in equitable capacity for, access to, participation in and experiences (cape) of computer science education for students who have been excluded from computer science education (csed) pathways. ecep's mission, grounded in the collective impact model, is to change the deeply ingrained policies, pathways, and practices that perpetuate inequitable outcomes throughout the k-12 csed ecosystem. ecep has four primary goals: 1) ecep will serve as a national hub for state leaders dedicated to collaboratively increasing the number and **diversity** of k-12 students in the pipeline to computing and computing-intensive degrees; 2) state leaders will leverage ecep to develop, advocate for, implement, and share equity-explicit, state-initiated policies, pathways, and practices that promote broadening participation in computing (bpc); 3) utilizing the cape framework, state teams will develop goals, common metrics, and data systems to track progress toward equitable k-12 csed; 4) state teams will implement strategies to increase capacity for and diverse student access to, participation in, and experiences of k-12 csed. in order to accomplish these goals ecep will facilitate and nurture a robust learning community among state leaders through monthly virtual meetings, co-sponsorships to states that seed fund bpc interventions and research projects, coaching of state teams, and technical assistance for the creation of cs landscape reports, state csed summits, and other equity-explicit interventions that help states to advance their bpc goals. ecep also supports the national dissemination of equity-explicit professional development for k-12 teachers through its scaling inclusive pedagogy project and its partnership with the computer science teachers association. a defining feature of ecep is the common metrics project, which will result in tools and protocols for consistent measurement cape outcomes. ecep's research and coaching will support state leadership teams as they establish goals for bpc, evaluate the efficacy of their bpc initiatives, and track their progress longitudinally. this award reflects nsf's statutory mission and has been deemed

worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: FIU-2D Crystal Consortium Partnership for Research and Education in Materials

Awardee: Florida International University

Amount: \$3,471,655.00

Abstract: the fiu-2dcc partnership for research and education in materials (prem) between florida international university (fiu) and the 2d crystal consortium materials innovation platform (2dcc mip) at the pennsylvania state university (penn state), will function as a science and education platform between fiu and 2dcc with the ultimate goal of increasing **\*\*diversity\*\*** in materials research. fiu, a premier minority serving institution located in miami, florida, enrolls 58,928 students combining all levels of academic instruction, with 79% of students from an underrepresented minority in stem (more than 65% hispanic or latino and more than 12% black or african american), and 57% women, is uniquely positioned to promote broadening participation in stem fields. fiu-2dcc prem will integrate transformative research with innovative education and outreach to promote recruitment and implement participation of over 30 ph.d., over 20 m.s. and over 40 b.s. students, the majority being from underrepresented minority groups in stem and women. the students will be immersed in a research-intensive environment to gain expertise in quantum materials research and will be provided with a 360-degree toolkit for success, comprising dual mentoring by faculty at both institutions, access to experts and instrumentation, and career skills training. through the student exchange initiative, the team will grow in **\*\*diversity\*\*** and drive innovative problem-solving. through the prem, fiu will become a materials research hub in south florida while enriching the collaborative partnership with 2dcc mip at penn state. the research outcomes will be disseminated through peer-reviewed articles and conference presentations, and the student success will be publicized through the dedicated project website and outreach events. the project will lead to a sustainable pipeline of

minority students and women joining the materials science workforce. the interdisciplinary research of fiu-2dcc prem will enable uncovering of phenomena related to quantum emission in two-dimensional (2d) materials, the realization of 2d-materials based quantum converters, and understanding of the mechanical properties governing the interfaces between the 2d quantum materials and the substrates supporting their integration into future quantum devices. the prem team will focus on fundamental and practical aspects of new 2d materials and processes that can be transformative in the emerging field of quantum science and provide advanced characterization methods to ensure long-term 2d resilience in future quantum devices. organized in three major thrusts, the collaborative research will focus on: (1) novel 2d quantum dots for developing single photon emitters useful in quantum science; (2) layered crystals with optical nonlinearity for developing 2d quantum frequency converters; and (3) mechanical behavior of stand-alone and substrate-deposited 2d materials, assisted by predictive models to support 2d materials discovery and atomic-level characterization of 2d materials. the user facilities at 2dcc mip of penn state, along with unique equipment at fiu, will accelerate quantum materials discovery and enable cross-disciplinary student training. ultimately, this research partnership will increase the understanding of fundamental mechanisms governing room-temperature 2d quantum emission, generate layered crystals for miniaturized quantum converters, and pave the way for scalable quantum computing, with potential to deliver significant societal progress. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CyberCorps Scholarship for Service (Renewal): Strengthening Cyber Community and Pathways Using Research Experiences, Technical Training and Institutional Outreach

Awardee: Pace University New York Campus

Amount: \$3,415,224.00

Abstract: this project supports the continuation and expansion of pace university's cybercorps® scholarship for service (sfs) program. over the next five years, the program will recruit new sfs scholars to study cybersecurity in order to support the government in securing its cyber defense and operations. the new scholars will come from the bachelor's, master's, and doctoral levels of the institution's academic programs in computing and from community college partners, including the state university of new york - westchester community college, a minority-serving institution. students will form a community of cybersecurity scholars who inspire each other and work together in various activities, including workshops, competitions, and conference participation. in addition, the program will support the cybersecurity student club as a means to further broaden the community. the sfs scholars will engage in research, technical training, and professional certification preparation to ensure they will be ready to meet rapidly evolving cybersecurity challenges. lastly, the project will continue its commitment to **\*\*diversity\*\*** through institutional outreach to k-12 schools and community colleges and focusing on recruiting students from underrepresented minority backgrounds and on women. pace university's program has produced cybersecurity professionals working at various levels of the government. the objectives of the project are 1) to produce twenty or more cybersecurity professionals who will enter the government workforce upon graduation, 2) to prepare cybersecurity professionals with diverse educational backgrounds through five cyber pathways, 3) to support **\*\*diversity\*\*** in the field by providing opportunities for minority students and women, 4) to mentor non-sfs institutions and their students through institutional partnerships, 5) to strengthen collaboration between pace university and its government partners, and 6) to generate interest in becoming cybersecurity professionals among broader student populations both at pace university and at partner institutions. the program consists of five cyber pathways ranging from an associate's degree to the phd. the pathways allow the program to prepare scholars differently based on their background and interests. in addition, scholars will engage in research projects that reinforce their cybersecurity competencies. these research projects, with support from the cybersecurity scholars, have the potential to contribute to research innovation in the areas of

open-source intelligence, data analytics, machine learning, computer forensics and robotics. professional development activities will expose scholars to cybersecurity professionals from academia and industry. this project will use competency-based advising, using digital badging to provide scholars with a roadmap aligned to their strengths and interests and with the nice cybersecurity workforce framework. this advising approach, accompanied by the five cyber pathways, curriculum integration and the research program, will enable the project team to recruit and prepare students to satisfy diverse needs for cybersecurity professionals in the government. this project is supported by the cybercorps® scholarship for service (sfs) program, which funds proposals establishing or continuing scholarship programs in cybersecurity and aligns with the u.s. national cyber strategy to develop a superior cybersecurity workforce. following graduation, scholarship recipients are required to work in cybersecurity for a federal, state, local, or tribal government organization for the same duration as their scholarship support. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CyberCorps Scholarship for Service (Renewal): An Enhanced and Integrated Scholar Experience in Cybersecurity

Awardee: Tennessee Technological University

Amount: \$3,280,630.00

Abstract: the renewal of the tennessee tech university (tntech) project will allow this cybercorps®: scholarship for service (sfs) program to continue supporting national defense through the production of well-trained cybersecurity professionals. the program supports the success of the sfs scholars by combining integrated experiences in education, research and outreach and leveraging existing resources and university-wide collaboration among faculty and administration. the tntech cybercorps® program supports both undergraduate and graduate students with a focus on



improving the **diversity** of the cybersecurity workforce through increasing the representation of women and underrepresented minorities. in addition, the program is the first in the state of tennessee with the opportunity to serve the economically distressed appalachian region. with the rapid growth of tech's computer science and cybersecurity program, the renewal allows tntech to continue to produce highly trained cybersecurity professionals who contribute to the nation's cyberspace security. it also allows new innovations in the sfs program and enables the cybersecurity education research and outreach center at tntech to continue deepening its local, regional, and national impacts. the objectives of the tntech sfs program include continuing to expand higher education choices in cybersecurity for local and regional students through federal scholarship opportunities. the project will also enhance sfs scholars' knowledge, skills, research aptitude, and service-learning motivation through a program that values fair participation in education, research and outreach. the program will continue supporting the pipeline of sfs scholars to federal agencies in tennessee (and the region) while aiming to increase women and underrepresented minority students' participation. program performance will continue to be assessed in this new project period. the project continues to refine strategies and techniques that can potentially be effective in addressing sfs program management challenges including scholar on-boarding and providing wide-ranging experiences and flexible paths for scholars. this project is supported by the cybercorps® scholarship for service (sfs) program, which funds proposals establishing or continuing scholarship programs in cybersecurity and aligns with the u.s. national cyber strategy to develop a superior cybersecurity workforce. following graduation, scholarship recipients are required to work in cybersecurity for a federal, state, local, or tribal government organization for the same duration as their scholarship support. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: NRT-HDR: Bridges in Digital Health

Awardee: West Virginia University Research Corporation

Amount: \$3,062,662.00

Abstract: proposal id: 2125872 proposal title: nrt-hdr: bridges in digital health pi: donald adjero

institution: west virginia university public abstract the rapidly increasing cost of healthcare represents one of the most pressing problems facing the united states and most other countries around the world. at the same time, increased life expectancy has resulted in a significant expansion of the nation's elderly population. the combination of rising health care costs and increased life spans poses tough challenges for many families. the widespread disruptions caused by the covid-19 pandemic have exacerbated these national challenges and health disparities, particularly in rural communities with poor health rankings. these problems could be addressed by new advances in digital health (dh) and how we train the next generation of scientists, engineers, and healthcare professionals to develop and deploy such advances. this national science foundation research traineeship award to west virginia university (wvu) will address these challenges by developing a new graduate education and traineeship model to prepare professionals who can work in collaborative transdisciplinary teams to develop and apply data science and artificial intelligence (ai)

techniques in addressing difficult problems in dh, including in rural areas. the project anticipates training twenty-four (24) funded and forty (40) unfunded ms and phd students from different backgrounds, including engineering, computer science, medicine, health sciences, physical sciences, and economics. data science and ai techniques have been successfully applied to address a diverse range of health problems. the traineeship will address how to scale and build on dh successes by developing: 1) effective and transferable frameworks for training a larger and more diverse workforce with the foundations underlying these advances while inculcating soft skills beyond traditional coursework and ensuring rural communities are served; and 2) new ways to address other problems in dh related to the nature of dh data, the significant data analysis gap, and computational problems. a key element in the traineeship is its specific attention to the "bridges" required for effective and scalable traineeship and workforce development in dh. these bridges will connect: (a) different fields within health sciences, and across other areas, including barriers posed by the distinct terminologies used by different fields; (b) different scales of study in biomedicine (from micro to macro) via integration of different data types; and (c) underrepresented groups and innovative research in dh to ensure "diversity" in the traineeship. this "diversity" will be achieved by: 1) recruiting and supporting success for participants from historically black colleges and universities, those who are rural, those from the first generation in their families to go to college, and/or those from other groups underserved in stem, and 2) by bridging primarily undergraduate institutions and large research institutions. trainees will develop novel approaches to tackle some of the core problems in ai (e.g., trust and safe decision making, scalable data structures, and attention-based information integration). trainees will apply these approaches to specific problems in health, such as myocardial fingerprinting from echocardiograms and large-scale functional annotation in genomics. the project uses an innovative sequence of components to interweave the research theme, important professional skills (e.g., communication, ethics, leadership, collaboration), and coursework into the traineeship model without extending time-to-degree. upon completion, trainees will be awarded a certificate in dh. the traineeship will also form a basis for a

new, transdisciplinary phd program in dh at wvu. the nsf research traineeship (nrt) program is designed to encourage the development and implementation of bold, new potentially transformative models for stem graduate education training. the program is dedicated to effective training of stem graduate students in high priority interdisciplinary or convergent research areas through comprehensive traineeship models that are innovative, evidence-based, and aligned with changing workforce and research needs. this project is jointly funded by the nrt program and the established program to stimulate competitive research (epscor). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CyberCorps Scholarship for Service (Renewal): Advancing a Successful Cybersecurity Education and Workforce Development Program

Awardee: University of Texas at El Paso

Amount: \$3,003,188.00

Abstract: the central role of software in the operation of defense, energy, communication, transportation, and manufacturing systems makes it increasingly important that these systems are designed in a way that integrates cybersecurity principles. the renewal of the cybercorps® scholarship for service (sfs) program at the university of texas at el paso (utep) will continue the support of highly qualified students, in particular latinx and female students, who complete a cybersecurity-focused program and graduate with the ability to apply disciplined software development principles and processes. utep is uniquely positioned to contribute to efforts to improve **\*\*diversity\*\*** in the cybersecurity workforce due to the population it serves, which includes hispanic, first generation, and lowest income quartile students. utep students do not fit the "traditional" student profile of a full-time student transitioning directly from high school to a four-year college or university as many students transfer from local community colleges and pursue their education

part-time. over the past five years, utep has made significant advances in developing cybersecurity educational programs, research, and outreach activities at utep and beyond. these efforts have resulted in recognitions including the national security agency designation as a center of academic excellence in both cyber defense and cyber operations (only one of 21 across the nation), as well as the designation as an army research lab-south remote campus in cybersecurity. utep's sfs scholars complete rigorous educational programs with a focus on cybersecurity and complement the knowledge gained in the classroom through significant involvement in cybersecurity research, training, competitions, and hands-on activities. all utep sfs scholars are also required to engage in service to the community to build cybersecurity awareness and capabilities among utep students and beyond. the goals of the utep sfs program are to 1) recruit and retain at least 30 students into utep's master of science in software engineering and the doctoral computer science programs; 2) graduate students who will enter the workforce with the ability to transfer state-of-the-art cybersecurity techniques and approaches into practice; 3) place students in government positions that utilize their knowledge and capabilities in cybersecurity, with a focus on placing graduates in federal/executive entities; and 4) advance cybersecurity awareness and competencies among k-12 students and educators. this project is supported by the cybercorps® scholarship for service (sfs) program, which funds proposals establishing or continuing scholarship programs in cybersecurity and aligns with the u.s. national cyber strategy to develop a superior cybersecurity workforce. following graduation, scholarship recipients are required to work in cybersecurity for a federal, state, local, or tribal government organization for the same duration as their scholarship support. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NRT-WoU: Establishing Multimessenger Astronomy Inclusive Training (EMIT)

Awardee: Vanderbilt University

Amount: \$3,000,000.00

Abstract: this national science foundation research traineeship (nrt) award to vanderbilt university will prepare the first generation of students in the emerging field of multimessenger astronomy (mma). with the discovery of gravitational waves, there is a new window on the universe and with it, a once-in-a-generation opportunity to launch a new field. the goal of this program is to pilot the establishing multimessenger astronomy inclusive training (emit) initiative. emit will be a transdisciplinary graduate program that promotes **\*\*diversity\*\*** and inclusion and produces scholars with the skills needed to drive discoveries in mma while expanding the stem workforce. the project will train 300 students from physics, astronomy, math, and engineering, including 19 funded trainees, through new formal curricula, seminars, summer programs, and research. the aim is to build a community of practice that is diverse from the outset through cohort building, shared research experiences, visible underrepresented minority role models, and a suite of evidence-based programming designed to promote inclusive excellence. emit trainees will learn the interdisciplinary concepts, research techniques, and the conduct of research critical to advance mma. using educational research-supported practices, the program will prepare students to take a team science approach while developing transferable skills for transition to the workforce. some trainees will earn a master of science degree at fisk university, a collaborating institution, and may directly enter employment or go on to join a ph.d. program. other trainees will enter vanderbilt directly in a doctoral program. regardless of the option chosen, students will earn a graduate certificate in mma through research, coursework, and outreach. joint student research between fisk, vanderbilt, and external collaborators will bring together new nodes of expertise. these collaborative research projects will complement and enhance the strengths of the partnering institutions. the team will provide stage-specific professional development for the entire student training period. the program supplements traditional coursework with a novel modular curriculum specific to mma. some courses and blast modules will be posted on an emit youtube channel to reach the larger community. a summer workshop, open nationally, will occur every other year and broaden

understanding of the research needs, promote the skills required for mma, and further stimulate teaching and communication for emit trainees. after earning the graduate certificate, emit trainees will help lead this workshop. the nsf research traineeship (nrt) program is designed to encourage the development and implementation of bold, new potentially transformative models for stem graduate education training. the program is dedicated to effective training of stem graduate students in high priority interdisciplinary or convergent research areas through comprehensive traineeship models that are innovative, evidence-based, and aligned with changing workforce and research needs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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The NSF Research Traineeship (NRT) program is designed to encourage the development and implementation of bold, new potentially transformative models for STEM graduate education training. The program is dedicated to effective training of STEM graduate students in high priority interdisciplinary or convergent research areas through comprehensive traineeship models that are innovative, evidence-based, and aligned with changing workforce and research needs. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NRT-AI: Digital Transformation of Development (DTOD)

Awardee: University of California-Berkeley

Amount: \$3,000,000.00

Abstract: over the past two decades, a massive amount of digital information has become available on every aspect of human existence, from income and climate to housing and health. combining these data from the internet of things, and drawing on techniques for analyzing them through artificial intelligence/machine learning (ai/ml), is now considered crucial for progress in all sectors. digital transformation is the staple of multiple sectors of industry and commerce. however, more far-reaching consequences of digital transformation for poverty alleviation, humanitarian assistance, disaster relief, and, more generally, improving outcomes for under-resourced or low-income populations are understudied. this national science foundation research traineeship (nrt) award to the university of california-berkeley will allow us to provide interdisciplinary training for our students in design methodologies, algorithms, and problem-solving approaches to substantively analyze, ethically investigate, and develop verifiable, fair, inclusive, and useful observations from datasets and models. from these insights, students will be able to devise and deploy digital tools to accelerate growth for low-income populations in the u.s. and globally. the project anticipates training 100 master's and doctoral students, including 28 nrt-funded trainees, from any degree program at the university that expresses interest in researching digital transformation of development (dtod). a key concern has been how the analytics and other mechanisms developed using big data benefit the populations surveyed. by ensuring that the analytic techniques and algorithms, privacy, fairness, mechanism design, and implementation of digital technology are relevant to under-served populations, the dtod traineeship also expects to increase **diversity** and inclusion of members of underrepresented minority groups in stem. the dtod program will include interdisciplinary research activities, formal coursework and curriculum building, immersive lab and field training, the creation of official dtod concentrations at both the doctoral and master's degree levels, and career development. in addition, the program's effectiveness in developing critical skillsets for multinational workforces will be assessed through formative evaluation. the program will rely on both interdisciplinary research faculty and development practitioners in three broad application areas: (1)

measures for alleviating poverty with data, algorithms, and ai applied to policy; (2) poverty interventions that integrate the natural and built environments in low-resource settings; and (3) improving health and wellbeing in low-income populations. dtod will also contribute to the development of shared public datasets aligned with national strategies and priorities related to advancing ai. the nsf research traineeship (nrt) program is designed to encourage the development and implementation of bold, new, potentially transformative models for stem graduate education training. the program is dedicated to effective training of stem graduate students in high-priority interdisciplinary or convergent research areas through comprehensive traineeship models that are innovative, evidence-based, and aligned with changing workforce and research needs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: A Knowledge-Based Framework for Creating and Sustaining Transformational Change for Latinx Student Success in STEM

Awardee: University of Texas at El Paso

Amount: \$2,999,942.00

Abstract: this project aims to use a **\*\*diversity\*\***, equity, and inclusion lens to create systemic, transformational change at the university of texas at el paso to increase the number of latinx students, in particular latina students, who are competitive in stem careers. to achieve the aim of increased participation in stem fields at the national level, a cross-cutting and replicable institutional approach that considers learning outcomes, students' experiences, internal organizational structures, and external influences will be implemented. with support from the improving undergraduate stem education: hispanic-serving institutions program (hsi program), the project team will intentionally embed concern for **\*\*diversity\*\***, equity, and inclusion in teaching and learning, professional development, and policies and procedures, seeking to shift culture across the institution. a key aspect of the project to support long term impact is capacity building for research on the interplay between stem education and "servingness," a conceptual way to understand what it means to move from simply enrolling latinx students to actually serving them. the project seeks to institutionalize the systematic use of data and the authentic engagement of key stakeholders to build sustained change through continuous improvement and to maintain, sustain, and build upon inclusive infrastructure and resources. project personnel will identify, stratify, organize, present, and distribute data to be used for decision-making. a transformation team coordinated by the provost's office will use those data to recommend, plan, and evaluate action on relevant issues. the institution plans to transform stem undergraduate education through changes in core curricula that provide equitable opportunities to students. in a revitalization of the curriculum, working groups of faculty will develop modular materials for inclusion in the university core to increase inclusive instruction, stem

competencies, and engagement. the center for faculty leadership and development will implement a professional development series on inclusive and asset-based pedagogy. the administration will work to select, compensate, develop, and mentor future faculty leaders invested in \*\*diversity\*\*, equity, and inclusion. the provost's office will work with administration and the faculty senate to codify policies and procedures that recognize faculty and staff efforts in inclusive teaching and learning. the project will increase publications on metrics-based planning; promote regular use of metrics and research by deans, chairs, and program directors in planning and improving interventions; enhance the ability of stakeholders to understand multiple perspectives on data through visualization; and expand shared understanding of effective practices. changes will be institutionalized and sustained through policies and procedures that recognize and reward faculty and staff who focus on student success and servingness. the hsi program aims to enhance undergraduate stem education, broaden participation in stem, and build capacity at hsis. achieving these aims, given the diverse nature and context of the hsis, requires innovative approaches that incentivize institutional and community transformation and promote fundamental research (i) on engaged student learning, (ii) about what it takes to diversify and increase participation in stem effectively, and (iii) that improves our understanding of how to build institutional capacity at hsis. projects supported by the hsi program will also draw from these approaches to generate new knowledge on how to achieve these aims. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NRT- FW-HTF: Linguistic diversity across the lifespan (LINDIV): transforming training to advance human-technology interaction

Awardee: Pennsylvania State Univ University Park

Amount: \$2,999,920.00

Abstract: technology such as smart voice assistants or computer-based intelligent tutoring systems has become crucial to people's private lives, education, and the workforce. this technology is largely based on standard american english and the misconception that there is a single, idealized variety of american english, which conflicts with the true **\*\*diversity\*\*** of language users. many u.s. speakers use a regional variety of american english, african american vernacular english, a signed language, a language other than english, or have some form of communication disorder. as the u.s. population is becoming older, age-related hearing loss and language impairments will also increase. the linguistic sophistication of technology has not kept pace with the growing linguistic **\*\*diversity\*\*** within the u.s. this technology is intended to improve the lives of humans and society at large, and people increasingly depend on it for access to governmental, community, health, and educational services, making the technology's current reliance on standard american english problematic. this national science foundation research traineeship award to the pennsylvania state university will educate a new generation of experts in human-technology interactions to address this issue. the project anticipates training 48 graduate students, including 23 funded trainees, from graduate programs in psychology, german, spanish, communication science and disorders, computer science and engineering, information sciences and technology, and learning design and technology. the comprehensive two-year traineeships will prepare trainees to address key challenges in human-technology interactions. improvements in human-technology interactions will help ensure the full participation of individuals with diverse language backgrounds, fostering an equal, diverse, and inclusive society. by applying integrated learning and transdisciplinary team science principles, trainees will be prepared to bridge the gap between language science and technology. trainees will also be prepared to think beyond disciplinary boundaries. this approach is considered optimal to prepare the next generation for the future of work. in a two-year program culminating in the new graduate certificate 'linguistic **\*\*diversity\*\*** and technology?', trainees will complete cross-disciplinary courses and professional development in language and technology. trainees will work on transdisciplinary team research projects that address tractable goal and produce clear products,

such as a design project, pilot application, or research study focused on integrating language science and human-technology interaction. trainees will also participate in seminars, research events, mentoring, and a linguistic **\*\*diversity\*\*** outreach program. they will complete the program with an internship with academic and private sector extramural partners to support careers bridging linguistics and technology, both inside and outside academia, in national and international settings. trained to work in diverse teams, trainees will be competent in creating knowledge and translating research outcomes into technological solutions that alleviate social, educational, and economic disparities for linguistically diverse populations. the nsf research traineeship (nrt) program is designed to encourage the development and implementation of bold, new potentially transformative models for stem graduate education training. the program is dedicated to effective training of stem graduate students in high priority interdisciplinary or convergent research areas through comprehensive traineeship models that are innovative, evidence-based, and aligned with changing workforce and research needs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: URoL:EN Quantifying the phytochemical landscape through Indigenous Knowledge, interaction diversity, genomics, and network dynamics

Awardee: Board of Regents, NSHE, obo University of Nevada, Reno

Amount: \$2,999,552.00

Abstract: this project seeks to understand emerging network dynamics from global to molecular scales through convergent research that spans the most recent methodological advances in biology, chemistry, mathematics, anthropology, and traditional indigenous knowledge. the proposal specifically focuses on the effects of harvesting balsa wood from amazonian rainforests for wind-turbine production in china on forest bio**\*\*diversity\*\*** and indigenous communities. the main



objectives are to: 1) enhance knowledge of forest species ecological and chemical interactions through indigenous knowledge of bio\*\*diversity\*\* and medicinal plant value, 2) measure the effects of balsa-harvesting on these species interaction networks, and 3) use mathematical modeling to generalize these processes and make predictions about ecosystem resilience and sustainability. the project will be in collaboration with indigenous community members and will incorporate their traditional knowledge of plant and animal species as part of an integrated research team. this project directly increases our understanding of the rules of life by gaining insight into the genetic, chemical and ecological mechanisms at all scales of organization that maintain bio\*\*diversity\*\* in tropical systems and predicting the subsequent effects on ecosystem resilience in a changing environment. quantifying how phytochemical and genetic variation are jointly structured across the landscape and contribute to the maintenance of bio\*\*diversity\*\* can contribute substantially to understanding this rule of life: the resiliency of complex ecosystems can be predicted from carefully quantified genetics, ecological interactions, and disturbances, many of which are mediated through biochemical networks. the proposal specifically focuses on the effects of harvesting balsa wood for wind-turbine production in china from amazonian rainforests, and the research will examine the effects of forest disruptions on kichwa and waorani communities and on the phytochemistry and \*\*diversity\*\* associated with the tropical pepper shrub, piper. the proposed project will examine how these systems are linked across multiple scales, from global networks focused on producing sustainable energy, to networks of interactions with the indigenous peoples whose livelihoods and medicinal plant communities are affected by those production networks, to the ecological, chemical, and genetic networks that are the basis of species interactions with plant communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: FMRG: Eco: Future Eco Manufacturing of Recyclable Soft Electronics

Awardee: North Carolina State University

Amount: \$2,998,710.00

Abstract: this future manufacturing research grant (fmrg) ecomanufacturing project will enable eco manufacturing of recyclable soft electronics by seamlessly integrating a select group of biodegradable/recyclable materials and sustainable manufacturing processes, guided by economic and environmental life-cycle assessment. the rapidly increasing number of electronic devices that have decreasing lifetime in use pose three important challenges: (1) a huge amount of waste from used electronics, (2) rapid consumption of scarce elements, and (3) enormous energy consumption for manufacturing electronic devices. on the other hand, soft electronics is an emerging field. therefore, the team will develop new classes of soft electronics that are created from renewable materials using energy-efficient manufacturing processes, and that can either be degraded naturally or repurposed into high-value products after their lifetime. the project will bring together researchers in flexible/stretchable electronics, polymer chemistry, chemical and materials engineering, manufacturing engineering, sustainability, and science education. this interdisciplinary convergence project will provide a compelling basis to train a diverse cohort of future engineers and scientists. the education and workforce development efforts will include curriculum innovation, teacher professional development, outreach, and student internships, with a commitment to increasing the **\*\*diversity\*\*** in the workforce. this project is structured in five thrust areas addressing materials development, eco manufacturing, biodegradation/recycling, environmental and economic life-cycle assessment, and education and workforce development. more specifically, the project team will design reinforced cellulose composite as the substrate, new conjugated polymer as the semiconductor, composite with selected fillers as the dielectric, and silver nanowire network as the conductor. the research will address the challenges of developing high-performance materials that are renewable, biodegradable or recyclable. it will result in a viable all-printing-based manufacturing framework to enable the scalable fabrication of sustainable soft electronics. the scalability will be demonstrated with a laboratory-scale roll-to-roll system. the device components at their end of life will follow three

routes ? biodegradation (back to nature), recycling (back to manufacturing), or upcycling (converting to value-added new materials). the project will incorporate biodegradation and material circularity into the life-cycle assessment framework for soft electronics. this future manufacturing project is jointly funded by the divisions of civil, mechanical and manufacturing innovation (cmmi), electrical, communication, and cyber systems (eccs), and engineering education and centers (eec) in the directorate of engineering, and by the divisions of chemistry (che) and materials research (dmr) in the directorate for mathematical and physical sciences (mps). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: NRT-URoL: Decoding the Mechanisms Underpinning Biofilm Function and Architecture in Extreme Environments

Awardee: Montana State University

Amount: \$2,984,140.00

Abstract: biofilms, communities of microorganisms attached to surfaces, occur in/on almost any environment and surface type. as a result, they have widespread impact on many aspects of both engineered and natural systems including agriculture, industry, and human health. extreme environments provide unique opportunities to conduct cross-cutting transformative science. their reduced bio\*\*diversity\*\* and extreme physical and chemical conditions enable detailed characterization and quantitative descriptions of important physical, chemical, and biological processes. this national research traineeship (nrt) award to montana state university (msu) will train a diverse group of ph.d. students to effectively engage and understand critical properties of extreme biofilm systems across multiple disciplines. the interdisciplinary research training will help to generate new insights that can control biofilms in engineered and natural systems. the integrative scientific training program uses innovative teaching elements that will equip participants with professional, communication, teamwork, research, and problem-solving skills that are broadly applicable across a variety of industrial and academic research careers. the project anticipates training 71 ph.d. students, including 21 nrt-funded trainees, with program activities also serving ph.d. and m.s. students across a range of stem departments. the nrt trainees will use life in extreme environments to push the boundaries of interdisciplinary research, integrating meta-omics-based approaches with high resolution imaging to understand intricate and cross-cutting interactions occurring in multi-species and multi-domain biofilms. students will investigate extreme biological systems that span the range of conditions where life survives, from the icy antarctic cryosphere, to yellowstone national park terrestrial hot springs, to the hydrothermal vents of guaymas basin in the gulf of california. major research themes include: (1) using metagenomics to examine genotypic variations and commonalities related to metabolic potential and \*\*diversity\*\* in extreme biofilm communities; (2) investigating patterns of biofilm composition and architecture using multi-scale microscopic imaging instrumentation; and (3) identifying patterns of extreme biofilm development, expression of novel pathways, and signaling molecules using proteomics and metabolomics. the

traineeship's project-based and collaborative science curriculum will help participants acquire the fundamental knowledge and skills necessary to converge across disciplinary boundaries to investigate the research themes, identifying properties and patterns of activity that explain biofilm cohesion and organization in extreme systems. key elements of this nrt program are scalable and sustainable, including (1) a program that allows students personalize their technical training, curriculum, and mentor team; (2) seminars, courses, and activities that help trainees develop transferrable professional and technical skills that feature strongly across a range of research-related careers, and (3) recruitment, mentoring, and retention strategies that broaden stem participation, foster mentoring and professional relationships, and improve students' research productivity. the program provides a holistic educational experience for the trainees, where innovative training elements thoughtfully prepare participants to thrive in a variety of research careers. the nsf research traineeship (nrt) program is designed to encourage the development and implementation of bold, new potentially transformative models for stem graduate education training. the program is dedicated to effective training of stem graduate students in high priority interdisciplinary or convergent research areas through comprehensive traineeship models that are innovative, evidence-based, and aligned with changing workforce and research needs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: HSI Institutional Transformation Project: Cal Poly Pomona INtentional Venture Engaging STEM Students (CPP INVESTS)

Awardee: Cal Poly Pomona Foundation, Inc.

Amount: \$2,955,647.00

Abstract: with support from the improving undergraduate stem education: hispanic-serving institutions (hsi program), this track 3 itp project at california state polytechnic university, pomona

(cpp) will advance the goals of the hsi program by embedding high-impact practices (hips) during three critical transitions in the stem student life cycle: (1) secondary to post-secondary education -- scale first year experience (fye) courses and course-based undergraduate research experiences (cures), and embed peer learning assistants (plas) in fyes; (2) lower division to upper division stem courses -- embed cures in second year stem gateway courses and capstone and upper-division ge courses; (3) graduation into the stem workforce -- utilize two innovative components: "micro" internships and alternative learning records (alrs). the project will scale the number of stem students participating in internships by embedding six-week "micro" internship experiences in junior gateway and senior capstone courses. the project will develop and implement two alrs -- leadership and research career development. to support stem faculty, the project will provide stem faculty institutes to coach faculty in developing culturally relevant pedagogy anchored in **diversity**, equity, and inclusion, developing fye courses, embedding cures, micro-internships, and alrs in their courses and programs. the specific aim of the project is to contribute to the understanding of how to build institutional capacity to enhance the quality of undergraduate stem education at hsis. the program evaluation plan will focus on institutional-level variables including recruitment, retention, and graduation rates of stem students in the project by utilizing both formative and summative assessment methods. this project will employ quasi-experimental design to examine the impact of plas on the sense of belonging and academic self-efficacy of first year students in fye courses. it will use mixed-methods to examine both the impact of micro-internships and alrs on the professional identities of stem students and the impact of the faculty professional development efforts, including pre-post surveys, interviews, and focused group discussions. the project will generate new knowledge and contribute to the development of the nascent research on the impact of alrs and course-embedded micro-internships on stem student success. the broader impact of the project is the potential to develop and test a model that will be disseminated to and can be utilized by the california state university system which serves the greatest number of hispanics and underserved stem students in the nation, and other institutions that serve large populations of students who are

urms, first-generation and low-income. the hsi program aims to enhance undergraduate stem education, broaden participation in stem, and build capacity at hsis. achieving these aims, given the diverse nature and context of the hsis, requires innovative approaches that incentivize institutional and community transformation and promote fundamental research (i) on engaged student learning, (ii) about what it takes to diversify and increase participation in stem effectively, and (iii) that improves our understanding of how to build institutional capacity at hsis. projects supported by the hsi program will also draw from these approaches to generate new knowledge on how to achieve these aims. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SCC-IRG Track 1: Fostering Smart and Sustainable Travel through Engaged Communities using Integrated Multidimensional Information-Based Solutions

Awardee: Georgia Tech Research Corporation

Amount: \$2,548,000.00

Abstract: this smart and connected communities award supports research that will develop systematic deployment tools that smart and connected communities can use to achieve their sustainable travel goals in a quantifiable manner by leveraging advances in information, communication and sensor technologies. while the deployment of advanced technological solutions offers great promise for communities to improve residents' quality of life and prosperity, they are faced with significant challenges in realizing these aspirations due to the **\*\*diversity\*\*** in technological and travel needs and barriers faced by the residents. solutions to achieve sustainability objectives related to enhancing travel mobility, safety, equity, and access will be developed using the city of peachtree corners (ga) as an immersive living lab. they include building novel partnerships involving emerging micromobility services in the private sector and the well-established public transit modes. further, they will involve personalized behavioral interventions



to nudge and incentivize personal auto users to consider sustainable alternatives through seamless information provision. at the community level, public policy interventions will seek to enable flexible and novel travel alternatives while ensuring that all residents have access to timely travel-related information. for underserved and underrepresented residents, the solutions will include strategies to overcome information deserts in lower-income neighborhoods, age-related technology savviness issues for senior residents, and reduced access to smartphones and transportation options. these solutions will be developed using data collected from community residents and other sources, and deployed using an information design system that provides targeted information delivery to the various stakeholders in the community using multiple delivery mechanisms, including a community app. this project will advance theory and deployment paradigms associated with holistic, community-level decision-making to achieve travel sustainability goals characterized by multiple, disparate objectives while meeting the needs and constraints of different stakeholders. in particular, it will address the challenges of how to integrate disparate, multi-source data from various stakeholders and use it to systematically generate multidimensional solution options (partnerships, behavioral interventions, policy interventions) to meet multiple sustainability objectives at the community level in a systematic, quantifiable manner over time. it will draw on methods from multi-objective and multi-agent optimization, machine learning, behavioral economics, and data and policy analytics, to generate the multidimensional solutions. further, it will lead to novel paradigms and algorithms for the solution options themselves, and for the development of generalizable principles related to practical deployment frameworks in the inherently complex, multidimensional smart and connected communities. the project will also develop formal methods for information design and delivery that translate the multidimensional solutions into actionable information that is seamless for the various stakeholders. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Co-Development of Telehealth, Remote Patient Monitoring, and AI-based Tools for Inclusive Technology-Facilitated Healthcare Work of the Future

Awardee: New York University

Amount: \$2,515,999.00

Abstract: as the use of digital health technologies grows, gaps between the potential of new technologies, existing healthcare practices, and workers' preparedness for new technologies limit the potential of digital health to achieve acceptance and effective utilization at scale. this transition to scale research project views inclusion as a key driver of scale in future technology-facilitated healthcare work. inclusive technology for healthcare work will enable workers in diverse roles and skills to leverage increasing access to data-driven technologies. the project focuses on the growth of data-intensive technologies (dit), which include telehealth and ai-based tools. the project's approach to transition to scale centers on alleviating existing misalignment between current healthcare work and data-intensive technologies in three ways. first is through the co-development of tools and generalizable design principles with users that lower the barrier to technology integration for healthcare workers. second is by empowering individuals within healthcare systems who have diverse roles to adopt and use the tools and improve their skills. third is to enable patient-centered healthcare that promotes autonomy and strengthens clinician-patient concordance. the project represents a multi-institutional commitment to transitioning innovative healthcare to scale, through dit facilitated inclusion of diverse workers in healthcare systems across the u.s., which together encompass over 1000 care sites in u.s. 24 states, multiple work roles, and different levels of training and hierarchy. this project brings together several scientific fields, including human-computer interaction, health informatics, artificial intelligence (ai), sensing, medicine, organizational behavior, and research on **diversity** and inclusion. the investigator team is structured to achieve multiple convergent goals such as quantifying the impacts of scaling dit on inclusive healthcare work and modelling prescription and adoption of dit towards inclusive

deployment at scale. additionally, the investigators seek to identify generalizable dit design principles for inclusive healthcare work at scale, and to develop theory and tools to facilitate at-scale inclusion through dit-based patient-provider concordance. finally, the project expects to develop tools and practices for lowering barriers to comprehension of and engagement with dit by diverse healthcare workers; to create ai-based team-focused tools; and to analyze the opportunities and challenges in using ai for diverse healthcare teams? work. this project has been funded by the nsf future of work at the human-technology frontier cross-directorate program to promote deeper basic understanding of the interdependent human-technology partnership in work contexts by advancing design of intelligent work technologies that operate in harmony with human workers. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MIM: Using Machine Learning and a Model Watershed to Understand how Microbes Govern Food Web Architecture and Efficiency

Awardee: University of Hawaii

Amount: \$2,499,432.00

Abstract: rules that govern food web dynamics, which describe how energy is transferred among different living organisms, are among the most universal laws of nature. consumption up a food-chain is an inherently inefficient process that leads to significant and predictable losses through waste and respiration. this rule of life can be leveraged to model how biological **\*\*diversity\*\*** will respond to phenomena such as sudden changes in the environment or species extinctions, and is an important constraint in food production. until now, food web research has largely focused on the interactions among plants and animals, however, microbes living in and on larger organisms play essential roles in their health, rates of reproduction, and ability to digest food. this project will examine how symbiotic microbes govern the efficiency of food webs, and how aspects of food webs,

in turn, determine the composition of symbiotic microbes. the predictive insight gained from this research may make it possible to manipulate the composition of microbes to create more efficient food webs that can potentially guide restoration of degraded habitats, capture carbon, and increase yield in agriculture, aquaculture and biofuels systems. in addition, workforce development and outreach to under-represented groups including native hawaiians and pacific islanders, will be performed. postdoctoral researchers, graduate students and undergraduates will be trained in microbiome science through research experiences and class modules. this proposal addresses the hypothesis that canonical laws governing the transfer of energy among trophic levels of food webs both constrain, and are constrained by the composition and function of microbiomes. leveraging a model hawaiian watershed system, this project aims to understand how host-associated microbiomes govern food chain efficiency and how, in turn, trophic position within a food web affects the microbiome. the project will develop transfer learning approaches based on machine-learning tools trained on higher-feature datasets (such as the earth microbiome project) to enable robust predictions of the interaction between food chain length, trophic position and microbiome **diversity**. two tractable experimental systems will be used to explore these predictions. the first is a simple four-tiered bromeliad food web mesocosm where the number and of trophic levels is controlled. the second consists of a three-tiered mosquito microcosm in which all microbial symbionts are isolated and manipulated. associated genomic data will enable a mechanistic understanding of how microbiomes influence food web efficiency and function by altering metabolic capacity of hosts. in summary, this project will employ food web theory to explain and predict the interactions between the microbiome, the host, and the environment. this project is jointly funded by the understanding rules of life: microbiome interactions and mechanisms program and the established program to stimulate competitive research (epscor). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Engaging Multicultural Audiences through Inclusive STEM content on YouTube

Awardee: PBS FOUNDATION

Amount: \$2,499,320.00

Abstract: this innovations in development project is funded by the advancing informal stem learning (aisl) program, which seeks to (a) advance new approaches to and evidence-based understanding of the design and development of stem learning in informal environments; (b) provide multiple pathways for broadening access to and engagement in stem learning experiences; (c) advance innovative research on and assessment of stem learning in informal environments; and (d) engage the public of all ages in learning stem in informal environments increasing greater **\*\*diversity\*\***, equity, and inclusion in science not only presents a social justice goal, but is also vital to the financial and social success of the nation. the stereotype of the older white male scientist has obscured the contributions of women and people of color. this project seeks to remedy these perceptions which are barriers to entry into stem fields. the project will create a large-scale hub for stem themed video content on youtube and other social media platforms, featuring 100+ original stem videos produced by pbs partners. this hub and accompanying research seeks to identify the characteristics of online stem content that attract (or fail to attract) underrepresented groups, specifically black and hispanic communities as well as women of all races. the objectives of this project are to 1) provide a unified online science-themed hub, pbs terra, on youtube and other platforms for hosting, sharing, and distributing digital stem series from diverse producers from across the pbs system; 2) conduct surveys and focus groups to examine and understand the needs and expectations of women, black and hispanic communities and their consumption of stem video content online and 3) test hypotheses about the communicative strategies of stem videos that feature black and hispanic female scientists. project collaborators include pbs, researchers at the university of utah and the university of georgia, and consultants and advisors with expertise in broadening participation and inclusion in stem. little is known about how or why adult americans

seek science content on youtube, especially the motivations of adults from underrepresented minorities and females. the key research questions in this project are: 1) why do black and hispanic audiences and women of all races seek science video content online? 2) how does showing black and hispanic female scientists in science video content on youtube impact viewers? identification with and sense of belonging in stem? 3) how does the use of humor by black and hispanic scientists in youtube science content affect viewers? perceptions of the communicator and their engagement with stem content? 4) how does the appearance and manner of dress of black and hispanic scientists in youtube science content affect viewers? perceptions in the aforementioned areas? a nationally representative baseline survey will be conducted. a probability sample of 2000 respondents will be obtained including oversampling of black and hispanic audiences. to complement findings from the survey, focus groups will be conducted in eight different regions of the country to learn why these targeted audiences do or do not seek science content on youtube and what motivates them to share the content with their social media network. in addition, an experiment embedded in an online survey will test the hypothesis that greater on-screen representation of women and scientists of color will broaden existing perceptions about scientists. the experiment will consist of a 3 (scientist's race: black/hispanic/white)  $\times$  2 (science issue: controversial/non-controversial)  $\times$  2 (style: casual/professional) between-subjects design. survey participants will be randomly assigned to the experimental conditions. these factors (science issue and host appearance) can be altered by content producers to better reach and engage the targeted audiences. the project not only investigates theoretical questions at the intersection of stem stereotypes and race, but findings related to these experimental conditions will offer practical insight into strategies that can be used by science communication practitioners. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: NSF INCLUDES Alliance: Broadening Career Pathways in Food, Energy, and Water Systems with and within Native American Communities (Native FEWS Alliance)

Awardee: University of Arizona

Amount: \$2,493,961.00

Abstract: the native FEWS (food, energy, water systems) alliance is focused on innovative research and community partnerships linking two interconnected challenges: a crisis in access to food, energy, and water in indigenous communities; and limited educational and career pathways available to indigenous populations to address these needs. the disproportionate number of indigenous people who have been negatively impacted by climate change, the on-going covid-19 pandemic, and pollution on tribal lands demonstrate the urgent need for effective solutions. currently, there are limited institutional pathways for native americans and other underrepresented students to pursue environmental careers. the university of california at berkeley, university of arizona and american indian higher education consortium will work with over 20 partners to significantly broaden the opportunities for participation and the ecosystem of research and practice training by and for native americans and other underrepresented student groups. a focus will be on students who possess, and those who seek, the necessary training and preparation to address these critical challenges. through the application of culturally-relevant approaches (successfully developed and evaluated by partners at all levels of the educational continuum), the alliance will develop curricula and mentoring guides, offer workshops, adapt and adopt best practices, and share results. these activities will enable institutions across the country to access native FEWS educational and mentoring materials. broadening participation will produce greater **\*\*diversity\*\*** of thought and generate culturally relevant sustainable solutions that are applicable to local communities yet can be used as a basis for applications more broadly. mainstream science and technology programs have to date been ineffective in responding to indigenous challenges at the nexus of food, energy, water systems (FEWS), and do not adequately serve or engage indigenous communities. the result is a deepening of social alienation and professional marginalization of indigenous youth. the native FEWS

alliance will integrate place-based approaches to teaching and **\*\*diversity\*\*** with applied research and indigenous knowledges to transform fews education to be more relevant to indigenous communities. the implementation plan is designed to produce more successful recruitment, matriculation, retention, and degree attainment outcomes. by bringing together the resources, expertise and experiences of multiple educational institutions and stakeholders who all share a proven track record in widening pathways for indigenous students, the alliance will develop a networked improvement community to achieve the following interrelated goals: address urgent fews challenges in indigenous communities; co-develop integrated, indigenous, place-based fews curricula, mentoring, and practice experiences; transform institutional science and technology fields to be relevant and accessible to indigenous communities; and recruit, retain and graduate indigenous students to pursue higher education and careers in fews and bring their knowledge back to their communities. alliance initiatives will be rigorously evaluated and disseminated, contributing new knowledge to the research base of effective practices in recruiting, teaching, and mentoring native american students and professionals, and in building ethical, effective co-designed partnerships. the forms of dissemination will include publications, case studies, curricula, guidebooks, webinars, podcasts and multimedia resources for indigenous stakeholders and to educate the wider sustainability science communities. this nsf includes alliance is funded by nsf inclusion across the nation of communities of learners of underrepresented discoverers in engineering and science (nsf includes), a comprehensive national initiative to enhance u.s. leadership in discoveries and innovations by focusing on **\*\*diversity\*\***, inclusion and broadening participation in stem at scale and co-funded by the directorate for biological sciences, division of biological infrastructure, and the division of environmental biology. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Joan and Sanford I. Weill Medical College of Cornell University

Amount: \$2,446,750.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and \*\*diversity\*\* of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CyberCorps Scholarship for Service (Renewal): Promoting Cybersecurity Excellence and Diversity via Dynamic and Applied Learning Tactics

Awardee: University Enterprises Corporation at CSUSB

Amount: \$2,432,950.00

Abstract: this project supports continuation of the cybercorps®: scholarship for service (sfs) program at california state university, san bernardino (csusb). the csusb program promotes cybersecurity excellence through a dynamic curriculum, unique applied learning requirements, and a diverse student population. students work on a curriculum designed around the needs of government organizations seeking well-qualified cybersecurity personnel. the program provides training options for many in-demand skills within the federal government and encompasses four bachelor?s and five master?s degree programs. a typical csusb cybercorps® student is well-versed in cybersecurity

policy, tactics, threat analysis, counterintelligence, networking, database, offensive and defensive hacking, penetration testing, and forensics, including with applied professional experiences. csusb's service area is richly populated with residents from diverse ethnic backgrounds, including those groups that are currently underrepresented in the cybersecurity field. in addition, most students are first generation minority students, transferring from community colleges, often from low-income and disadvantaged backgrounds. from tutoring to etiquette to professional behavior, csusb places great emphasis on ensuring this diverse student cohort (50% hispanic and 43% female) learns the skills necessary to successfully obtain and retain professional employment. the csusb sfs program also mentors other institutions regarding best practices in recruitment **\*\*diversity\*\***, placement strategies, leveraging university resources, and program management. csusb's cybercorps® program will continue as a source of high-quality cybersecurity workforce personnel with three project objectives. first, the program will train four cohorts of graduate and undergraduate students from diverse backgrounds. second, the project team will provide ongoing academic support and mentoring to the scholars with the goal of a 100% annual retention rate (barring extenuating circumstances). last, the program aims to place all scholarship recipients in federal, state, local, or tribal cyber service positions, with at least 80% in federal executive branch positions. the program's components and its effectiveness will contribute to the body of knowledge and best practice strategies for successful recruitment, mentorship, retention, and placement of cybersecurity professionals. under the mentorship of experienced faculty and professionals, cybercorps® students are required to work in applied activities beyond the classroom including competitions, research, and community outreach. the csusb program is also pursuing unconventional approaches to showcase student talents from game development and outreach to challenging technical projects, creating a nationally recognized cybersecurity program. this project is supported by the cybercorps® scholarship for service (sfs) program, which funds proposals establishing or continuing scholarship programs in cybersecurity and aligns with the u.s. national cyber strategy to develop a superior cybersecurity workforce. following graduation, scholarship recipients are required to work in cybersecurity for a federal, state,

local, or tribal government organization for the same duration as their scholarship support. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MIM: A thermodynamic theory of microbiome assembly, adaptation and evolution evaluated using modular microbial environments

Awardee: University of California-Berkeley

Amount: \$2,400,000.00

Abstract: across earth's ecosystems, microbes adapt and form communities (microbiomes) across gradients of energy and resource richness. like the machines and electrical circuits we engineer, power and efficiency are key features that also determine the competitiveness of microbes in communities. over evolutionary time, microbes have optimized their own molecular machines to convert available energy with high efficiency, minimizing the loss of waste energy as heat. microbes have a range of strategies, reflecting the balance between the rate of new cell production (power), and its efficiency (yield), while also dealing with various costs of survival that reduce yield. this research project will test the hypothesis that microbiomes, assemble from individual members to form communities that also optimize power while increasing efficiency. this principle of power and efficiency optimization may apply generally across different levels of biological organization from proteins to ecosystems. researchers will study microbiomes from soils and the human gut as model systems to test this idea. they will develop a new experimental platform, involving multiple compartments to control how microbiomes interact, with integrated nanotechnology sensors to measure microbial efficiency as heat output, plus advanced microscopy to measure yield as microbes grow. this work will test if information stored in microbial genomes can predict their power-yield strategies, and if aspects of microbiome **\*\*diversity\*\*** can be related to efficiency, developing a predictive modeling framework. if this fundamental thermodynamic theory can explain

patterns in biological organization from cells to communities, it will provide an important new framework to predict how biology will respond to future conditions on earth. broader impacts include involving community college students in the research, in addition to graduate and postdoctoral students. outreach activities consist of developing scientific videos for a storytelling platform, which would be available to the general public.

microbes, like all living organisms, maintain the order of life through the creation of entropy. they exist in open, non-equilibrium thermodynamic systems, across gradients of free-energy that fuel the formation and maintenance of structures (proteins, cells, communities) that enhance exergy flow, while attempting to minimize dissipation of waste heat ? enhancing overall entropy production in the process. the assembly and succession of microbial communities are driven by flows of exergy, and it is the trade-off between maximum power and minimum heat dissipation that regulate yield (i.e. efficiency). this trade-off towards the production of entropy is a fundamental thermodynamic principle. as a biological optimization function, the optimization of power and yield aligns thermodynamics and evolution through natural selection, in that constraints such as resource availability or stress, modulate the fitness of an organism depending on the placement of their power:yield strategy across a pareto optimal curve. how these trade-offs manifest at the community scale has not been empirically tested. this research will test this by (1) developing a novel integrated nanocalorimetry-microfluidics platform to control gradients of resources and stress, simultaneously quantifying power, yield and entropy production in an open system; (2) performing a series of manipulative experiments to evaluate how properties of microorganisms and microbiomes relate to power, yield and entropy production and bio(geo)chemical outputs, and (3) develop simulation tools based on the thermodynamics of power-yield trade-offs to predict the emergence of microbiome function and composition. this thermodynamic theory is applicable to all living organisms, with the outcomes being generalizable beyond microbiome sciences.

co-funding for this award was provided by the division of materials research. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: FRHTTP: Center for Quantum Information and Control

Awardee: University of New Mexico

Amount: \$2,400,000.00

Abstract: quantum information science (qis) is an interdisciplinary field at the interface of two of the greatest scientific and technical triumphs of the 20th century: quantum physics and information science. the digital revolution that followed, based on semiconductor chips, laser communications, and computer science, has fueled the economic engine of today's information society. qis will fuel a second quantum revolution into the 21st century. the second quantum revolution will harness the full power of quantum mechanics (the physics of the atomic world) with devices that rely on quantum-weird phenomena such as superposition and entanglement to process information in ways that are much more powerful than today's best supercomputers and cybersecurity systems. the focused research hub in theoretical physics (frhttp): center for quantum information and control (cqic) funded in this grant from the nsf will create a "theory hub" for fundamental research that provides the foundation for the second quantum revolution. housed at the university of new mexico (unm), cqic brings together an interdisciplinary team of theoreticians with expertise in physics, computer science, electrical engineering, and chemistry, as well as partners at sandia national laboratories, los alamos national laboratory, and honeywell quantum solutions, to collaborate, innovate, and tackle the most important outstanding problems in qis. cqic will provide a focal point for united states qis-theory community to retain its competitive advantage. cqic will serve the national quantum initiative (nqi) act by hosting focused workshops that target common problems, share lessons learned, and help to break logjams when they arise to push forward the goals of the nqi. the hub will be critical for education and training, with a focus on building a diverse and inclusive next-generation qis workforce. to achieve these goals, cqic will administer a prize postdoctoral fellowship program, host seminars, workshops, conferences, and a visitor's program,

and critically focus on synergistic research that brings together the principal investigators at unmc with its partnering institutions. the research will be anchored in tackling four "big questions" in contemporary qis: i. what is the computational power of quantum matter? ii. how do we efficiently represent quantum systems, and when do these representations lead to efficient classical algorithms? iii. what quantum advantage can be achieved with noisy intermediate-scale quantum (nisq) devices? iv. what near-term quantum algorithms and architectures can yield practical results?

postdoctoral fellows will provide the "connective tissue," creating bridges between senior participants and bringing additional expertise to the center. cqic's intensely collaborative environment will provide the necessary incubator for the qis-theory community to work together to tackle the big questions. in addition, cqic will host a variety of hub activities that will bring together the community to interact, create, and tackle critical problems, and integrate this with education, training, and shared educational resources to help develop the next generation of quantum information scientists. hub activities include the long-running squint annual workshop, with a 25-year history of focus on building community for early-career scientists at a world-class conference. cqic will create outreach programs that focus on building "diversity" and inclusion of traditionally underrepresented groups in qis. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: FMRG: Eco: Process-Structure-Property Relationships of 3D Printed Earth Materials and Structures

Awardee: Columbia University

Amount: \$2,390,040.00

Abstract: this future manufacturing research grant (fmrgecomanufacturing project will comprehensively characterize optimal mix designs for 3d printed earth materials and structures,

linking microstructural development and soil science with material and structural property characterization and optimization of 3d printing methods. earth materials are an emerging, sustainable alternative to cementitious materials because of their low embodied carbon, affordability, safety, and thermal characteristics. by using minimally processed materials and sourcing raw materials from the construction site, 3d-printed earth structures could substantially reduce transportation, chemical treatments, excess manufacturing, warehouse storage, and intermediary storages that are inextricably intertwined with cementitious materials. using a range of bacterial and biopolymer binding agents, as well as bio-based fibers and nano-fibers reinforcing additives, this project will characterize printable mixtures of earth- and bio-based building materials?modernized versions of ancient technologies?as a critical step for climate-friendly digital manufacturing of the built environment. in addition to creating new scientific knowledge for additive manufacturing using nonconventional materials, this project supports education and **\*\*diversity\*\*** by developing a graduate earth-based technology course and an extracurricular experience for students from marginalized communities that includes hands-on materials assessment, digital fabrication of an earth-based shelter, and community activities. through a comprehensive series of optimized mix design development, fresh- and hardened-state properties characterization will produce an effective and sustainable framework for improved shape stability and interlayer properties of the final printed earth structures. the proposed research links, for the first time, the following multi-scale investigations to advance the science and engineering of 3d printed earth materials and structures: (1) establishing the soil characterization and microstructural design methodologies of 3d printable earth mixtures, (2) elucidating the process-structure relationships of 3d printed earth materials and the effects of additives, including a range of biomineralizing microbes and biopolymers, on fresh-state properties, (3) characterizing the hardened-state properties with a focus on alternatives to stabilization, and (4) advancing the processing science of small- and large-scale 3d printed earthen structures. this research and educational effort will contribute to a broader interdisciplinary scope on quantitative and qualitative expertise related to the automated construction, mechanical,

thermal, and environmental impacts of earth materials, a critical future in low-carbon and affordable buildings. this future manufacturing project is jointly funded by the divisions of civil, mechanical and manufacturing innovation (cmmi), engineering education and centers (eec), and industrial innovation and partnerships (iip) in the directorate of engineering, and by the division of materials research (dmr) in the directorate for mathematical and physical sciences (mps). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: IMPACTS OF RAPID LANDSCAPE CHANGE AND BIODIVERSITY ON VIRUS HOST SPECIFICITY

Awardee: University of California-Davis

Amount: \$2,379,565.00

Abstract: rapid changes to landscapes and the bio\*\*diversity\*\* of plants and animals are altering relationships between microbes and their natural hosts with direct implications for human health. this study investigates the impacts of deforestation, landscape change, and bio\*\*diversity\*\* on virus characteristics that determine zoonotic potential, including virus ?host plasticity?, which is the \*\*diversity\*\* of host species a virus can infect in nature. previous work has indicated that higher virus host plasticity is linked to increased likelihood of human-to-human transmission and wider geographic spread. this project seeks to understand whether landscape and bio\*\*diversity\*\* change drive microbes towards greater host plasticity and therefore heightened pandemic risk. findings from this research will contribute to ecological theory on the impact of environmental changes on microbial adaptation, with practical implications for management of ecosystems at high risk for pathogen spillover. this research is especially relevant to public authorities seeking evidence on the relationship between environmental change, bio\*\*diversity\*\*, disease outbreaks, and pandemics. training opportunities provided through this project will help foster a network of cross-trained



scientists interested in disease dynamics, public health and animal health who will strengthen one health research into the future. Viruses have more opportunities to adapt to new hosts at the edge of ecosystem boundaries, which could influence virus host plasticity and increase spillover risk as new ecosystem edges are formed through habitat fragmentation. To test this hypothesis, this research investigates the host range of bat-borne coronaviruses and mosquito-borne arboviruses (flaviviruses, alphaviruses and bunyaviruses) across replicated gradients of landscape change and community composition in the biodiverse tropical forests of Southeast Asia. Theoretical and computational modeling, underpinned by field investigations and in vitro experiments, will evaluate (1) how virus host and vector plasticity changes at the edge of ecosystems, such as at the boundary between forest and urban habitats, (2) how virus host plasticity is related to virus epidemiology across landscapes, and (3) how intra-host genetic **diversity** of viruses is influenced by host and vector plasticity. Data and model driven insights will inform on the role that mosquito vectors play in constraining or expanding virus host plasticity and genetic **diversity**. Characterization of bat-borne coronaviruses and host affinities in an ecosystem with SARS-CoV-related viruses will further inform on coronavirus evolution and emergence of zoonotic potential. This study explores an important paradigm of functional relationships between **bio**diversity**** and public health to advance a mechanistic understanding of zoonotic virus emergence with potential to be generalized to other systems. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity  
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Title: IntBIO: Integrative Demography: Combining Ecology, Remote Sensing, and Genomics to Understand Population Dynamics

Awardee: University of California-Davis

Amount: \$2,372,311.00

Abstract: **bio**diversity**** is critical for the health of ecosystems, our biosphere, and humankind.

however, bio\*\*diversity\*\* is threatened by habitat loss and climate change. habitat loss and climate change have resulted in the acceleration of species extinctions across the world. within species, the extinction or persistence of populations determines whether a species will survive at all. thus, understanding the factors that contribute to population persistence or extinction is critical for predicting future population dynamics and managing bio\*\*diversity\*\* in a changing world. population persistence is determined by genetic composition, ecological habitat, environmental stresses, and interactions among these factors. this award will integrate advances in genomics, remote sensing, and statistical modelling to develop new predictive models of population persistence and extinction. the models created in this project will be critical for understanding population dynamics, predicting responses to future change, and providing tools to direct the implementation of genetically-informed conservation strategies. the project also includes an educational component that will provide research and training opportunities for a new generation of biologists to prepare them to incorporate integrative approaches to understand complex aspects of climate change and its effect on biological systems. training the next generation of biologists to be able to integrate across fields is vital to addressing the complex impacts of climate change. to achieve this, graduate level workshops in field ecology, remote sensing, genomic data analysis, demographic modeling, and science communication and professionalism will be developed and taught. to help build an inclusive stem pipeline, an integrative course based undergraduate research experience (cure) for freshmen will be developed, and the project will support master's students for summer research as part of the advancing \*\*diversity\*\* to educate the professors of tomorrow (adept) program. the ability to predict how the genetic composition of populations impacts their long-term persistence or extinction in different and changing environments requires integrating analysis techniques and data across diverse fields. evolutionary genomics can identify past targets of selection and current determinants of fitness, but has not been effectively integrated with demography to explain multi-generation population dynamics. conversely, demographic modeling can determine which aspects of organismal establishment, growth, survival, and reproduction (life history) are most critical for

population growth or decline, but does not usually consider genomic determinants of these fitness components. *Streptanthus tortuosus* (mountain jewelflower) will be used for this research. *S. tortuosus* is an ideal species for this research due to its sensitivity to climate, variation within and among populations in traits and life history timing, and demographic and genomic tools currently in development. This project will: 1) use genomics to quantify genetic variation among individuals; 2) apply spectral remote sensing to understand the impact of stressors, the environment, and genotype on plant physiology and growth; and, 3) develop a statistical and demographic modeling framework to integrate these measures to understand and predict the factors underlying population persistence or extinction. While past research has investigated these components individually and some interactions among them, this award explores whether population dynamics is an emergent property that can be best understood by developing new demographic models that integrate all of these inputs. Together, understanding how **diversity** in genes, traits, physiology, and environment scales to impact individual performance and population dynamics will provide critical new insights into the ecological and evolutionary processes driving persistence or extinction. The resulting integrative demography models will provide a road map for conservation biologists and managers to use genomic information to predict effects of different conservation strategies, such as assisted migration or introducing genetic variation, which can be applied across wild, managed, and agricultural populations. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Expanding a Model for Interactive Social Science Exhibits Presented in Outdoor Public Spaces

Awardee: Exploratorium

Amount: \$2,359,010.00

Abstract: Public outdoor spaces present opportunities for social experiences and learning. This

broader implementation project will expand and evaluate a model that transforms urban public spaces into accessible and engaging environments for learning social science in outdoor public spaces. the model combines social science inquiry exhibits, place making and human facilitation of learning experiences in outdoor public areas. project exhibits use the facilitated social interactions as both the content of and medium for the experiences. this project will adapt the existing exhibits and add new exhibits and facilitation techniques for testing in three different urban environments. project research will explore the efficacy of these adaptations and revised facilitation techniques for the different settings in collaboration with civic partners at each site. the project will share the model and research findings widely through the exploratorium website and publications for researchers, developers, and educators. the team's prior research showed that facilitators improved multiple learning outcomes with the current exhibits. visitors acquired new social observation skills, reflected on their own experiences, perceptions, and actions, and increased their awareness for how social behavior, cognition, and emotion can be studied scientifically. building on the prior research, the project will install the exhibition and test its efficacy in three different urban environments and explore the adaptations that are required for different settings with different civic partners. the project will use design-based research to develop a new theoretical model of facilitation strategies for supporting science learning in outdoor public spaces. for evaluation, the project will use mixed methods, including observations, interviews, surveys, and document review. evaluation will assess success in attracting and engaging visitors; conveying social science concepts; prompting self-reflection of judgments and actions; and fostering empathy among those with different social identities. the project will assess the extent to which participants, particularly those from marginalized communities, experience feelings of belonging and inclusion. the project will be presented in three sites which represent the significant \*\*diversity\*\*, income levels, and urban environments of san francisco. facilitation strategies are being co-developed with urban alchemy, an organization that works within distressed urban communities in san francisco. project site partners and collaborators include the san francisco public library, the port of san francisco, and the san

francisco department of parks and recreation. the project will also measure partnership outcomes, through surveys and interviews, to look at the extent and ways the project integrates a co-creation model and develops an authentic, mutually beneficial, sustainable partnership. the project will generate and disseminate generalizable knowledge about the affordances of combining informal science learning, placemaking, and facilitation in a variety of free, outdoor stem learning spaces in collaboration with local community groups. the project will also advance public understanding of the social and behavioral sciences. this research project is funded by the advancing informal stem learning (aisl) program, which seeks to (a) advance new approaches to and evidence-based understanding of the design and development of stem learning in informal environments; (b) provide multiple pathways for broadening access to and engagement in stem learning experiences; (c) advance innovative research on and assessment of stem learning in informal environments; and (d) engage the public of all ages in learning stem in informal environments. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Connecticut

Amount: \$2,357,733.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: NRT-QL: A Program for Training a Quantum Workforce

Awardee: Colorado School of Mines

Amount: \$2,344,084.00

Abstract: recent progress in quantum information science and technology (qist) promises advances that will fundamentally reshape today's leading technologies, including computing, communications, and sensing. a well-prepared workforce is essential to fulfilling this promise. in response to this critical workforce need, this national science foundation research traineeship (nrt) award to the colorado school of mines (mines) and san jose state university (sjsu) supports the development of rigorous, integrated, interdisciplinary training programs preparing both master's and doctoral students for careers in qist. the program has three components that address key challenges in training a quantum workforce. first, new training materials will be developed to introduce qist basics to students from different disciplines. trainees will come from physics, electrical engineering, metallurgical and materials engineering, applied mathematics and statistics, computer science, and quantum engineering. second, industrial and national lab partners will be engaged to provide trainees access to cutting-edge technologies and research experiences. finally, student recruitment and mentoring programs, unconscious bias training, ally workshops, and regular climate surveys will be developed to ensure **\*\*diversity\*\*** in the qist workforce. the project will train one-hundred and twenty-five (125) ms and ph.d. students, including thirty-five (35) fully-funded trainees. these efforts will result in an institutionalized program that produces leaders in qist for careers in academia, industry, government, and national labs. the research program addresses three grand challenges in quantum technology: (1) how can demonstrable quantum speed-up using existing or near-term quantum computing architectures be achieved? (2) how can materials and electrical engineering interface with quantum technology to provide meaningful advances in device development and fabrication? (3) how can new directions in quantum algorithms advance and challenge the notion that quantum technology can solve problems that are impossible to tackle with conventional technology? these interdisciplinary research challenges require close synergy between fundamental physics, materials science, electrical engineering, and algorithm development. new courses and



degree pathways in qist are being developed at both mines and sjsu, which include integration of professional skills development into the graduate curriculum. through classroom training and research, trainees will be exposed to the full range of quantum technology architectures, providing a holistic view of this rapidly developing field. an innovative educational agreement between mines and sjsu will provide opportunities for students to complete an ms/ph.d. bridge program from sjsu to mines. the program will result in a template for qist graduate education, which will be accessible to stem students from all backgrounds and types of institutions, increasing **\*\*diversity\*\*** in qist. the nsf research traineeship (nrt) program is designed to encourage the development and implementation of bold, new potentially transformative models for stem graduate education training. the program is dedicated to effective training of stem graduate students in high priority interdisciplinary or convergent research areas through comprehensive traineeship models that are innovative, evidence-based, and aligned with changing workforce and research needs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Improving STEM Degree Completion with Professional Development to Support Inclusive and Equitable Classroom Practices

Awardee: University of California-Irvine

Amount: \$2,332,829.00

Abstract: with support from the improving undergraduate stem education: hispanic-serving institutions program (hsi program), this project aims to facilitate institutional transformation by addressing environmental factors that negatively influence stem degree completion for groups of students. the project will offer a series of workshops that promote inclusivity in stem fields by considering research on systemic issues and barriers to academic success. the project will seek to address degree completion disparities by providing faculty and administrators with activities,

exercises, and facilitated discussions of research literature to examine social and cultural factors associated with their own and their students' lived experiences at the institution. the project will also leverage existing efforts on campus that aim to create more inclusive academic spaces. by taking a collaborative research-oriented approach to working with faculty and administrators, the project will seek to provide processes that other institutions can follow. to directly address the importance of culture in the classroom, the project will employ a mixed methods research design, and a multi-session faculty professional development series integrated into the broader campus community, that provides faculty with a curriculum that will advance inclusion and equity in their learning spaces. three overarching goals guide this project. first is to lay a solid foundation of local and national data related to disparities in persistence and retention that will be used to inform participant practices and behaviors in the classroom. second is to increase awareness of the social and cultural locations of stem students. third is to modify classroom practices and policies in order to increase student engagement and success. several research questions will be explored by the project team. according to stem students, what social and cultural factors need to be considered to improve the classroom climate? what is the impact of participation in project activities on faculty conceptions of **diversity** and inclusion in the classroom? how does faculty participation in the project lead to increased implementation of evidence-based inclusive teaching? the key motivating factors for this project are to address systemic inequity that is manifested in stem degree completion disparities and to share methods, data, and findings with hsis across the country. dissemination efforts will include a project website for sharing pertinent project information, multiple research publications and presentations, a research conference on creating inclusive academic spaces, and strategic connections with existing programs that are part of the nsf includes network. the hsi program aims to enhance undergraduate stem education, broaden participation in stem, and build capacity at hsis. achieving these aims, given the diverse nature and context of the hsis, requires innovative approaches that incentivize institutional and community transformation and promote fundamental research (i) on engaged student learning, (ii) about what it takes to diversify and

increase participation in stem effectively, and (iii) that improves our understanding of how to build institutional capacity at hsis. projects supported by the hsi program will also draw from these approaches to generate new knowledge on how to achieve these aims. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Collaborative Research: BPC-AE: STARS: Catalyzing Action-Oriented Academic Communities for Broadening Participation in Computing

Awardee: Temple University

Amount: \$2,237,296.00

Abstract: it is critical to address the longstanding issue of underrepresentation of women, black, and hispanic students in computing degree programs to provide an equitable foundation for all to participate in our society and the global economy as controllers and creators of technology, and to advance the preparation of a diverse, innovative, and competitive tech workforce. building on the prior success of the stars computing corps alliance for broadening participation in computing, the goal of the stars catalyst project is to: 1) increase the number of women, black, and hispanic students that persist in computing degree programs, and 2) advance the careers of students and faculty from groups that have been historically underrepresented in computing. through research and evaluation around stars catalyst activities, this project will advance knowledge about practices designed to increase persistence and support career advancement in computing for college computing students and faculty, particularly for those from underrepresented and intersectional groups in computing. the stars catalyst alliance is a collaborative effort across temple university, north carolina state, kent state, florida state university, morgan state, and university of north carolina charlotte. the stars computing corps alliance for broadening participation in computing (bpc) engages computing faculty and students at colleges, universities, and community colleges in a community of practice with a shared commitment to take action to advance **diversity**, equity, and inclusion in computing. stars computing corps conferences, communities, and networks create significant institutional and human resources that can expand bpc research to a larger audience of researchers, educators, administrators, cs departments, and k-20 students, and can dramatically increase the number of people taking action in bpc efforts. prior results show that the stars computing corps alliance increases intentions to persist in computing among stars students and faculty, with enhanced outcomes for black students and faculty. this project will significantly extend the stars alliance to expand upon those impacts, by 1) including new partners that expand the reach of stars and that emphasize participation of black and hispanic students and faculty, particularly from

emerging hispanic serving institutions and community colleges, 2) creating new program elements that test new and propagate evidence-based bpc practices within computing departments, and 3) leveraging partnerships to support identity-focused affinity groups, and 4) developing stars alumni groups employed in industry positions to promote transition to and retention within the tech workforce. extensions to the stars leadership corps program, stars launch program, and the stars celebration conference will serve to develop and propagate evidence-based approaches aimed at improving the teaching and learning of computing for black and hispanic students and build evidence of their effectiveness, and the respect research conference will continue to advance peer-reviewed bpc scholarship. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: URoL:EN: Towards a unified theory of regulatory functions and networks across biological and social systems

Awardee: Northwestern University

Amount: \$2,199,383.00

Abstract: complex organizational structures range from the very small (such as cells) to the very large (such as a system of government), and maintaining these structures requires a lot of energy and resources. consider, for example, the part of the us legal system that is devoted to handling lawsuits and resolving conflicts. the structure of the legal system includes the law itself, the attorneys, judges, and all the other people involved in bringing a lawsuit forward and ensuring that it is resolved. as a result, us companies spend a lot of funds on litigation alone. in us colleges, administrative spending is comparable with instructional spending and has been cited as a key factor in the increasing tuition of us universities. the continuing growth of these kinds of costs is a major challenge, but they aren't understood very well. when these costs are studied, they are often

viewed as hidden or unintended expenses that are unique to the systems in which they are found. the research supported by this grant develops a unified theoretical framework for studying regulatory mechanisms across different kinds of systems, from single cells to entire societies. the research improves society by suggesting ways to make the organization of institutions, such as companies, universities and governments, more efficient. regulatory functions and mechanisms are a necessary, essential, and ubiquitous feature across all biological, social, and mechanical systems. bacteria have regulatory genes, companies have managers, and car engines have engine control units. indeed, the challenge for all complex adaptive systems that aim to survive in multi-faceted and competitive environments is to optimally manage internal functions and interactions. the presence of regulatory mechanisms in complex systems is therefore a universal rule of life, and network structures emerge under the rule of life. this grant develops a unified science of regulatory functions and their associated emergent structures to answer questions such as: what causes an increase in regulatory costs? can we predict the amount of regulatory costs an organism or organization needs, based on its size, function, and complexity? is it necessary to grow the administrative or regulatory functions of a system to ensure the continued functioning of the system, or is it an unnecessary burden? this research develops scientific measurements to determine the appropriate or optimal size and network structure of bureaucracy for a system to perform its tasks. the research takes place in two steps: 1) gathering and organizing datasets that span biological and social systems; and 2) using these datasets to develop a theory for regulatory structures across a wide range of systems. the theory will start from a mathematical framework that describes cost as a function of the size and complexity of a system and integrate this theory with new results and models of the functional **\*\*diversity\*\*** of organizations and their structures. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EFRI E3P: Supercritical Extraction for the Elimination of End-of-Life Plastics (SCE3P)

Awardee: Auburn University

Amount: \$2,174,344.00

Abstract: multilayer plastic packaging is critical to keeping a wide range of food products, including meats, juice pouches, cheeses, and prepared foods, safe during transportation and storage. to function, multiple materials are used together to meet requirements that individual materials cannot. however, most multilayer food packaging winds up in landfills because current recycling processes cannot separate the various components. in this project, researchers will use high pressure and high temperature to turn gases into supercritical fluids that enable separating the materials used in typical multilayer food packaging. the higher value of the resulting purer material streams will improve the economics of recycling multilayer structures. the process will be designed to allow straightforward implementation on equipment commonly found at existing recycling plants. the work will include a thorough assessment of both the economic and environmental impacts of increased recycling rates for multilayer packaging. if successful, the project will result in new technology that increases the recyclability of plastic waste, reduces the amount of plastic waste entering landfills, and limits the environmental impact of food packaging. the project will also enhance education, **\*\*diversity\*\***, and workforce development by combining efforts from a large four-year university, a historically black university, and a two-year community college in a highly interdisciplinary approach to addressing the research questions. graduate and undergraduate students participating in the research will cross-train at the partner institutions and develop community outreach activities on polymers, recycling, and related science for use at open houses and area classrooms. this project aims to valorize the multilayer polymer waste stream through a process designed to reclaim high-value barrier polymers from multilayer food packaging and simultaneously recycle the polyolefins. the investigators hypothesize: 1) supercritical co<sub>2</sub>, in combination with cosolvents, will improve the extraction of ethylene vinyl alcohol (evoh) and polyxylylene adipamide (mxd6) from multilayer systems by increasing the polymer concentration in the solvent phase and enhancing the solvent's



ability to penetrate the multilayer structure via plasticization, 2) modifying extrusion equipment to use supercritical fluids offers several advantages including enhanced layer separation and dissolution kinetics and reduced costs including overall recycling energy and recycling facility retrofitting expenses, 3) the materials reclaimed by this process will be suitable for use in closed-loop recycling, and 4) the proposed technology will increase overall recycling rates, having a net positive environmental impact. the work will increase our thermodynamic and kinetic understanding of the phase behavior of commercially important plastics and their mixtures in supercritical co<sub>2</sub> with cosolvents. fundamental understanding of how solvent choice, processing conditions (e.g., temperature and pressure), and extruder screw design impact partition coefficients and polymer extraction kinetics will be gained. a combination of techno-economic analysis, life-cycle assessment, and economic and environmental impact analysis will be used to establish the potential impact of recycling multilayer food packaging on the environment and determine the need for policy instruments to promote the recycling of these materials. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: AccelNet-Implementation: Crustal Ocean Biosphere Research Accelerator (COBRA)

Awardee: Bigelow Laboratory for Ocean Sciences

Amount: \$2,156,626.00

Abstract: the deep seafloor covers two-thirds of earth's surface area, but there is limited understanding of the deep-ocean ecosystems and resources and the ability of these ecosystems to withstand human impacts. human uses such as deep-sea mining and carbon sequestration are poised to fundamentally alter physical, chemical, and biological conditions of the seafloor and surrounding environments. these activities have the potential to rival negative effects from bottom fishing and other human impacts to the deep sea, yet the science to inform and evaluate the

impacts of these new industries is lacking. the crustal ocean biosphere research accelerator (cobra) project connects diverse stakeholders and experts ? interdisciplinary academic and government scientists, private institutions, policy makers, industry experts and other stakeholders ? through virtual meetings to coordinate efforts. the goal is to generate new knowledge and inform decision-making relating to emergent industrial uses of the deep ocean and decrease the likelihood of serious harm to the environment while maintaining the broad benefits that society currently enjoys. the cobra network of networks has nine key partners that bring access to international science and crustal ocean exploration assets (ocean exploration trust, schmidt ocean institute, ocean networks canada, cluster ocean floor at marum, and c-deepsea), to experts that provide science-based recommendations to policy makers (deep ocean stewardship initiative working groups, including the challenger 150 program), to governmental groups responsible for assessing crustal ocean resources (usgs global marine minerals group), and to experts in team science (credits program). cobra unites these partners in a common mission to accelerate research on the structure, function, resilience, and ecosystem services of the crustal ocean biosphere to inform decision making. cobra will help to close knowledge gaps by facilitating dedicated and coordinated expedition and observatory efforts combined with emergent characterization approaches. in parallel, cobra will train at least 50 globally distributed early-career researchers in ocean exploration, science, and policy through innovative virtual expedition leadership training and support two dozen international research exchanges that promote team science collaboration, **\*\*diversity\*\***, equity, and inclusivity. cobra will also establish a web-based search portal that points to all data types deposited in appropriate internationally accessible data repositories to promote data discovery and accelerate knowledge transfer and collaboration.

the accelerating research through international network-to-network collaborations (accelnet) program is designed to accelerate the process of scientific discovery and prepare the next generation of u.s. researchers for multiteam international collaborations. the accelnet program supports strategic linkages among u.s. research networks and complementary networks abroad that will leverage research and educational resources to tackle

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Title: RCN: LEAPS: Rooting Out Oppression Together and SHaring Our Outcomes Transparently

Awardee: American Society of Plant Biologists

Amount: \$2,141,750.00

Abstract: the demographic distribution of scientists, especially those in positions of authority, does not reflect that of the us population. some of the causes of this disparity are known, such as a lack of role models and the tendency for people to look within their own circles when they recruit, appoint, and promote. this award will provide resources, trainings, opportunities, and structures that

will allow participating plant science and affiliated organizations to change that construct by rooting out oppression together (root) and sharing our outcomes transparently (shoot). the network is unusual in its breadth and scope, and it extends upon previous collaborative activities in the plant sciences by incorporating partners that serve underrepresented populations, as well as other non-profits and companies. the participating organizations have each independently begun this work, and through this award they will coordinate to exert meaningful and lasting change to reshape the plant science community into one that is truly equitable, inclusive, and anti-racist. the network partners will design and implement interventions to remove barriers that prevent the participation and success of individuals historically excluded from leadership and influence roles in science, assess the success of these interventions, and share the outcomes. broadly sharing the lessons and outcomes from this deep and careful self-study will inform other organizations and professional societies as they strive towards becoming more inclusive and diverse scientific communities. the goal of the rooting out oppression together (root) and sharing our outcomes transparently (shoot) research coordination network (rcn) is to develop a collaborative network that facilitates cultural changes throughout the plant sciences to advance **diversity**, equity, and inclusion. the network will coordinate the development and dissemination of resources for building and sustaining equitable and inclusive scientific organizations, including assessment tools and equity action plans. it will provide broad training of the plant science communities in equitable practices and operations, while implementing dual-membership programs and shared participation in conferences. hundreds of scholars and practitioners will be trained in topics such as inclusive teamwork, climate and culture assessment, and culturally responsive mentoring, even as the participating organizations themselves implement well-informed changes to their governance and leadership structures. the network will create shared web pages, guides, workshops, webinars, and action plans to educate and inform our community members and others across stem. the rcn initially consists of seven plant science professional societies and organizations; it has also established formal partnerships with organizations committed to supporting underrepresented and marginalized scientists, as well as

industry partners. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RCN: LEAPS: Rooting Out Oppression Together and SHaring Our Outcomes Transparently

Awardee: American Society of Plant Biologists

Amount: \$2,141,750.00

Abstract: the demographic distribution of scientists, especially those in positions of authority, does not reflect that of the us population. some of the causes of this disparity are known, such as a lack of role models and the tendency for people to look within their own circles when they recruit, appoint, and promote. this award will provide resources, trainings, opportunities, and structures that will allow participating plant science and affiliated organizations to change that construct by rooting out oppression together (root) and sharing our outcomes transparently (shoot). the network is unusual in its breadth and scope, and it extends upon previous collaborative activities in the plant sciences by incorporating partners that serve underrepresented populations, as well as other non-profits and companies. the participating organizations have each independently begun this work, and through this award they will coordinate to exert meaningful and lasting change to reshape the plant science community into one that is truly equitable, inclusive, and anti-racist. the network partners will design and implement interventions to remove barriers that prevent the participation and success of individuals historically excluded from leadership and influence roles in science, assess the success of these interventions, and share the outcomes. broadly sharing the lessons and outcomes from this deep and careful self-study will inform other organizations and professional societies as they strive towards becoming more inclusive and diverse scientific communities. the goal of the rooting out oppression together (root) and sharing our outcomes transparently (shoot) research coordination network (rcn) is to develop a collaborative network that facilitates cultural

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Matched Words: diversity

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Title: NRT: Research Training in Sustainable Packaging and Biodegradable Polymer Composites for the Next Generation of STEM Graduates

Awardee: Tuskegee University

Amount: \$2,122,103.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). current generation packaging materials are made of polymer composites that are derived from petroleum sources. these materials are not degradable and either end up in landfills or are incinerated, releasing toxic gases. factors such as greater environmental awareness, societal concerns, and the depletion of petrochemical resources collectively drive a desire to develop new

materials and products based on plant fibers and degradable biopolymers. this national science foundation research traineeship (nrt) award to tuskegee university will establish a multidisciplinary traineeship in sustainable nanobiomaterials. the program is a partnership between three doctoral programs to collaboratively develop innovative sustainable biomaterials for biodegradable packaging systems, including biomedical and food packaging. the project anticipates training 40 students (30 ph.d. and 10 masters), including 30 funded trainees, from materials science and engineering, integrative biosciences, and integrative pathobiology. the tuskegee nrt effort will produce a large number of minority graduates, including a significant number of women with ph.d. degrees in stem. an area of focus for the traineeship includes support and training of faculty to mentor the trainees and provide trainees with training and opportunities to mentor as well. these graduates will become excellent role models for many young students and help bring much-needed **\*\*diversity\*\*** to the nation's advanced technological workforce in sustainable nanobiomaterials. the multidisciplinary project team will train emerging scientists, engineers, entrepreneurs, and managers to develop the next generation of sustainable, biodegradable food and medical packaging applications. the trainees will carry out research in: (a) synthesis of calcium and silica-based nanoparticles from waste resources such as bone ash, fish scales, egg and seashells, (b) antimicrobial functionalization of nanoparticles and short plant fibers using green synthesis methods, (c) structural, morphological, and spectral characterization of as-prepared nanoparticles, (d) fabrication of antimicrobial polymer packaging films using polymer blow films, 3d printing, and solution casting, (e) nanomechanical, structural, morphological, and thermal characterization of as-prepared polymer composite films, and (f) antimicrobial inhibition, product design, prototyping, biodegradability, and commercial feasibility studies. the knowledge and training gained by the trainees will eventually result in new design and manufacturing methodologies. the program emphasizes mentoring at three levels. students will be co-advised and mentored by a minimum of two faculty members. faculty and trainees will be involved in outreach to and mentoring of high school students. moreover, an annual mentoring workshop will be conducted to provide both faculty and trainees with strategies for effective



mentoring. other professional development activities are also in place to ensure students receive formal and informal preparation in proposal development and technical writing, teamwork, and ethics. the nsf research traineeship (nrt) program is designed to encourage the development and implementation of bold, new, potentially transformative models for stem graduate education training. the program is dedicated to effective training of stem graduate students in high priority interdisciplinary or convergent research areas through comprehensive traineeship models that are innovative, evidence-based, and aligned with changing workforce and research needs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: AccelNet-Implementation: FLUXNET Coordination to Understand Ecosystem Function through Continuous Observations of Ecosystem-Atmosphere Interactions

Awardee: University of California-Berkeley

Amount: \$2,033,930.00

Abstract: global ecosystems provide services that sustain society, including providing food, fiber and timber, and water cycle regulation. an important service is the sequestering of carbon dioxide from the atmosphere, which greatly slows the rate of climate change. understanding ecosystem-atmosphere interactions, and the response of these to environmental change, is an urgent challenge. this accelnet implementation track award will link over ten existing national and international networks focused on continuous observations of ecosystem-atmosphere interactions at over 1000 locations around the world. the fluxnet coordination project will fill fundamental knowledge gaps in science, engineering, and societal issues associated with ongoing changes in ecosystem function and the related cycling of carbon and water. fluxnet is a global network of regional networks, consisting of scientists measuring the exchange of carbon dioxide, water, energy, and other greenhouse gas fluxes between ecosystems and the atmosphere. this project will

develop the next generation of the fluxnet network of networks to be a self-sustaining global collaboration focused on supporting early career scientists, expanding the **\*\*diversity\*\*** of scientists, biomes, and climate regions involved, and empowering international collaboration. given the **\*\*diversity\*\*** of life on earth, a full understanding of the role of ecosystems in the earth system can only be achieved through a network-of-networks approach. the central goals of the fluxnet coordination project are to provide novel training and exchange opportunities, develop strong international collaborations, and build tools and protocols that ensure continued capacity of fluxnet to provide continuous observations of ecosystem-atmosphere interactions across the globe. such measurements have proven essential for understanding ecosystem function, calibrating space-borne observations, and developing models used to project future climate. the project will develop data-focused processing protocols and pipelines, as well as people-focused education and exchange opportunities. network activities include annual in-person meetings at national and international venues, monthly webinars, workshops and synthesis publications, and student and early-career researcher personnel exchanges. the project will use creative and transformative approaches to international collaboration and networked science to achieve its goal of building the next generation of fluxnet to be a self-sustaining flagship of networked global scientific cooperation.

the accelerating research through international network-to-network collaborations (accelnet) program is designed to accelerate the process of scientific discovery and prepare the next generation of u.s. researchers for multiteam international collaborations. the accelnet program supports strategic linkages among u.s. research networks and complementary networks abroad that will leverage research and educational resources to tackle grand scientific challenges that require significant coordinated international efforts. co-funding for this award is provided by the macrosystems biology and neon-enabled science program and the neon program in the directorate for biological sciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: LEAP-HI: AI-Optimized 3D Printing of Super-Soft Materials for Personalized Sensing

Awardee: Iowa State University

Amount: \$2,008,000.00

Abstract: a common need in the medical community is an ability to monitor local tissue continuously, but current sensing technology lacks the personalization necessary to contour sensors for the unique anatomy of different individuals. this leading engineering for america's prosperity, health, and infrastructure (leap-hi) research seeks to develop low-cost personalized sensors which can be fabricated on demand to enhance the health and well-being of americans from all walks of life. the approach leverages fundamental research into new materials in tandem with advanced machine learning and artificial intelligence to "3d print" personalized sensors with applications in health care?from prosthetics to diagnostics and therapeutics?that could impact millions of people. these advances spanning materials science, engineering, and computation will improve the economic competitiveness of the united states? innovation and help train the next generation of scientists and engineers through a tight synergy between experimental and computational research. a series of initiatives spanning **\*\*diversity\*\***, education, and outreach to further will advance key aspects of the work across age groups. this includes (a) modules on cybermanufacturing in a new cyber physical systems minor at iowa state university, (b) working with the local chapters of society for advancement of chicanos/hispanics, native americans in science, and the national society of black engineers to draw students into research, (c) k-12 engagement through activities at the wolf museum of exploration and innovation (moxi) for children, (d) working with center for industrial research and service (ciras) to disseminate best practices and training modules in cyber manufacturing, and (e) working with the communications offices of both the university of california at santa barbara and iowa state university to disseminate the research to the public to promote the need for engineering leadership in the united states. this research will overcome the limitations of

conventional sensor technologies for personalized health monitoring by developing new materials and processing techniques to 3d print polymers with mechanical properties that are matched to human tissue. our strategy will yield fundamental insights into the translation of advanced materials to manufacturing by: (1) designing and synthesizing materials that inherently provide processability for 3d printing while maintaining biocompatibility and mechanical function; (2) advanced multi-scale simulations of the printing process through modeling and predictive dynamics at the device scale to understand macroscopic progression during the build process, and at the microstructure scale to tailor the material properties as a function of material deposition and curing; (3) data fusion from sensor response and physics-aware machine learning models to enable real-time prediction and control of the 3d printing process; and (4) creating ultra-soft structured sensors that enable unique sensing modalities for societal impact in personalized human health. these research aims to harness the data revolution by exploiting computational and machine-learning models to design more effective polymers and sensors in a convergent fashion. this research will yield experimental and computational methodologies that can also be applied to other engineering disciplines. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Dimensions US-São Paulo: Animal biases in fruit selection and seed dispersal as drivers of biotic filters in the assembly of successional forests and their carbon capture potential

Awardee: Pennsylvania State Univ University Park

Amount: \$1,995,178.00

Abstract: tropical forests play a major role in regulating the earth's climate through their effects on water cycles and their large capacity to remove and store atmospheric carbon. because of their global preeminence as life-supporting systems and the widespread threats they face, understanding how tropical forests regenerate, store carbon, and maintain high bio\*\*diversity\*\* levels is urgent. the

project will advance the understanding of the roles that animal-plant mutualisms, involving animals that eat fruit and disperse seeds, affect the tree composition, **diversity**, growth rates, and soil-microbe communities that influence forest growth and atmospheric carbon storage potential. the project will advance the practical principles that promote cost reduction and maximization of **diversity** conservation in restored forested areas. the project fosters international collaboration and cross-fertilization between brazilian and us scientists and the mentoring of junior faculty, postdocs, and students of all levels. specifically project will train at least 10 graduate and 40 undergraduate students, and develop a field biology course for students of diverse backgrounds. community outreach activities include involvement of rural school students from middle and high school in science-learning activities at the classroom and the field study site. the project builds around three aims that link phylogenetic, genetic, and functional aspects of **diversity** in the context of the role of plant-frugivore mutualisms (fsd) on community assembly patterns of early-successional tropical forests. with an well-replicated experimental design that strategically incorporates functional plant traits and phylogenetic relationships as fixed-effects, the project test functional relationships between fsd processes and phylogeny on community assembly. the project then examines how the interaction of fsd processes with the functional-phylogenetic traits of pioneer plants affect the genetic **diversity** of the colonizer species that follow, and in turn, how patterns of genetic **diversity** lead to differences in plant survival, growth, and community assembly. the project ultimately explores how the biotic filtering interactions of fsd processes and the functional and phylogenetic traits of successional communities influence, or are influenced by, soil microbiomes and the nutrient pools and carbon transformation processes they control. the project advances basic knowledge by exploring mechanisms and outcomes across diverse scales of biological organization rarely brought together in a single experimental framework: from trophic interactions and dispersal processes, to soil microbes and their biogeochemical cycling effects. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: AccelNet-Implementation: Implementing a Deep Ocean Observing Strategy (iDOOS)

Awardee: University of Texas at Austin

Amount: \$1,992,928.00

Abstract: the deep ocean below 200 m is poorly known. this dynamic realm is a vast repository for bio\*\*diversity\*\*, provides critical climate regulation, and houses a wealth of hydrocarbon, mineral, and genetic resources. observing the deep ocean at a level required to inform sustainable development and management faces significant technical and logistical challenges. to address these challenges, the idoos project will implement a deep-ocean observing strategy (doos) that brings together u.s. and international networks engaged in sustained deep-ocean observing, mapping, exploration, modeling, research, and management to leverage each other's efforts, knowledge, and resources. this implementation project will boost the doos community-driven initiative, working under the umbrella of the global ocean observing system (goos) and endorsed as a united nations ocean decade action. by connecting deep-ocean observers across disciplines, expanding the observing community to include non-traditional partners, and linking data providers to users, idoos will enhance the goos deep-ocean capabilities and target societal needs. through engagement with policy makers, regulators, and science coordinators, idoos will raise awareness and support for deep-ocean science, and bring science into critical decisions regarding climate, bio\*\*diversity\*\* and sustainability. idoos will foster a community of future leaders informed in deep-ocean observing, modeling, and data science at a global level who are adept at communicating to regulators and policy makers as well as fellow scientists. idoos addresses three main themes: (1) requirement setting for deep ocean observing; (2) promoting the coordination and implementation of integrated observing to address sustainable development goals and societal needs; and (3) translating knowledge and data to allow science-based decision-making, regulation and governance of the global deep ocean. these themes will be integrated and applied via the

framework of regional demonstration projects. idoos will work with the goos disciplinary expert panels to refine essential ocean variables in terms of deep ocean requirements, and with network partners to maximize their implementation and use. in addition, the project has two cross-cutting activities. a focus on data/informatics will contribute best practices and standards to the requirement-setting theme, support activities across the working groups, and offer tailored training to early-career researchers. the project aims to enable findable, accessible, interoperable, and reusable (fair) deep-sea data and a data-enabled, deep-sea workforce. a key element of idoos is the mentorship and training of the next generation. idoos will assemble a network of deep ocean early career researchers (doers) drawing from collaborating networks, the broader deep-ocean observing community, as well as from developing countries and indigenous communities. through the theme working groups, the project will conduct training activities and meetings to substantially improve justice, equity, **\*\*diversity\*\***, inclusion, and belonging among the participating networks and more broadly within deep-ocean science. the accelerating research through international network-to-network collaborations (accelnet) program is designed to accelerate the process of scientific discovery and prepare the next generation of u.s. researchers for multiteam international collaborations. the accelnet program supports strategic linkages among u.s. research networks and complementary networks abroad that will leverage research and educational resources to tackle grand scientific challenges that require significant coordinated international efforts. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MIM: Elucidating the Rules of Cooperation and Resiliency in Microbial Communities through Stochastic Graph Grammars

Awardee: William Marsh Rice University

Amount: \$1,989,933.00

Abstract: microbial communities in aquatic ecosystems are central to maintaining the resiliency of these important environments. these dense microbial populations are rich in species **diversity** and their genomes are dynamic because of processes such as gene duplication and horizontal gene transfer. despite extensive genomic flux due to these evolutionary processes, microbial communities cooperate and maintain stable interactions and are resilient to environmental perturbations. this project aims to develop a suite of computational tools for deciphering the rules that govern cooperation and resiliency in hot spring microbial mats, or biofilms, from yellowstone park. these well-studied environments are ideal for examining how critical environmental parameters such as temperature, light and nutrients influence the **diversity**, abundance, and evolution of microbial populations. novel computational tools will be developed to identify rules that govern relevant biological processes. understanding how microbiomes evolve and adapt, especially with respect to the environment and to perturbations is crucial to understand many aspects of life. thus, the results obtained from this project will have a significant impact on biology, health, conservation efforts, and animal and plant management. furthermore, this research will support the interdisciplinary development of a diverse cohort of phd and undergraduate students at rice university and carnegie institution for science located on the stanford university campus. this project will also support the development of a summer reu focused on bioinformatics, ecology, evolution, and microbiology, and will also include summer training opportunities for graduate students with collaborators at the pasteur institute in paris, france. this collaborative, multidisciplinary project presents an innovative plan for combining education and outreach activities to achieve real and lasting impact. all software developed will be made available on open-source code repositories. the overall goal of the project is to understand how microbiomes evolve and adapt, especially with respect to the environment and to perturbations. to meet these goals, the team of researchers will introduce methodological advances at the intersection of graph theory, formal languages, and machine learning to identify rules governing gene duplication and horizontal gene transfer from metagenomic sequencing data. in aim 1, the project will construct and correlate species abundance networks with genome



exchange networks through genome assembly graphs. in aim 2, the project will produce a stochastic graph grammar framework for modeling network evolution over time, as well as unveil new rules with deep graph generators. in aim 3, genome-level simulations will be combined with the genomic events identified in aims 1 and 2 to assess the evolutionary benefits of these biological processes and their associated rates. the final project aim will focus on characterizing cooperation and resiliency through the study of graph grammars and network analysis techniques. the open-source computational methods developed across all four project aims will be evaluated on four distinct metagenomic datasets, including both environmental and host-associated microbiomes. finally, a wide variety of metagenomic datasets will be used to show generalizability of the computational approaches to host-associated microbiomes. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: A framework for reconciling competing effects of competitors on disease transmission

Awardee: University of Montana

Amount: \$1,979,823.00

Abstract: bio\*\*diversity\*\* is disappearing at an alarming rate, and at the same time, infectious diseases increasingly spill over from wildlife to humans. therefore, it is urgent to understand how species \*\*diversity\*\* affects infectious diseases in wildlife. in some ecosystems, increasing \*\*diversity\*\* of competitor species decreases disease risk, termed the 'dilution' effect because \*\*diversity\*\* dilutes out infection. however, in other systems, a more diverse community increases disease risk, termed the 'amplification' effect. when to expect dilution or amplification is a topic of debate among disease ecologists. this project aims to reconcile the competing effects of bio\*\*diversity\*\* using sin nombre hantavirus (snv) in deer mice as a model. this system displays aspects of both dilution and amplification at the same time. this project lays out a framework for

examining potential mechanisms of dilution and amplification and how they can interact to potentially be synergistic or antagonistic. this will facilitate moving beyond the long-standing debate of which pattern (dilution or amplification) is more prevalent, clarifying when different mechanisms may be dominant and help explain the different patterns seen in various studies. it will also benefit society by advancing prevention efforts for hantavirus pulmonary syndrome (hps). this human illness caused by snv, has affected more than 700 people (killing more than 250) since its discovery in 1993. other broader impacts of this research include outreach and work with native americans, with particular focus on k-12 outreach.

three mechanisms determine if increasing competitor **\*\*diversity\*\*** will lead to dilution or amplification of a directly transmitted pathogen. dilution will occur if increased species **\*\*diversity\*\*** leads to 1) decreased host density, 2) decreased contact rates, or 3) decreased probability of transmission given contact (transmissibility). conversely, amplification could occur if increased **\*\*diversity\*\*** does the opposite. this project develops a framework to disentangle these component dilution and amplification effects, centered around a mathematical model that combines sir (susceptible-infected-recovered) dynamics with a lotka-volterra competition coefficient. aim 1 is to determine how increased small mammal **\*\*diversity\*\*** / composition affects mouse population demography and subsequent snv prevalence, by performing bayesian population analyses on longitudinal data. aim 2 is to determine how increased small mammal **\*\*diversity\*\*** affects the transmission rate, through changes in transmissibility (via stress, co-infections, immunity, and viral shedding) and/or contact rates between deer mice, using a combination of long-term monitoring of physiology in natural populations, and experimental manipulation in the field. aim 3 is to synthesize the findings from aims 1 and 2 into a general model of how competitors can differentially affect all three components of transmission and scale up to determine the variety of observed patterns in disease prevalence within and across systems.

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Colorado School of Mines

Amount: \$1,918,299.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity  
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Title: Collaborative Research: GRate ? Integrating data and modeling to quantify rates of Greenland Ice Sheet change, Holocene to future

Awardee: SUNY at Buffalo

Amount: \$1,891,148.00

Abstract: the greenland ice sheet has experienced devastating melt in recent years. recent scientific reports highlight how vulnerable the greenland ice sheet is to arctic climate change and draw a dire picture of the impact of sea-level rise. in order to equip society with the best forecasts of sea level rise for planning, scientists need to improve the ability to simulate ? or model ? the response of ice sheets to climate change. for this project, scientists from different branches of ice-sheet research will work together to improve ice sheet modelling. the researchers will leverage recent scientific

advances to model the entire Greenland ice sheet in order to investigate long-term ice-sheet sensitivity to changes taking place in the ocean and atmosphere. The research group is committed to creating an inclusive environment where all team members can learn and excel. The team contains **diversity** in ethnicity, gender and rank, and will train six early career scholars, recruiting specifically from groups underrepresented in the geosciences, which is among the least diverse STEM fields in the U.S. Results will be made publicly available and will facilitate a broad range of future research about the Arctic system, including ice sheet modeling, model spin-up, paleoclimate reconstruction/synthesis and glacier history. To elevate the capacity of outreach and education programs developed during their first project, the team will build on their "scientists are superheroes" outreach program and leverage other, existing outreach frameworks, including making connections with Greenlandic communities and with high school student intern programs at their universities linked to the Young Women's Leadership School (Bronx, NY) and the Spring Valley (NY) branch of the NAACP, coordinated by our dedicated project educator and outreach specialist.

Reducing uncertainties in ice-sheet model predictions is crucial in society's handling of the sea level crisis. Uncertainties related to ice-sheet instability arise from limited observations, inadequate model representation of ice-sheet processes, and limited understanding of the complex interactions between the atmosphere, ocean, and ice sheets. How atmospheric and oceanic forcing vary through time, and at what timescales each are capable of forcing rapid change, are critical for predicting future ice mass loss, but scientists have been observing ice sheet change for only a short period of time (decades). The PIs propose to scrutinize Greenland ice sheet change spanning from the beginning of the Holocene (12,000 years ago) to 2100 CE, making it possible to evaluate the varying roles of atmospheric and ocean forcing on decadal-to-centennial timescales relevant for the future Greenland ice sheet evolution. The PIs will utilize their established multi-disciplinary collaboration to combine ice sheet modelling, climate forcing and reconstructions of past ice-sheet change. This will position the team to make predictions of future ice sheet change that are grounded in Greenland ice sheet behavior during past climate swings that occurred prior to our brief window of modern

observation. the work will lead to lasting products to serve the community's collective effort to better understand ice sheet change: 1) a state-of-the-art ice-sheet model optimized for simulations over long timescales, 2) a holocene-through-modern set of atmospheric and ocean state estimates optimized for forcing an ice-sheet model, and 3) a database of past-ice sheet configurations and paleoclimate records formatted for model-data comparison. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CCRI: ENS: Cognitive Hardware and Software Ecosystem Community Infrastructure (CHASE-CI)

Awardee: University of California-San Diego

Amount: \$1,882,000.00

Abstract: machine learning (ml) is a rapidly expanding field. computationally intensive workflows train neural nets and then use the results in smartphones, robots, drones, self-driving vehicles, and to run the internet of things. access to graphics processing units (gpus) is provided through chase-ci's nautilus, a highly distributed but centrally managed on-demand computer cluster designed for ml and computational media (cm). chase-ci provides over 20 campuses the scaffold for adding on-premises compute cycles and fast data handling and it offers researcher-focused support and training. using chase-ci's detailed measurements of performance, researchers learn to become experts in optimization of their computational resources. chase-ci is a community-building effort that sustains a growing community of ml/cm researchers using a purpose-built continuously enhanced nationally distributed computing and data storage infrastructure. researchers explore combinations of algorithms and architectures optimized with the help of graphed performance metrics. researchers benefit from extensive shared workflows and open-source software. they use chase-ci's on-line social media platform to receive and give support and share techniques.

community use of chase-ci informs computer architecture discussions about future national cyberinfrastructure research and instructional lab needs. chase-ci forms a national on-line community that is easy to join, designed for sharing code, data, and results. the hardware, software, and socio-technical approaches developed by chase-ci have provided a roadmap for broader research uses and student training in ml/cm technologies. researchers get expanded access to hundreds of gpus for developing algorithms and software to train sensing devices and visualize results thus engaging the students who will soon join the essential workforce for the ongoing massive expansion of mobile platforms such as robots, drones, and self-driving cars. chase-ci impacts social **\*\*diversity\*\*** in computer science, broadening participation among minority-serving institutions and underserved states. chase-ci thoroughly measures and monitors data access by applications over the regional and national r&e networks. the repository for the project may be found at [prp.ucsd.edu](http://prp.ucsd.edu), to be maintained for the length of the project at a minimum. it is the anchor website containing pointers to all the research efforts that build upon the pacific research platform. it contains code repositories, presentations, references like publications, presentations, and recorded lectures, and it maintains and archives an active social media channel. chase-ci is led by uc san diego, partnering with investigators at uc santa cruz, the university of nebraska-lincoln, florida agricultural and mechanical university, new york university, the university of illinois at chicago, and san diego state university. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Amount: \$1,882,000.00

Abstract: machine learning (ml) is a rapidly expanding field. computationally intensive workflows train neural nets and then use the results in smartphones, robots, drones, self-driving vehicles, and to run the internet of things. access to graphics processing units (gpu) is provided through chase-ci's nautilus, a highly distributed but centrally managed on-demand computer cluster designed for ml and computational media (cm). chase-ci provides over 20 campuses the scaffold for adding on-premises compute cycles and fast data handling and it offers researcher-focused support and training. using chase-ci's detailed measurements of performance, researchers learn to become experts in optimization of their computational resources. chase-ci is a community-building effort that sustains a growing community of ml/cm researchers using a purpose-built continuously enhanced nationally distributed computing and data storage infrastructure. researchers explore combinations of algorithms and architectures optimized with the help of graphed performance metrics. researchers benefit from extensive shared workflows and open-source software. they use chase-ci's on-line social media platform to receive and give support and share techniques. community use of chase-ci informs computer architecture discussions about future national cyberinfrastructure research and instructional lab needs. chase-ci forms a national on-line community that is easy to join, designed for sharing code, data, and results. the hardware, software, and socio-technical approaches developed by chase-ci have provided a roadmap for broader research uses and student training in ml/cm technologies. researchers get expanded access to hundreds of gpu for developing algorithms and software to train sensing devices and visualize results thus engaging the students who will soon join the essential workforce for the ongoing massive expansion of mobile platforms such as robots, drones, and self-driving cars. chase-ci impacts social **\*\*diversity\*\*** in computer science, broadening participation among minority-serving institutions and underserved states. chase-ci thoroughly measures and monitors data access by applications over the regional and national r&e networks. the repository for the project may be found at [prp.ucsd.edu](http://prp.ucsd.edu), to be maintained for the length of the project at a minimum. it is the anchor website containing pointers to all the research efforts that build upon the pacific

research platform. it contains code repositories, presentations, references like publications, presentations, and recorded lectures, and it maintains and archives an active social media channel. chase-ci is led by uc san diego, partnering with investigators at uc santa cruz, the university of nebraska-lincoln, florida agricultural and mechanical university, new york university, the university of illinois at chicago, and san diego state university. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: WINTRE-MIX: Winter Precipitation Type Research Multi-scale Experiment

Awardee: University of Colorado at Boulder

Amount: \$1,837,002.00

Abstract: during near-freezing weather conditions, a **\*\*diversity\*\*** of surface precipitation types are possible, including: rain, drizzle, freezing rain, freezing drizzle, wet snow, ice pellets, and snow. such near freezing precipitation affects wide swaths of the united states and canada, impacting aviation, road transportation, power generation and distribution, winter recreation, ecology, and hydrology. this award is for a field experiment, named the winter precipitation type research multi-scale experiment (wintre-mix) with the overarching goal of improving understanding of how a variety of processes influence the variability and predictability of the type and amount of precipitation that falls during winter weather events. the project has direct societal impact through the potential for improved forecasting of these events. additionally, the project will have significant student involvement, public outreach events, and citizen science participation. the wintre-mix campaign will be conducted in southern quebec, canada and northern ny and vt in the united states. the canadian national research council convair-580 research aircraft and the university of illinois mobile radars will be deployed along with a host of surface-based instrumentation in february and march of



2022 to make observations that can be used to determine the thermodynamic, dynamic, and microphysical processes that interact to determine near-freezing precipitation type. more specifically, the project has three overarching scientific questions that will be addressed using observations, analysis, and modeling: 1) how do mesoscale dynamics modulate near-freezing precipitation, 2) how do microscale processes modulate near-freezing precipitation, and 3) how do multi-scale processes combine to determine the predictability of near-freezing precipitation? this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EDGE FGT: Bee Functional Genomics Using Engineered Symbionts

Awardee: University of Texas at Austin

Amount: \$1,820,000.00

Abstract: insects are among the most widespread and diverse animals on our planet. they have critical roles in natural ecosystems and agriculture and have evolved unique biomaterials and lifestyles. scientific tools for studying the functions of the genes responsible for these traits are well-established for only a few types of insects, such as fruit flies. genetic tools do not exist for millions of other species. honey bees and bumblebees are economically important as widespread pollinators of food crops and are scientifically interesting due to the complex social behaviors observed in bee colonies. currently, there are few effective tools for studying the functions of bee genes. this project will develop and disseminate a toolkit that allows researchers to alter the expression of bee genes by engineering their native symbiotic gut bacteria. this technology will enable studies of how specific genes contribute to bee physiology, development, and behavior. this work will contribute to understanding bee ecology and health in ways that are expected to benefit bio\*\*diversity\*\* and us food security in the long term. the technology for engineering symbiotic bacteria is expected to be widely applicable to studying other insect species. these research and

outreach activities will be integrated with education by supporting two experiential learning courses that are part of the freshman research initiative program at the university of texas at austin. supporting this program will foster the development of a diverse science and technology workforce by involving underrepresented and first-generation college students in genuine research experiences. silencing the expression of a gene by inducing an rna interference (rna) response is a common approach for performing studies of gene function in invertebrates. however, delivering enough double-stranded rna to achieve sufficient gene knockdown through injection or feeding is expensive and ineffective in many insects, including bees. in this project, a functional genomics using engineered symbionts (fugues) methodology will be developed and applied to honey bees (*apis mellifera*) and bumblebees (*bombus* spp.). in fugues, microbial symbionts are engineered to continuously produce and deliver double-stranded rna to induce a targeted rna response in their host. newly emerged bees colonized with an engineered bacterial symbiont exhibit reduced expression of a target gene throughout the bee body, enabling one to ascertain the function of a bee gene and its role in determining specific phenotypes. there are key advantages of using fugues to study gene function over current techniques that generate transgenic animals: it can be accomplished more quickly, it can be conducted in high-throughput when coupled with insect colonization via feeding, and it can be applied to species, such as bees, with mating systems and collective behaviors that complicate using genome editing techniques. improving and disseminating the fugues tools created in this work will broadly enable studies of genes underlying bee behavior, development, and physiology. these tools will likely also be useful for studying many other insect species and other organisms that harbor symbiotic bacteria. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: RESEARCH-PGR: Genetic and environmentally-induced functional variation in the rice RNA structurome

Awardee: Pennsylvania State Univ University Park

Amount: \$1,800,000.00

Abstract: ribonucleic acids (rna) are essential molecules in living organisms, including in plants. rna can serve roles as both an informational molecule (genetic code) and a functional molecule (perform and regulate chemical reactions). rna can fold into complex shapes that can control whether it stays intact or is degraded. this in turn can control how a plant responds to environmental stresses it faces such as heat and cold. the research involves the development of new experimental technologies to investigate rna structures one molecule at a time and new computational technologies of artificial intelligence wherein a computer learns patterns that can predict rna structure and its variation. rice is an important world-wide crop, and the research applies these

technologies to rice varieties that are grown in different parts of the world. there are thousands of different varieties of rice adapted to local environments and their rnas often differ from each other by relatively few changes. some of these changes will alter the shape of the rna and thus the response of that rice variety to stress. a major goal of these study is to identify those changes that alter rna shape and thereby affect temperature tolerance. once identified, these shape-shifters could be engineered into specific rice varieties to breed crops more resistant to stress. aspects of the research will involve high school students and their teachers, and research results and methods will be disseminated in public outreach activities. rna structure is a primary determinant of gene expression. individual copies of the same transcript can take on different structures as influenced by their microenvironment, but methods have been lacking to categorize this **\*\*diversity\*\***. single nucleotide polymorphisms (snps) also can affect rna structure as ?ribosnitches?; however, ribosnitches have not been studied in plants, and their conditionality on environmental conditions has not been assessed. using rice (*oryza sativa*) as the primary model system, the proposed research will develop new wet bench and computational approaches that will allow categorization of the mrna ?pan-structurome,? its consequent impacts on gene expression, and its functional association with respect to local climate conditions in rice landraces. training will be provided to postdoctoral fellows, graduate students, undergraduates, and high school students and teachers. broader impacts will include development of the *oryza* climtools webtool to relate rice genotypes with climate variables and to identify beneficial structural haplotypes for use in development of elite rice cultivars. impact will be broadened through technology including enhanced browser-based rna structure-reactivity visualization and publicly available instructional screencasts. collaborations with pui swarthmore college will engage undergraduate researchers in computational aspects of the project. local high school students will perform whole plant physiological experiments, engaging a future generation of biologists and chemists. finally, the 23rd penn state plant biology symposium, on rna biology, will be organized, which will promote the global field of post-transcriptional gene regulation. this award was co-funded by the plant genome research program in the division of

integrative organismal systems and the genetic mechanisms cluster in the division of molecular and cellular biosciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CCI Phase I: NSF Center for Quantum Dynamics on Modular Quantum Devices (CQD-MQD)

Awardee: Yale University

Amount: \$1,800,000.00

Abstract: the nsf center for quantum dynamics on modular quantum devices (cq-d-mqd) is supported by the centers for chemical innovation (cci) program of the division of chemistry. this phase i center is led by professor victor batista from yale university. other team members include professors michel devoret from yale university, sabre kais from purdue university, lea ferreira dos santos from yeshiva university, and eitan geva from the university of michigan. the project is motivated by the huge gap that currently exists between the problems for which a quantum computer could be useful in chemistry and what can actually be simulated today with state-of-the-art quantum computers. the challenge is that most well-known quantum computing (qc) algorithms have hardware requirements that far exceed the capabilities of current state-of-the-art quantum computers by several orders of magnitude. closing that qc gap is thus essential to make qc technology finally available to studies of reaction dynamics and spectroscopy, beyond the rather simple proof-of-concept applications that so far have been developed. demonstrating a new generation of quantum electro-dynamics (cq-ed) platforms, in conjunction with quantum algorithms and fundamental studies of quantum reaction dynamics, has the potential to change the landscape of quantum simulations and lead to significant advances in chemistry with impact on other fields ranging from biology to materials science to engineering. partnerships with the stern college for women at yeshiva university, the yale pathways summer scholars program, and programs at purdue and the university of michigan will be developed

to specifically establish an ecosystem for development of a well-trained workforce in quantum information science and in the modeling of molecular systems with quantum devices. the main goal of the cq-d-mqd is to investigate chemical processes by using modular 3d circuit quantum electro-dynamics (cqed) platforms that can enable efficient realizations of molecular problems at the hardware level. an example of the type of quantum dynamical processes to be studied with the proposed quantum computing modules is the dynamics of photoisomerization that initiates the process of vision in vertebrates, involving non-adiabatic quantum dynamics at a conical intersection of potential energy surfaces. thus, the cq-d-mqd will design bosonic modular circuits described by potential energy surfaces that directly map the corresponding molecular hamiltonians of interest, thereby enabling quantum simulations with fundamentally new and potentially very efficient quantum devices. the cq-d-mqd will embrace a climate of inclusion and **\*\*diversity\*\*** so that underrepresented minorities and women are included in the interdisciplinary, team-based research. specific goals for phase i include (i) the design of modular 3d circuit quantum electro-dynamics (cqed) platforms for molecular quantum dynamics simulations, (ii) development of algorithms for quantum simulations and quantum computing on the new cqed platforms, and (iii) applications of the developed bosonic modular devices and algorithms to simulations of photo-induced quantum reaction dynamics, vibronic many-body systems; and quantum chemical dynamics in the condensed phase. the cq-d-mqd research and training program will establish an ecosystem with emphasis on recruitment and retention of female scientists and other members of underrepresented groups to advance the frontiers of knowledge in this burgeoning field and to train the next-generation workforce. the scientific and technological outcomes have the potential to be transformative for the quantum simulation of chemical systems and have the potential to out-perform conventional quantum computing platforms and find application across a wide range of molecular systems and quantum phenomena. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CCI Phase 1: NSF Center for Quantum Electrodynamics for Selective Transformations (QuEST)

Awardee: University of Rochester

Amount: \$1,800,000.00

Abstract: the nsf center for quantum electrodynamics for selective transformations (quest) is supported by the centers for chemical innovation (cci) program of the division of chemistry. quest is directed by todd krauss at the university of rochester, with a team that includes pengfei huo, william jones and nick vamivakas all from the university of rochester, jillian dempsey at the university of north carolina-chapel hill, nicolas large and zachary tonzetich from the university of texas-san antonio, teri odom from northwestern university and daniel weix from the university of wisconsin-madison. the development of better drugs to treat diseases, new materials that are both affordable and sustainable, and new ways to harness renewable energy all depend upon the synthesis of new molecules. when making new molecules, chemists are generally bound by a well-established set of "rules" for how a given molecule will and will not react. a limited number of tools exist to tune the result of a chemical synthesis, such as by varying the temperature, shining light on the reaction, or using a metal catalyst. however, the outcomes of a chemical reaction are largely pre-determined by the fundamental nature of the reacting molecules themselves. the goal of quest is to discover a new tool that will allow the development of new chemical reactions that are not currently possible. quest will do this by performing chemical reactions inside an optical cavity. in an optical cavity, light is best described as consisting of discrete quanta called photons. when such quantum-light from inside the cavity strongly interacts with the reactant molecules in a chemical reaction, the molecules are fundamentally altered in a manner that should unlock new types of chemical reactions. the ability to direct the outcomes of chemical reactions by simply changing properties of light delivered to the system represents a completely new way to tune a particular chemical synthesis, which, in turn, has the potential to transform approaches to chemical synthesis



and have broad benefits to society. quest will also train future leaders in the field, ensuring that they are well-prepared to communicate the excitement of quantum science applied to chemistry to a broad audience, and striving to build a cohort of developing quantum chemistry researchers that is truly diverse. the cci phase i nsf center for quantum electrodynamics for selective transformations aims to discover uniquely selective chemical functionalizations that are enabled by the strong interaction of matter and the quantum light of an optical cavity. quest is exploring a fundamentally new tool for the development of selective organic chemistry by utilizing optical cavity polaritons, hybrid light-matter quasiparticles, in a manner similar to chemical catalysts. quest brings together methods and approaches from across organic, inorganic, materials, theoretical, and physical chemistry as well as quantum optics. quest aims to establish a clear understanding of how polaritons influence properties of molecules relevant for chemistry--such as potential energy surfaces--and develop effective methods to create polaritons for a broad array of molecules in solution. model chemical reactions in phase i have been chosen to test the fundamental mechanism and basic principles of polariton chemistry. in addition to rigorous scientific training, quest will instruct students in best practices for bringing quantum-chemical science to a broad audience. efforts will be directed toward increasing **\*\*diversity\*\*** in the scientific pipeline through science experiences for underrepresented undergraduate students, as well as translating quest science into high-school laboratory activities, social media dialogues, and portable museum exhibits appropriate for all ages. this cci presents a bold vision for facilitating the growth of an entirely new and emerging field: using quantum electrodynamics principles to enable selective chemistry. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Recrafting Computer Science: Fiber Crafting as Computational Thinking

Awardee: University of California-Irvine

Amount: \$1,750,000.00

Abstract: this project aims to serve the national interest by paving the way to creating a technical workforce that is able to function effectively in highly collaborative, diverse environments. enhanced ability to nurture these skills and abilities will occur through development of measurement instruments, a novel curriculum, and research into the impacts of the curriculum. the project seeks to align with the ehr core research (ecr) program's intent by reflecting the interdisciplinarity of computational thinking (ct) and encouraging critical reflection with respect to the historical role of women and people of color in computer science (cs) and robotics. this project moves the traditional cs curriculum beyond the screen and back to its tangible roots to support learning, collaboration, and participation in cs. in this project, the newly crafted cs curriculum will engage undergraduates in the construction, programming, and use of a robotic loom, foregrounding the inherently interdisciplinary nature of ct in a formal cs curriculum. the project activities expect to broaden participation and collaboration in cs and stem, redefining what counts as a valuable learning activity in cs education. grounded in the learning sciences and embodied cognition, this project will further the development of interdisciplinarity and address key challenges to **\*\*diversity\*\*** in computing. the project activities will interweave iterative design-based research with periodic experimental research experiments to test the efficacy of the robotic loom designs and course materials for undergraduate learning of interdisciplinarity and collaborative computing. to ensure that the proposed designs effectively complement curricular and practical realities, the project team will consult with an advisory board, the undergraduates, and the participating institution's curriculum advisory boards to inform design and development throughout the project period. this project is supported by the ecr program, which supports work that advances fundamental research on stem learning and learning environments, broadening participation in stem, and stem workforce development. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Strategic Course-based Adaptations of an Ecological Belonging Intervention to Broaden Participation in Engineering at Scale

Awardee: University of Pittsburgh

Amount: \$1,731,741.00

Abstract: this project aims to serve the national interest by increasing the number and **\*\*diversity\*\*** of engineers produced in the united states. science overall has made great progress in increasing the participation of women. however, engineering has made no overall progress in the last 20 years, with women continuing to earn only 20% of engineering bachelor's degrees each year. improving retention in the first two years of engineering programs is important in addressing ongoing attrition. in particular, engineering will become more inclusive when the concerns that many students have about feeling alone in thinking they are incapable of mastering the course's content are addressed. in this project, short interventions will be implemented. these interventions are intended to reveal to students that most of the students in their class have these same concerns, that previous students just like them with similar concerns have successfully completed this coursework, and that their instructor believes they are capable of succeeding. prior research by the project team using the intervention in first-year courses has shown that these interventions can entirely eliminate course retention differences by gender as well as by race/ethnicity. a new method for customizing this intervention will be developed, tested, and further improved so that it can have similar strong benefits in different courses and at different universities. simple interventions that can be easily and scientifically customized to many contexts may have potential for significantly improving engineering outcomes across the united states. this project uses an ecological-belonging intervention approach that only requires a one-class or one-recitation session to implement and has been shown to erase long-standing achievement gaps by gender and race/ethnicity in several introductory stem courses. however, while simple, the intervention cannot involve a fixed script for different university and course contexts. rather, the content of the intervention needs to be customized to the local

context in order to address the specific concerns students have in that specific context. this project brings a highly interdisciplinary team across three strategically-selected universities with the goal of developing an approach to identify which 1st and 2nd year courses need this intervention, reveal student concerns in that course, adapt the intervention to address those concerns, and address other pragmatic constraints of how that course is taught. this systematic approach also includes processes for onboarding all the instructors of the given course. in answering a set of seven core research questions, the project intends to expand knowledge about 1) where (on which outcome variables), when (in which contexts, for which students), and why the ecological belonging intervention has positive effects, and 2) the extent to which this intervention on its own has measurable impacts on the overall problem of representation in the larger challenge of representation within the large engineering pathways that have struggled with representation. this kind of foundational knowledge is critical to making decisions about when to apply the intervention as well as providing important insights into how to apply the intervention. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the institutional and community transformation track, the program supports efforts to transform and improve stem education across institutions of higher education and disciplinary communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Improving Engineering Student Engagement, Self-Efficacy, Diversity Awareness, and Retention using Visualization and Virtual/Augmented Reality Technologies

Awardee: Georgia Tech Research Corporation

Amount: \$1,700,000.00

Abstract: this project serves the national interest by creating visualization and augmented/virtual reality (ar/vr) education modules in architectural engineering and construction (aec) courses that will help improve students' persistence in the program, self-confidence, and **\*\*diversity\*\*** awareness. students will work on real world projects in teams using the visualization and interactive ar/vr modules. social and technical interactions between students will be facilitated using virtual spaces that simulate physical meeting rooms in which students can share engineering artifacts. student learning will be supported with an interactive building environment, interactive exercises in a 3d virtual environment, and embedded audio/videos that provide feedback on student design decisions. students will visualize themselves as aec professionals and increase their self-efficacy starting in

k-12 or community college contexts as well as in the first year of their degree program. more advanced real-life engineering experiences will continue to reinforce self-efficacy and engagement in engineering throughout the aec curriculum. this collaboration between a research-intensive institution, university of nebraska-lincoln, and an hbcu, tennessee state university, will provide an opportunity for students to interact with other students from diverse backgrounds and produce valuable insights on the effectiveness of the education modules with different audiences. a virtual workshop series will be used to support the adoption of the modules by other aec programs, other engineering disciplines, and high school teachers. three education modules will be developed and implemented in courses at the collaborating institutions. an introductory module will be used for outreach to k-12 and community colleges to generate interest in aec fields. the remaining modules will be used for first and second-year aec students in existing courses. the design of the modules is informed by the model of domain learning theoretical framework including its constructs of stages of learning and phases of interest. modules will be developed with attention to the learning objectives of the courses and the level of aec curriculum that is being targeted. the project seeks to answer the following overarching research questions: 1) how does a module impact students' engagement, self-efficacy, and \*\*diversity\*\* awareness? 2) how do enrollment, retention, and graduation rates change as modules are introduced into the curriculum? and 3) how do the findings to the first two questions vary by institution? each module will provide the basis for a multi-case study where the institutional context defines each case. rich case descriptions and cross-case analysis will guide improvements to the module, highlight module transferability barriers and affordances, and enable interpretation of findings based on data from survey instruments and interviews. this project will advance knowledge about the impact of ar/vr-based learning modules in stem teaching and learning. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the engaged student learning track, the program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through

evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Improving Engineering Student Engagement, Self-Efficacy, Diversity Awareness, and Retention using Visualization and Virtual/Augmented Reality Technologies

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Matched Words: diversity

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Title: Digitization TCN: Collaborative Research: Bringing Asia to digital life: mobilizing underrepresented Asian herbarium collections in the US to propel biodiversity discovery

Awardee: Harvard University

Amount: \$1,632,344.00

Abstract: asia is the largest continent on earth, and includes the world?s tallest mountains, lowest landscapes, and habitats ranging from arctic tundra to tropical rainforests and mangroves to deserts. the plants of this region are incredibly diverse in their identities and functions. more than one-third of

the world's 350,000 plant species grow in asia and include tiny alpine cushion plants, medicinal herbs, ancient crops, and some of the planet's tallest rainforest trees. but documentation of this **diversity** remains inaccessible and research about it is difficult because most herbarium specimens of asian plants have not been digitized. the all asia thematic collections network (tcn) will mobilize online 15 million specimens of asian plants currently housed in the us and around the world. the project will especially focus on digitizing specimens from the unique and critically endangered **diversity** hotspots of southeast asia and the himalaya-hengduan region. these mobilized digital data will accelerate research to conserve endangered plant species and understand the interacting effects of evolution and global environmental change on plant species **diversity**. the project will apply state-of-the-art informatics tools and high-throughput digitization methods to efficiently and affordably digitize an unprecedented number of herbarium collections. this effort will connect and build long-lasting relationships among 25 large and small consortium institutions in the u.s., europe, and asia. the focal areas from which specimens will be digitized encompass five **diversity** hotspots that include ~20% of the world's vascular plant flora and historically spanned 3 million km<sup>2</sup> of primary vegetation that now covers less than 300,000 km<sup>2</sup>. fundamental **diversity** data for these **diversity** hotspots are lacking, along with the necessary baselines required to characterize species' identity, range, and responses to ongoing climatic change. the overall goals of the all asia tcn are to rapidly digitize herbarium specimens of asian plants to advance **diversity** discovery and provide critical baseline assessments essential for establishing floristic change in the anthropocene. the project will accomplish this by (1) digitizing 3 million asian vascular plant specimens from u.s. herbaria; (2) developing and applying novel informatics tools and high-throughput digitization methods to massively scale herbarium digitization; (3) aggregating and mobilizing the digitized records from the project with those by international partners in china, france, the netherlands, and russia to establish a single online all asia portal of ca. 15 million specimens; and (4) enhancing opportunities for early career learners in science, technology, engineering, and mathematics by stimulating synergies between

bio\*\*diversity\*\* and computer scientists who will use design thinking principles to create real-world informatics solutions to bio\*\*diversity\*\* challenges. to stimulate curiosity in plant \*\*diversity\*\* and botanical exploration among the general public, the consortium members will host several asia-themed notes from nature virtual expeditions to facilitate additional specimen digitization by citizen-scientists. digitized specimen data mobilized through this project will be shared and made available through idigbio.org. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Digitization TCN: Collaborative Research: Bringing Asia to digital life: mobilizing underrepresented Asian herbarium collections in the US to propel biodiversity discovery

Awardee: Harvard University

Amount: \$1,632,344.00

Abstract: asia is the largest continent on earth, and includes the world's tallest mountains, lowest landscapes, and habitats ranging from arctic tundra to tropical rainforests and mangroves to deserts. the plants of this region are incredibly diverse in their identities and functions. more than one-third of the world's 350,000 plant species grow in asia and include tiny alpine cushion plants, medicinal herbs, ancient crops, and some of the planet's tallest rainforest trees. but documentation of this \*\*diversity\*\* remains inaccessible and research about it is difficult because most herbarium specimens of asian plants have not been digitized. the all asia thematic collections network (tcn) will mobilize online 15 million specimens of asian plants currently housed in the us and around the world. the project will especially focus on digitizing specimens from the unique and critically endangered bio\*\*diversity\*\* hotspots of southeast asia and the himalaya-hengduan region. these mobilized digital data will accelerate research to conserve endangered plant species and understand the interacting effects of evolution and global environmental change on plant species

**diversity**. the project will apply state-of-the-art informatics tools and high-throughput digitization methods to efficiently and affordably digitize an unprecedented number of herbarium collections. this effort will connect and build long-lasting relationships among 25 large and small consortium institutions in the u.s., europe, and asia. the focal areas from which specimens will be digitized encompass five **diversity** hotspots that include ~20% of the world's vascular plant flora and historically spanned 3 million km<sup>2</sup> of primary vegetation that now covers less than 300,000 km<sup>2</sup>. fundamental **diversity** data for these **diversity** hotspots are lacking, along with the necessary baselines required to characterize species' identity, range, and responses to ongoing climatic change. the overall goals of the all asia tcn are to rapidly digitize herbarium specimens of asian plants to advance **diversity** discovery and provide critical baseline assessments essential for establishing floristic change in the anthropocene. the project will accomplish this by (1) digitizing 3 million asian vascular plant specimens from u.s. herbaria; (2) developing and applying novel informatics tools and high-throughput digitization methods to massively scale herbarium digitization; (3) aggregating and mobilizing the digitized records from the project with those by international partners in china, france, the netherlands, and russia to establish a single online all asia portal of ca. 15 million specimens; and (4) enhancing opportunities for early career learners in science, technology, engineering, and mathematics by stimulating synergies between **diversity** and computer scientists who will use design thinking principles to create real-world informatics solutions to **diversity** challenges. to stimulate curiosity in plant **diversity** and botanical exploration among the general public, the consortium members will host several asia-themed notes from nature virtual expeditions to facilitate additional specimen digitization by citizen-scientists. digitized specimen data mobilized through this project will be shared and made available through idigbio.org. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: BEE: The Evolution of Fluctuation-Dependent Species Coexistence

Awardee: Williams College

Amount: \$1,616,701.00

Abstract: understanding how similar species coexist has been a central question in ecology since its inception. the question is important because species **diversity** is a defining characteristic of natural ecosystems. traditional answers to this question focus on how species differ in the types of resources they use in non-fluctuating environments. under this paradigm, evolution can facilitate species coexistence when it makes species less similar in their resource use. however, natural ecosystems are not constant, and there has been recent interest in understanding how temporal variation in the environment, and differences in how species respond to this variation, can lead to conditions that favor coexistence. while we know about these fluctuation-dependent mechanisms in theory, we know little about whether they can promote species coexistence in natural populations. we know even less about how evolution either facilitates or impedes such fluctuation-dependent mechanisms. this research attacks these questions by leveraging studies of experimental evolution in nature together with mathematical models and experiments in artificial streams. the research will engage 38 young scientists from diverse backgrounds per year in the young scientist training program. the young scientists gain research experience that is complemented by training in ecology, evolution, and statistics. the researchers will also engage the public through an online outreach website and will develop training in ecology and evolution through mobile gaming, social media, and teacher training modules based on this system. this work will provide a multipronged test of fluctuation-dependent coexistence mechanisms in natural communities and investigate how they evolve. in doing so, this work will synthesize ideas in ecology and evolutionary biology. this research takes advantage of the natural laboratory provided by the structure of stream communities in trinidad, west indies where fish communities consist of either trinidadian guppies and hart's killifish or hart's killifish by themselves. killifish-guppy communities are formed when guppies invade

communities with only killifish. prior research has shown that following these invasions, guppies and killifish rapidly evolve differences in their life histories and resource use. these streams are also highly seasonal with pronounced dry and wet seasons. do killifish and guppies respond differently to these seasonal fluctuations? are guppies adapted to dry season conditions and killifish to wet season conditions? if so, then this difference provides an avenue for the two species to coexist. this research will also address how important these fluctuation-dependent mechanisms are relative to traditional fluctuation-independent mechanisms and identify how these contributions change through the formation of the community. this research will leverage replicated experimental evolution studies in natural ecosystems with structured models, factorial experiments in artificial streams, and stable isotope work. at the same time, the mathematical models will provide a framework for linking theory on species coexistence with evolutionary theory. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: DISES: Toward resilient and adaptive community-driven management of groundwater dependent agricultural systems

Awardee: Virginia Polytechnic Institute and State University

Amount: \$1,611,722.00

Abstract: groundwater for irrigation is foundational to the viability of numerous us farming communities, as well as the national and global food supplies they support. yet, this natural resource is being overexploited in many areas, threatening the social and economic viability of those that depend on it. irrigators in western kansas and south-central colorado are developing community-level rules regulating groundwater use and management in an effort to preserve the aquifer and their livelihoods ? a novel experiment in self-governance of groundwater commons. the initial success of these self-governance regimes has prompted their rapid spread, facilitated by a

transfer of experience and rule design from one community to another, resulting in the adoption of relatively similar rules across the communities. however, questions remain regarding the long-term effectiveness, resilience, and adaptability of these similar self-governance regimes under shocks, such as drought or volatile commodity markets. this work will explore these questions and help groundwater dependent agriculture communities create more effective, resilient, and adaptive groundwater management strategies. the project team will strive to not only bring timely findings to a pressing societal need but also to train undergraduate and graduate students in interdisciplinary science so they are positioned to help solve the vexing sustainability issues that confront society. the project will provide an empirical basis for new theory explaining how individuals and institutions contribute to socio-environmental system effectiveness, resilience, and adaptability. specifically, the work will answer important, but understudied, questions related to the processes, dynamics, and vulnerabilities of groundwater self-governance regimes. the work will tightly integrate research in both natural and social sciences to advance theory on how the spread of self-governance arrangements, and their interplay with natural and social factors, collectively influence the sustainability and resilience of groundwater-dependent communities. foundational to the research plan is the convergence of social and environmental data that will underpin a novel integrated model representing complex, dynamic interactions and feedback between social (irrigators and institutions) and environmental (aquifer and land) realms. the overall goal is to develop new theory of how socio-environmental and institutional **\*\*diversity\*\*** (or lack thereof) determines the effectiveness, resilience, and adaptability of groundwater self-governance regimes under current conditions and in response to social and environmental change. achieving this goal will advance broader understanding and theory of common-pool resource management and chart paths forward for groundwater dependent agriculture communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: DISES: Between maintenance and transformation: a socio-environmental systems framework for restoration decision-making under climate change

Awardee: University of California-Davis

Amount: \$1,599,937.00

Abstract: this project will develop a framework for understanding the range of responses, and their potential drivers, in restoration decision-making under climate change. following an extreme event such as a drought, storm, or heat wave, restoration actions might seek to recover and maintain a historically representative state. alternately, restoration actions might seek transformation to a new state that is anticipated to be more robust to future extreme events with climate change. both outcomes represent adaptation to climate change, but with distinct management goals for the end state. therefore, by analyzing the drivers of restoration outcomes on a continuum from maintenance to transformation, this project will identify drivers of adaptive capacity to climate change framed in terms of concrete, actionable goals. in addition, by focusing on marine systems, this project will benefit society by informing active restoration efforts. with fishery declines and closures, public agencies, ngos, fishing organizations, and citizen groups are implementing novel restoration interventions. partnership with these entities throughout the project will account for community and management needs in project activities and inform time-sensitive management decisions. the project advances stem educational training at three institutions, and broadens the participation of groups historically underrepresented in science. this project will explore kelp forests off the california coast as a model system to evaluate environmental and social drivers influencing efforts at restoration. following a series of marine heat wave events, california kelp have recently experienced unprecedented decline, with associated increases in kelp-consuming urchins impeding kelp recovery. kelp declines are associated with declines in bio\*\*diversity\*\* as well as declines in recreational and commercial fisheries that are vital to the associated coastal communities. the goal of this project is to characterize the drivers of maintenance and transformation outcomes in different



socio-environmental system (ses) components and explore their interactions through three integrated approaches. first, empirical investigation will characterize the drivers of ecological, social, and institutional capacity to respond to extreme events with a combination of oceanographic analysis, ecological field studies, and interviews and a survey of resource users, other stakeholders, managers, and regulators. second, informed by this empirical characterization, a dynamically coupled ses model will explore how the achievement of identified management goals on the maintenance-transformation continuum depends on uncertainty in system components and the relative time scales of ecological recovery and social response. third, linking the ses model to governance network analysis will indicate how ses network configurations affect the ability to realize goals on the maintenance-transformation continuum in fragmented institutional contexts. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: DISES: Modeling interactions between community forest dynamics and local livelihoods amidst institutional changes

Awardee: Oregon State University

Amount: \$1,598,100.00

Abstract: regulators and forest managers have long looked for answers regarding which institutional arrangements best serve to balance rural development and forest conservation. one such arrangement, is community forestry where some forest care and management is handled by local communities. while community forestry can be an effective in conserving forests and enhancing rural livelihoods, studies also show that that success is variable. this project will identify the conditions that lead to positive community forestry outcomes. it will identify the situations and arrangements that lead to success, across vietnam, laos, and cambodia. this work important for governments and non-governmental organizations in the u.s., where forests under community management are

increasing in number. it will also be beneficial in low- and middle-income countries where communities manage over 25% of forests. this project will train two phd students and a postdoctoral fellow in data science and modeling. course materials will bring modeling exercises into the classroom. this project will investigate changes in community forestry arrangements on forest condition and livelihoods. it will examine the role of institutional variability and social and ecological conditions in moderating community forestry impacts. it will also study feedback that drive changes in social and ecological outcomes. the researchers will build spatial datasets on forest condition and change, livelihoods, and institutions across three countries in the mekong region. this will be done using satellite imagery, citizen science datasets, longitudinal national socio-economic datasets, and community forest spatial data. they will apply a statistical matching research design to test the hypotheses that community forestry is more likely to maintain and restore forest cover and bio\*\*diversity\*\*. the method will also explore the ability of community forestry to enhance livelihoods, and how these impacts will be moderated by institutional variability and baseline social and ecological conditions. they will collect site-level ecological and social data to validate and refine the resulting models and examine causal mechanisms leading to varied outcomes. finally, they will build models that recognize feedbacks between forest condition and livelihoods under community forestry. those models will be capable of predicting landscape and livelihood changes at various spatial and temporal scales under changing institutional drivers and ecological conditions. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: DISES: Cumulative effects of ecological and social stressors on the dynamics of integrated ranching-wildlife systems: drought, wolves, and human decision-makers

Awardee: Regents of the University of Idaho

Amount: \$1,597,830.00

Abstract: as environmental changes intensify around the world, both humans and wildlife face greater uncertainty and risk, threatening both human livelihoods and wildlife bio\*\*diversity\*\*. this research seeks to understand how multiple sources of stress impact humans, free-ranging livestock, and wildlife in shared rangelands in the western us. increasingly frequent and more severe droughts make plant forage for wild herbivores and cattle less predictable and abundant, even as the return of gray wolves to parts of the landscape increases predation risk. as a result, wildlife such as deer and elk, as well as free-ranging livestock, may be forced to trade off food and security, and ranchers grazing their cattle on public land may face more uncertainty. this research will assess (1) how drought and wolves interact to affect wild herbivores and free-ranging cattle distributions across the landscape, (2) how decision-makers respond to these two sources of stress, and (3) how information, provided via a new wildlife and plant forecasting application, is received and used by both ranchers and wildlife managers. the project will also increase public awareness of human and wildlife connections and interactions in rangeland ecosystems via a documentary film, as well as by training citizen scientists to classify camera-trapped images of rangeland wildlife. a diverse group of undergraduate and graduate students as well as a post-doctoral researcher will be trained over the course of this project. outcomes of this project include a better understanding of how climate and carnivore risks affect human decision-making, as well as how humans impact rangeland food webs via cattle stocking and wildlife removal, potentially leading to increased opportunities for coexistence between humans and wildlife in changing environments. ecological shifts brought about by climatic change can strongly interact with other sources of change, such as recolonizing large carnivores, to alter food web dynamics and potentially reduce ecosystem provisioning for humans. the uncertainty created by such interactions also challenges human decision-making. a critical gap exists in our knowledge of how climate change affects human-wildlife systems via wild food webs, and how natural resource decision-makers respond to such stress. we hypothesize that multiple environmental stressors (e.g., climate change and novel predators) will have complex and interactive effects on human-wildlife systems. effects will likely occur via trophic interactions among

predators, prey, domestic animals, and plants within shared food webs, potentially reducing the provisioning of humans from the shared ecosystem and human tolerance for predatory and competitive wildlife, and increasing uncertainty for natural resource decision-makers. there is a pressing need to advance models, tools and theory to (a) understand how multiple stressors interactively affect food webs in which humans and domestic animals are embedded, and (b) identify and quantify feedbacks among natural resource decision-makers and human-wildlife systems in response to multiple environmental stressors. such information would assist in identifying potential ?tipping points? in system resiliency and allow for better management of interacting wildland and agricultural systems. using a factorial design of study sites across combinations of wolf presence and drought in oregon and idaho, we will study rancher-wildlife-plant dynamics. data will stem from rancher surveys, wildlife camera grids, and ground-surveyed and remotely-sensed plant data. we will integrate social and ecological data into a structural equation modeling framework, which will drive ecological forecasts of predation and competition risk to livestock for ranchers and managers to use in future decision making. to understand natural resource manager decisions, which occur at larger spatial scales than rancher decisions, we will conduct a broad-scale analysis of the rangeland ses across the western us using publicly-available wildlife and social data and remotely-sensed environmental characteristics. by analyzing decision-making across these spatial scales, we anticipate being able to identify key feedbacks, emergent phenomena, and potential tipping points in resilience for the human and wildlife components of the rangeland ses. this project is jointly funded by the dynamics of integrated socio-environmental systems (dises) and the established program to stimulate competitive research (epscor). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: DISES: Cumulative effects of ecological and social stressors on the dynamics of integrated

ranching-wildlife systems: drought, wolves, and human decision-makers

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Amount: \$1,597,830.00

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natural resource decision-makers respond to such stress. we hypothesize that multiple environmental stressors (e.g., climate change and novel predators) will have complex and interactive effects on human-wildlife systems. effects will likely occur via trophic interactions among predators, prey, domestic animals, and plants within shared food webs, potentially reducing the provisioning of humans from the shared ecosystem and human tolerance for predatory and competitive wildlife, and increasing uncertainty for natural resource decision-makers. there is a pressing need to advance models, tools and theory to (a) understand how multiple stressors interactively affect food webs in which humans and domestic animals are embedded, and (b) identify and quantify feedbacks among natural resource decision-makers and human-wildlife systems in response to multiple environmental stressors. such information would assist in identifying potential ?tipping points? in system resiliency and allow for better management of interacting wildland and agricultural systems. using a factorial design of study sites across combinations of wolf presence and drought in oregon and idaho, we will study rancher-wildlife-plant dynamics. data will stem from rancher surveys, wildlife camera grids, and ground-surveyed and remotely-sensed plant data. we will integrate social and ecological data into a structural equation modeling framework, which will drive ecological forecasts of predation and competition risk to livestock for ranchers and managers to use in future decision making. to understand natural resource manager decisions, which occur at larger spatial scales than rancher decisions, we will conduct a broad-scale analysis of the rangeland ses across the western us using publicly-available wildlife and social data and remotely-sensed environmental characteristics. by analyzing decision-making across these spatial scales, we anticipate being able to identify key feedbacks, emergent phenomena, and potential tipping points in resilience for the human and wildlife components of the rangeland ses. this project is jointly funded by the dynamics of integrated socio-environmental systems (dises) and the established program to stimulate competitive research (epscor). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: MIM: The impact of the fungal microbiome in metal tolerance and soil biogeochemical transformations

Awardee: University of Houston

Amount: \$1,574,057.00

Abstract: some metals are essential nutrients for life, while some are non-essential or even harmful to living organisms. fungi and bacteria are microorganisms that often live in a close association and play a key role in transforming and detoxifying metals in the environment. in spite of this importance, there is relatively little understanding of how the interactions between bacteria and fungi influence the transformation and/or detoxification of metals. the goal of this project is to address this knowledge gap by identifying how fungal-bacterial interactions affect metal transformation. this will be achieved through a novel multidisciplinary research approach employing advanced, state-of-the-science analytical techniques. knowledge gained through this project will allow the engineered control of metal transformations for a wide range of applications in environmental cleanup, biorefining, production of nanoparticles, and other beneficial applications. successful completion of this research has strong potential to benefit society through improvements in environmental remediation and industrial manufacturing. this project will improve the nation's stem workforce by providing a unique training opportunity for student researchers that bridges diverse fields such as environmental engineering, microbiology, geochemistry, bioinformatics, and art. remediation of metal contamination is a major environmental challenge because, unlike many organic pollutants, metal species cannot be degraded and can only be extracted or biotransformed to less toxic forms. while past approaches to biotransform metals have focused primarily on single microorganisms, host-microbiome interactions have shown potential to biotransform surrounding environments and improve host resiliency. however, the mechanisms for metal biotransformation by microbial host-microbiome systems are largely unknown. the overall goal of this project is to

elucidate the rules of life that govern fungal microbiomes. this goal will be achieved through a specific focus on fungal microbiomes, which include a fungal host, endosymbionts (endobacteria), and symbionts (exobacteria that live extracellularly) as a model host-microbiome system. the specific research objectives of this project designed to achieve the goal are to: understand the effects of metals and metalloids on the **\*\*diversity\*\*** and transmission of fungal microbiomes (facultative and obligatory); and determine the role of fungal microbiomes in metal tolerance by mediating the uptake, transformation, and sorption of metal ions, nanoparticles, or other metal species. a deeply integrated multidisciplinary approach will be used to investigate physiological, genetic/genomic, and metabolic processes that govern the structure and function of fungal microbiomes in the presence of metals. this will be achieved using novel state-of-the-science isotope probing, advanced microscopy, spectroscopy, and integrated genomics, transcriptomics, and metallomics to elucidate how the microbiome influences the metabolic activity of the host towards metal ions. successful completion of this research has strong potential to identify new genes and/or pathways for metal tolerance and biotransformation, as well as expand our mechanistic understanding of the structure and function of fungal microbiomes in nature. this knowledge has strong potential to benefit society by facilitating applications in remediation, water treatment, electronics manufacturing, antimicrobial production, medicine, and related fields. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: FW-HTF-R: Race, Gender and Class Equity in the Future of Work: Automation for the Artisanal Economy

Awardee: Regents of the University of Michigan - Ann Arbor

Amount: \$1,566,000.00

Abstract: ai is poised to eliminate millions of jobs, from finance to truck driving. but artisanal products



and labor?such as handmade textiles, furnishings, adornments, foods, and repair shops?are valued precisely because of their human origins, and thus have some inherent ?immunity? from ai job loss. and they are often more enjoyable. while many of the jobs ai can (and should) replace are dull or dangerous, artisanal labor is at the other end of the spectrum: some of the most satisfying professions possible. many artisans strive to be more environmentally sustainable, using ?green" supply chains and techniques. but most importantly, artisanal business is one of the few sectors where ownership can be found at the grassroots. from beauty salons to auto detailing; ethnic foods to repair shops, we find that groups underrepresented by race (black, native, latinx); by gender (women) and by socioeconomic status (poor people of all ethnicities) are more likely to own non-employee businesses than other companies. new forms of automation--ai, robotics, and others--are now being developed for mass-production contexts. this research will work to adapt these new forms of automation for use by small non-employee businesses, in order to enhance production rates, repertoires, product quality and sustainability for this more diverse demographic. it will work toward enhancing wealth equity through a diverse ecosystem of artisanal enterprises, utilizing innovations in information technology to foster collaborations in supply chains, marketing and other dimensions.      this project will develop new theory and knowledge addressing 2 primary research questions. (1) how can ai, robotics and related automation technologies enhance equity for underrepresented groups by enhancing the capabilities of artisanal production and services? (2) how can collaborative innovation with grassroots participants expand their niche to move us closer to a circular economy; one that empowers their labor value? these research questions will be investigated using a four step approach. (1) develop practical applications for immediate use with artisan collaborators in detroit, focusing on digital fabrication. prior studies show that many artisanal practices include computational thinking in their approach (iteration in weaving for example). by simulating these ?heritage algorithms? we can test strategies to enable the blending of beloved cultural traditions with digital fabrication, and from there develop training opportunities and resources for new products, skills, and innovation. the hypothesis is that, contrary to mass production

scenarios, there is no single optimum for human-machine task allocation in the artisanal domain. instead, we hypothesize a wide **\*\*diversity\*\*** of strategies that are optimal for different contexts. (2) utilize feedback from these experiences to run small scale experiments in the future of work with artisanal economic networks, such as platform cooperatives and the use of ai in guiding sustainable consumption and supply chains. (3) design, develop, and evaluate a community asset mapping database for tracking changes in inter-organizational alliances, supply chains, entrepreneurship incubation, and other elements of the potential artisanal economy network. the intention is to enable the evaluation of a broader vision for how automation-empowered artisanal labor could aid the general transformation to a circular, non-extractive economy. (4) expand the research context to include artisanal groups across the nation. this will address the generalizability of the project's emerging theoretical framework, and support dissemination of its open-source technologies. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Faculty Research and Education Development Program II

Awardee: American Society For Cell Biology

Amount: \$1,534,605.00

Abstract: over the past 40 years, there has been an expansion in our understanding of the world through a scientific lens; however, there is a recognition that we are not fully engaging our scientific talent pool. the faculty research and educational development (fred) program seeks to broaden participation through mentored relationships for postdoctoral scholars and junior faculty members, many of whom are from groups historically and currently underrepresented in the sciences. in addition, given the impact that minority-serving institutions (msis) have on broadening participation in the sciences, the fred program also encourages the participation of faculty members at msis. fred was developed by the minorities affairs committee (mac), a standing committee of the american

society for cell biology (ascb) tasked with addressing issues of historically underrepresented cell biologists. specifically, the fred program matches junior scientists with senior mentors who have demonstrated funding success at research-intensive institutions for a long-term mentoring relationship focused on the preparation and submission of a research or educational grant to an external funding agency. over the past 7 years, 46 historically underrepresented scholars or junior faculty at minority-serving institutions (msis) have participated in the fred program with a funding success rate of 62% and 27% of them receiving more than one award. the fred program is organized with participants attending a career development workshop, participating in a mentored relationship to prepare a proposal, and a mock review panel at the annual ascb conference to review the proposal and provide the mentee comments before submission to a funding agency. the fred-ii program will continue with the mission of improving grant funding success and career development for junior faculty and will implement improved support pathways for fred mentees who are not successful in their first proposal submission and will look to resubmit their proposal. it will continue with the successful implementation of a summer workshop to be held primarily near or at msis. in addition, in alignment with national imperatives in increasing **\*\*diversity\*\*** among faculty, the program will create a pre-fred workshop designed to engage potential fred mentees to develop an applicant pool for future fred workshops. the fred-ii program will continue to support and develop the next generation of research scientists and leaders and broaden their participation in science. the fred-ii program will support junior faculty and postdoctoral scholars through a structured mentored relationship with a senior faculty member. the year-long program will include a summer career development workshop for all fred mentees, monthly mentor-mentee meetings with in-person reciprocal visits to mentor-mentees campuses. fred mentees will develop a proposal with support from their selected mentor and participate in a winter mock review panel hosted at the annual ascb meeting. meetings and reciprocal visits will continue until a proposal is submitted to a federal agency. fred-ii will also include continued participation and additional support for fred mentees who are unsuccessful in securing funding on their first attempt. the fred-ii program will also include

evaluative efforts to inform the leadership of the effectiveness of the program and areas where improvements are needed. overall, the fred-ii program promotes the careers of underrepresented junior faculty and postdoctoral scholars at research institutions and msis through mentorship and grant success. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Belmont Forum Collaborative Research: Abandonment and rebound: Societal views on landscape- and land-use change and their impacts on water and soils (ABRESO)

Awardee: Pennsylvania State Univ University Park

Amount: \$1,531,825.00

Abstract: this award provides support to u.s. researchers participating in a project competitively selected by a 9-country initiative on global change research through the belmont forum. the belmont forum is a consortium of research funding organizations representing over 55 countries focused on support for transdisciplinary approaches to global environmental change challenges and opportunities. it aims to accelerate delivery of the international research most urgently needed to remove critical barriers to sustainability by aligning and mobilizing international resources. each partner country provides funding for their researchers within a consortium to alleviate the need for funds to cross international borders. this approach facilitates effective leveraging of national resources to support excellent research on topics of global relevance best tackled through a multinational approach, recognizing that global challenges need global solutions. this award provides support for the u.s. researchers to cooperate in consortia that consist of partners from at least three of the participating countries. the research teams will work to identify sustainable pathways to help alleviate the increasing and unprecedented pressure on the natural resources that interact to provide sustainable life support systems and essential benefits to societies such as food production and water quality and quantity. the impacts of changes in land management and

urbanization will be evaluated to develop sustainable soils and groundwater management options that will help create and maintain sustainable terrestrial ecosystems. the project seeks to develop a global transdisciplinary platform for understanding the impacts of land abandonment on sustainability of soil and water resources. land abandonment and subsequent land use or land cover change can have profound implications for water resources, as the changing fabric of the critical zone dictates changes in infiltration, runoff, and the delivery of sediment and nitrogen to groundwater and surface waters. the project team will describe social and natural forcing functions that drive land abandonment and subsequent land use change; and quantify impacts on water quality due to this abandonment. the team will also identify gaps in understanding of the impacts and those perceived by stakeholders so that land use change can be better understood and modeled. the team will use this information to develop a modeling framework to assess sustainability of various land use and land abandonment scenarios in the context of the intergovernmental science-policy platform on bio\*\*diversity\*\* and ecosystem services. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Particles, Strings and Gravity in a Dynamical Universe

Awardee: University of California-Berkeley

Amount: \$1,507,000.00

Abstract: this award funds the research activities of professors mina aganagic, raphael bousso, and petr horava at the university of california at berkeley. in the first two decades of this century, we have witnessed dramatic progress in our understanding of the fundamental laws of the universe from the shortest to the largest scales, firmly based on the principles of quantum mechanics (which describes the subatomic world) and general relativity (which describes gravitational forces acting at large distance scales). while string theory may represent the dominant paradigm for unifying these

two principles, many important puzzles and open questions still remain. professors aganagic, bousso, and horava will attempt to provide answers to some of these open questions and puzzles, with the goal of deepening our understanding of the quantum-mechanical universe. specifically, these professors will investigate the properties of quantum-mechanical theories of gravity by using the newly found connection between such theories and the rapidly developing interdisciplinary field of science known as "quantum information theory", as well as by using more traditional methods that have been successful in describing all the non-gravitational forces in nature. the results of this research are expected to have implications for the puzzles associated with the quantum-mechanical behavior of black holes, possible short-distance generalizations of einstein's general theory of relativity, and the structure of the evolving universe at largest distances. in addition, professors aganagic, bousso, and horava will work on the relations of string theory and quantum gravity to pure mathematics. such research is expected to have a broad impact not only in particle physics and cosmology, but also in neighboring areas of physics and beyond. this research thereby advances the national interest by promoting the progress of science in its most fundamental form. the universal nature of this research also serves as an excellent vehicle for supporting the education of young researchers (students and postdoctoral scholars), and provides a natural platform for further increasing **\*\*diversity\*\*** and inclusion in science. more specifically, professor aganagic will develop her program of categorifying quantum knot invariants using little string theory in six dimensions and its low-energy limit known as theory x. she will also pursue categorification of chern-simons gauge theory on general three-manifolds. professor bousso will expand the ads/cft holographic dictionary by studying the kink transform. he will examine the euclidean path integral in semiclassical quantum gravity, using his recently proposed gravity/ensemble duality. in addition, he will attempt to strengthen the quantum focussing condition, and will revisit the notorious measure problem in the landscape cosmology of string theory. professor horava will apply nonrelativistic completions of relativistic quantum field theories to the puzzles of technical naturalness (such as the higgs mass hierarchy problem and the cosmological constant problem). he will work to identify new classes of

short-distance completions of relativistic supersymmetric yang-mills gauge theories in higher dimensions, using nonrelativistic aristotelian supersymmetry at short distances. he will use the recently discovered topological nonrelativistic quantum gravity of perelman's ricci flow to study puzzles of quantum gravity, such as topology-changing transitions and quantum completeness. he will study string theory in its covariant formulation in the novel regime far from equilibrium, as described by the schwinger-keldysh formalism. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RECODE: Functional characterization of human skin organoids

Awardee: University of California-Irvine

Amount: \$1,500,000.00

Abstract: do skin organoid cultures, essentially growing human skin in a dish, accurately reflect how normal skin develops? this project aims to use cutting-edge technologies in biology, engineering, and mathematics to define how human epidermal stem cells differentiate at the single cell level. the major benefits will reveal new insights into developmental biology, adult homeostasis, disease modeling, and provide a platform for preclinical drug testing. new computational tools for analyzing cells at the single cell level will be developed by integrating dynamic modeling with the cell's spatial position to reconstruct how cells transition from one state to another, how they communicate, and how cells interact at the single cell to tissue levels. the broader societal impacts include developing an interdisciplinary training program to enhance research, **\*\*diversity\*\***, and outreach at the interface between mathematical, physical, and biological sciences. a major challenge in organoid biology is defining stem cell states and their interactions that lead to differentiation of the tissue. the goal of this recode project is to define human skin equivalent organoids to address how to faithfully reproduce the differentiation of human epidermal stem cells and generate fully functioning in vitro

stratified human skin. this project will integrate single cell rna-sequencing with spatial imaging data using new mathematical and computational tools applied to primary human epithelial progenitors undergoing active differentiation on engineered substrates in an in vitro organoid culture. novel computational tools will be developed to connect dynamic spatial models with novel data analytics and these tools will reveal transition cell states, cell-cell communication, and cell-cell spatial maps ? three important but underexplored areas in cell fate analysis. the new multiscale models will define when, where, and how human keratinocytes acquire their fates and robustly differentiate to establish stratified epidermis. this recode award is co-funded by the physiological and structural systems cluster in the division of integrative organismal systems and the engineering biology and health cluster in the division of chemical, bioengineering, environmental, and transport systems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Recognizing Science Scholars' Potential through Access and Engagement

Awardee: Saint Paul College-A community & Technical College

Amount: \$1,500,000.00

Abstract: this project will contribute to the national need for well-educated scientists, mathematicians, engineers, and technicians by supporting the retention and graduation of high-achieving, low- income students with demonstrated financial need at saint paul college, an urban community and technical college with a large population of students from populations traditionally underrepresented in stem. over its six-year duration, this project will fund scholarships to approximately 80 unique full and part time students who are pursuing associates degrees primarily in science and engineering technology. students will be awarded up to \$16,000 over up to eight semesters, including summer. the ?science scholar? students participate in relationship-building co-curricular activities: faculty and peer mentoring, science-related campus events and



service-learning activities, and a semester long undergraduate research project. the science and engineering technology a.s. program encourages transfer or entrance to the workforce, so students can work while continuing towards their b.s, degree. the educational research on the effect of the project on student success, experience, and career choice will help inform science education and co-curricular engagement at many two-year schools with a diverse student pool. the overall goal of this project is to increase stem degree completion of low-income, high-achieving undergraduates with demonstrated financial need. the first major objective is to recruit and award scholarships to these students, using internal recruitment strategies and partnerships with area high schools. the project will also increase participation of students from groups underrepresented in stem due to the **\*\*diversity\*\*** in the pool of potential students. the recruitment events at partner high schools will expose high school students to stem career opportunities and solidify a pipeline of students coming to the two-year institution. the scholarship amount is approximately the cost of tuition and fees for a full-time student, so the first expected outcome is the scholarships will increase the number of students completing an a.s. degree. the second objective is to add the relationship-building, co-curricular, high impact practices (hips) to the scholarship program. previous research, mainly performed at universities, suggests scholarships combined with support services increased student success and promote access. hence, an expected second outcome is an increase in retention and student success. the third objective is to perform and disseminate educational research on the effectiveness of the scholarship/hips on student success (course success, retention, and graduation/transfer), science attitudes, and career choice. a mixed- methods approach will link survey responses to student records, and the focus groups will give context to the quantitative data. further, there is a notable gap of applied science education research coming from two-year institutions. the dissemination of the project findings, the third project outcome, will play a small role in closing this gap. this project is funded by nsf's scholarships in science, technology, engineering, and mathematics program, which seeks to increase the number of low-income academically talented students with demonstrated financial need who earn degrees in stem fields. it also aims to

improve the education of future stem workers, and to generate knowledge about academic success, retention, transfer, graduation, and academic/career pathways of low-income students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SCC-IRG Track 2: Toxic-Free Footprints to Improve Community Health against Respiratory Hazards

Awardee: Northeastern University

Amount: \$1,500,000.00

Abstract: fifty years after the passing of the clean air act in the u.s., nearly half of the nation's population is estimated to live with and breathe polluted air in 2020. the recent acceleration in the number and intensity of wildfires driven by climate change and the devastating covid-19 pandemic have made air pollution effects on public health an even more heightened concern. this smart and connected communities project builds and enhances technological, economic, political, and social infrastructures in vulnerable communities to better sense and monitor air quality, prevent exposure to respiratory hazards, and raise awareness of and battle misinformation on air quality. the research aims to build smart and connected toxic-free communities, which resonates with nsf's mission ?to advance the national health, prosperity, and welfare.? the research team collaborates with local grass-root organizations, communities, research centers, and planning agencies in two communities, roxbury, boston, ma and st. john the baptist parish, la. the new technological approaches and air quality data generated by the project along with the deep community engagement will potentially influence and enhance policies and benefit underserved communities with more equitable access to a healthy environment. in this research project, the research team (1) develops data-driven approaches to seamlessly link human mobility (i.e., a person's footprints within and beyond the residential place) and respiratory hazards measured by air quality monitors;

(2) designs real-time ai technologies to connect information and communities that support both network-based interventions; and (3) deploys the methodology in two representative local communities characterized with minority and **\*\*diversity\*\*** both burdened by air pollution. the research focuses on volatile organic compounds (vocs) and particulate matter (e.g., pm2.5) for their known health impacts of causing lung cancers and cardiovascular and respiratory diseases. the key deliverables of work include: (1) a data-driven and real-time ai-based framework that links multi-model data streams (e.g., geolocations, air quality, social networks, etc.) to quantify and predict air pollution exposures associated with human footprints; (2) social network-based interventions strategies developed interactively with and tested by two communities burdened by air pollution (roxbury, boston, ma and st. john parish, new orleans, la); and (3) real-time ai-powered mobile application (app), toxic-free life, for mainstream smartphones that allows real-time estimations of air exposure and supports network-based interventions. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Alternate Pathways to Excellence: Engineering a Transfer-Friendly Experience

Awardee: University of St. Thomas

Amount: \$1,499,997.00

Abstract: this project will contribute to the national need for well-educated scientists, mathematicians, engineers, and technicians by supporting the retention and graduation of high-achieving, low-income students with demonstrated financial need at the university of st. thomas (ust). located in the twin cities, mn, ust is a designated "military friendly school" as well as a recognized "first-gen forward institution" and is known for its high rates of retention (87%) and graduation in four years (68%). over its six-year duration, this project will fund scholarships to 31 unique full-time students, including transfer students, who are pursuing bachelor's degrees in civil,

computer, electrical, or mechanical engineering. low-income, academically talented engineering students who have demonstrated financial need will receive scholarships for up to three years. the alternate pathways to excellence (apex) project will increase the number of engineering transfer graduates by leveraging innovative mentoring practices, advancing engineering-focused **\*\*diversity\*\***, equity, and inclusion efforts, and leveraging ust's partnerships with five local community colleges. the project team also expects to build strong connections with local employers to help achieve the project's goals. support activities for scholars will include a new summer bridge course, monthly seminars to boost skills, and faculty, peer, and industry mentoring. through the apex project, ust will accelerate the engineering department's efforts to advance an inclusive culture by addressing structural limitations that are common in engineering program curriculum, teaching practices, and recruitment efforts. these strategies will have significance for engineering education broadly, and for supporting and retaining transfer students. as a result, the apex project will produce diverse, well-qualified engineers who will meaningfully contribute to fueling innovation in the twin cities region.

to increase stem degree completion of low-income, high-achieving undergraduate transfer engineering students, including students traditionally underrepresented in their participation in stem courses of study and first-generation students, the project leadership will pursue three specific aims. first is to partner with five community colleges to recruit transfer students. second is to retain 90% of scholars each year and graduate 90% of all scholars within 3 years. third is to support at least 95% of graduates to become employed in engineering or enrolled in a graduate degree program within 4 months of degree attainment. apex is grounded in institutional research and knowledge from prior step awards, as well as an understanding of transfer students' unique needs for retention support, including needs to identify scientific mentors and establish a sense of belonging. community college engineering students have been shown to benefit from tailored academic and personal supports that address their unique challenges. however, more investigation is needed to understand how specific interventions such as mentoring, a summer bridge course, and enhanced internships or research can improve engineering transfer student retention. in addition,

there is limited research on the extent to which \*\*diversity\*\*, equity, and inclusion programming for engineering faculty and students creates a scientific community that supports transfer student retention. ust will evaluate and advance understanding of the extent to which these targeted activities contribute to retaining transfer students. results will be disseminated via the keen national conference and website, asee's two-year college division, and submissions to peer-reviewed publications such as the journal of engineering education. this project is funded by nsf's scholarships in science, technology, engineering, and mathematics (stem) program, which seeks to increase the number of low-income academically talented students with demonstrated financial need who earn degrees in stem fields. it also aims to improve the education of future stem workers, and to generate knowledge about academic success, retention, transfer, graduation, and academic/career pathways of low-income students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Biology Opportunities and Scholarships for Success II

Awardee: University of West Alabama

Amount: \$1,499,857.00

Abstract: this project will contribute to the national need for well-educated scientists, mathematicians, engineers, and technicians by supporting the retention and graduation of high-achieving, low-income students with demonstrated financial need at the university of west alabama (uwa). located in rural alabama, uwa is designated as a predominately black institution (pbi) and predominately undergraduate institution (pui). building on the experiences and lessons learned from a prior s-stem award, this project will fund scholarships to 30 unique full-time students pursuing bachelor's degrees in biological and environmental sciences. it will also expand student support services including a summer boot camp to aid with the transition to college life, training to

improve students' study strategies, monitoring students' well-being, and improving their communication skills. scholars will also be involved in peer- and faculty-mentoring, research opportunities, presentations at professional conferences, and participation in field trips. the project plans to increase retention and graduation rates, monitor student success in obtaining jobs or entering graduate school, and measure the significance of the project's services and activities in helping students achieve their goals. the project will advance understanding of the role well-being assessments, metacognitive study strategies, and communication skills in increasing student retention and success. the knowledge generated from this project is of significance to uwa and many other similar higher education institutions. the overall goal of this project is to increase stem degree completion of low-income, high-achieving undergraduates with demonstrated financial need. the biology opportunities and scholarships for success ii project aims to increase participants' persistence in science, success in academic careers, and, ultimately, **diversity** in the scientific workforce. two specific goals serve as driving forces for the project. the first is to increase the enrollment and graduation rates of academically talented students majoring in biological and environmental sciences and improve student success in obtaining jobs or entering graduate programs. the second is to evaluate the role of student support services (boot camp, student's well-being, metacognitive study training, and enhancement of students' communication skills) in improving students' retention and graduation rates. the project will generate knowledge through a mixed methods quantitative and qualitative study that investigates the effectiveness of the project's support services. the work will help to fill a knowledge gap about how the student support services impact students' retention and overall success, particularly on minority students in rural settings. the project will disseminate the generated knowledge via articles in peer-reviewed journals and presentations at regional and national stem education-related conferences. this project is funded by nsf's scholarships in science, technology, engineering, and mathematics program, which seeks to increase the number of low-income academically talented students with demonstrated financial need who earn degrees in stem fields. it also aims to improve the education of future stem workers, and to

generate knowledge about academic success, retention, transfer, graduation, and academic/career pathways of low-income students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: HDR DSC: AI across the statewide curriculum

Awardee: University of Florida

Amount: \$1,498,319.00



Abstract: artificial intelligence (ai) is reshaping the society we live in a profound manner. ai is changing how a nation protects its homeland and population, manages its natural resources and infrastructure, diagnoses and treats diseases, travel, communicates and creates artistic works, etc. ai has the potential to generate tremendous benefits for the society and people. however, the future ai workforce must represent the **\*\*diversity\*\*** of racial, ethnic, gender-identity and socioeconomic backgrounds reflective of the nation as a whole, otherwise, an ai-enabled future society could exacerbate existing disparities and benefit just a few, at the expense of too many. to address such a grand challenge, this dsc award is to train a diverse workforce capable of integrating ai equitably across a broad range of disciplines. the project provides unique ai training to students from any discipline using an approach that integrates classroom education in ai fundamentals, applications and ethics with real-world case studies and research experiences spanning the undergraduate curriculum with a focus on enhancing **\*\*diversity\*\***. by recruiting and retaining historically underrepresented minorities in ai-related education and research, this project helps ensure that a **\*\*diversity\*\*** of backgrounds and opinions are included at all levels of future ai developments and applications, so the ai-enabled society can broadly benefit everyone. to achieve the goal of educating a diverse next-generation ai workforce, this project develops a vertically-integrated curriculum in which students from outside traditional computer-science fields can learn ai-related concepts, skills and ai applications to address critical emerging problems in one's field. over 250 undergraduate fellowships will be created to help eliminate or lessen financial barriers to education. further, between a research university and a historically black college, a strategic partnership provides flexible avenues to engage diverse undergraduates in ai-related education and research. this project develops a core curriculum covering ai fundamentals, ethics and discipline-specific applications that can be deployed across traditional university disciplines and leverages distance-learning to enable students to participate on their own schedule from anywhere with internet. the award also provides unprecedented access to some of the most advanced computational resources in the world while maintaining the flexibility to adapt to a rapidly-changing

field by providing financial assistance supporting the development of new courses and undergraduate research in academic, industry and community studies. it is expected that this approach of integrating "ai across the curriculum" will equip all interested students to equitably engage ai in their chosen discipline. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Fostering Future Engineering Faculty Diversity by Building a Pipeline to Graduate Programs

Awardee: University of Massachusetts Lowell

Amount: \$1,495,564.00

Abstract: this project will contribute to the national need for well-educated scientists, mathematicians, engineers, and technicians by supporting the retention and graduation of high-achieving, low-income students with demonstrated financial need at the university of massachusetts lowell, a r2 public research university with a high percentage of first-generation undergraduate students. over its 6-year duration, this project will fund scholarships to 24 unique full-time students who will be supported for four years from their junior undergraduate year through the completion of a master's degree or completion of their qualifying exam within a ph.d. program. the goal of the project is to create a diverse and competitive pool of students who could become future faculty candidates in engineering by aiding them to explore their interest in these careers and supporting them to prepare and embark on these graduate education pathways. project activities include group-based mentoring meetings with internal and external faculty, safe space cohort building, job shadowing, individual graduate school application support, positive teaching and research experiences, a curriculum to cultivate pedagogical and content knowledge, and a mentorship program (entering research mentoring program; ermp) for first- and second-year graduate students. the project will also employ podcasting as a way to introduce high school

students to stem careers. this project has the potential to significantly increase the number of stem graduates from traditionally underrepresented populations in engineering at the graduate level, and strengthen the pipeline of highly qualified diverse candidates entering careers in higher education. another important broader impact is the project's strong potential to foster social justice educators with core personal and professional beliefs in **\*\*diversity\*\*** and inclusion, which help promote inclusive and equitable environment in higher education to retain a future generation of engineering students. the intellectual merit goal is to better understand the factors that motivate low-income, high-achieving, underrepresented engineering students to persist in the trajectory to engineering graduate programs and future faculty positions in higher education. the project plans to employ a variety of evidence-based interventions that have been used successfully to support students to achieve their career goals. the project will determine whether group-based mentoring and safe space cohort building contribute to low income, high achieving analyze the evaluation data collected from a teaching diverse populations course to advance knowledge about how to cultivate social justice educators. in addition, the project will explore the potential of podcasting as a way for scholars to self-express and explore their interest and confidence in pursuing a faculty career. lastly, the project will examine whether participation in ermp results in positive mentoring relationships, professional identity, research and academic skills, and confidence in pursuing faculty careers. results of this project will be disseminated via presentations at local and national conferences, publications in engineering education journals, a website featuring cohort activities, and podcast episodes targeted to high school students. this project is funded by nsf's scholarships in science, technology, engineering, and mathematics program, which seeks to increase the number of low-income academically talented students with demonstrated financial need who earn degrees in stem fields. it also aims to improve the education of future stem workers, and to generate knowledge about academic success, retention, transfer, graduation, and academic/career pathways of low-income students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review

criteria.

Matched Words: diversity

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Title: Dimensions US-China-South Africa: Establishing genetic, phylogenetic and functional mechanisms that shape microbiome diversity of polar and alpine soils

Awardee: Rutgers University New Brunswick

Amount: \$1,494,294.00

Abstract: microorganisms are the foundations of ecosystems and drive the biology and chemistry in soils, e.g. the conversion of soil organic matter into the greenhouse gases carbon dioxide and methane, as well as nitrogen and phosphorous compounds that can be used by plants. soil microbial community **\*\*diversity\*\*** maintains ecosystem stability and sustainability. understanding the ecology of these microorganisms is one of the most compelling scientific challenges. this project will focus on the microbial ecology of soil ecosystems in the arctic, antarctic, and tibetan plateau. these ?tri-polar? soils are chosen for study as they are disproportionately impacted by climate change and predicted to show increased microbial activity and enhanced turnover of soil organic matter in the future. while microbes excel at adapting to environmental change, the functional implications of microbial community transitions remain to be characterized. laboratory- and field-based approaches will identify microorganisms that are successful in these ?tri-polar? soil ecosystems and why, i.e., which bacterial species/strains are successful and what functional traits make them successful. understanding how soil ecosystems respond in these polar regions is critical for evaluating the controls of biogeochemical cycling and clarifying microbial feedbacks in a changing world. this project will assemble an international team and recruit young scholars to reflect a blend of expertise in microbiology, ecology and environmental sciences. research will be integrated with educational activities by involving samples and data into hands-on classroom training at the k-12, undergraduate, and graduate levels. this project will delineate mechanisms that lead to diverse soil microbial communities that are hallmarks of stable and sustainable soils. we lack predictive

understanding of mechanisms that regulate and maintain microbial bio\*\*diversity\*\* and how this relates to biogeochemically relevant microbial functions. integrative approaches are needed to identify the principles that shape and maintain this bio\*\*diversity\*\*. this project combines genetic, phylogenetic, and functional dimensions of bio\*\*diversity\*\* to probe factors that shape the "morass of \*\*diversity\*\*" of soil systems. the overarching hypothesis is that resource partitioning, selective predation, and temporal separation of activity each contribute to the success of particular bacterial strains/species in polar and alpine systems. the international research team will focus on testing these hypotheses in soils across arctic, antarctic and tibetan plateau habitats with the acidobacteria as a model microbial phylum for study. laboratory- and field-based approaches will be linked to describe the genetic, phylogenetic and functional \*\*diversity\*\* the acidobacteria, one of the most ubiquitous but elusive bacterial phyla found in terrestrial ecosystems around the globe. the study will identify their ecosystem functions in soils, their interactions with other microbes, their adaptations to environmental stress such as climate change, and will assess their in situ dynamics and activity. integration of these data will address which organisms compete for resources, avoid predation, and ultimately, occupy fundamentally distinct niches in these ecosystems. elucidating these equalizing/stabilizing mechanisms can begin to explain the tremendous bacterial \*\*diversity\*\* observed in soil microbiomes. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Improving Educational Outcomes at Two-Year Colleges through Mentorship, Support Services, and Equitable Classroom Practices

Awardee: College of the Canyons

Amount: \$1,493,379.00

Abstract: this project will contribute to the national need for well-educated scientists,

mathematicians, engineers, and technicians by supporting the retention and graduation of high-achieving, low-income students with demonstrated financial need at college of the canyons. as a two-year, hispanic serving institution (hsi) located in southern california, the college seeks to increase enrollment and graduation rates among stem majors within student populations that are underrepresented in their participation in stem fields of study, including black, latinx, female, first-generation, english language learner, and low-income groups. over its six-year duration, the project will fund scholarships to 100 unique full-time students pursuing associate degrees in biology, biological sciences, computer science, engineering, environmental science, mathematics, and physics. academically talented stem students who complete scholarship applications and demonstrate financial need will receive two-year scholarships. the project builds upon the college's successful mathematics, engineering, and science achievement (mesa) program to provide stem students with access to academic, social, and cultural capital. one of this project's distinguishing features is well-defined mentoring relationships between students and faculty aimed to increase student engagement in stem coursework and career exploration. faculty will also engage in activities designed to help them create inclusive learning environments that lead to culturally responsive and equitable stem classrooms. the project team hypothesizes that these additional supports will promote the development of positive stem-related identities among students and thereby improve retention, transfer, and success rates. this project has the potential to broaden stem participation among college of the canyons' large underrepresented and disadvantaged student population. to enhance retention, transfer, and success rates in stem among underrepresented populations, this project will explore the impact of meaningful student-faculty mentorships and culturally responsive classrooms in two-year institutions. the overall goal of this project is to increase stem degree completion of low-income, high-achieving undergraduates with demonstrated financial need. the project will create and embed a framework for enabling meaningful faculty-student mentorships within the context of a two-year institution, and empower faculty to incorporate equitable and culturally-responsive teaching elements into their stem classrooms. the project will investigate the

impact campus-wide of these interventions on the retention and success of students who remain underrepresented in stem. the knowledge gained will advance the understanding of how to successfully apply these concepts within the scope of a two-year college setting while emphasizing **\*\*diversity\*\***, equity, and inclusion. the anticipated outcomes include an increase in retention rates of stem students from underrepresented backgrounds, higher rates of graduation and transfer of stem students to four-year institutions, the inclusion of more equitable and supportive educational practices, and the upscaling of student support services by coordinating with mesa and other programs. college of the canyons will use both qualitative and quantitative measures to evaluate and monitor persistence, retention, graduation, and transfer rates for scholarship recipients and the general stem student body. the college seeks to disseminate the project?s findings to other institutions through the what works clearinghouse and other media including electronic news media, journals, news articles, stem industry publications, social media, print publications, and conference presentations. this project is funded by nsf?s scholarships in science, technology, engineering, and mathematics program, which seeks to increase the number of low-income academically talented students with demonstrated financial need who earn degrees in stem fields. it also aims to improve the education of future stem workers, and to generate knowledge about academic success, retention, transfer, graduation, and academic/career pathways of low-income students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity  
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Title: HDR DSC: Data Science for Energy Transition

Awardee: University of Houston

Amount: \$1,493,016.00

Abstract: with the growing public awareness of climate change, houston, the energy capital of the world, is undertaking efforts to lead the energy transition for a more sustainable and cleaner

environment. there is urgent demand for a data science workforce equipped with broad understanding for optimizing conventional energy and leading the energy transition. this project focuses on training undergraduates and masters-level students from diverse backgrounds to achieve a wide range of knowledge and skill sets essential for the future energy industry workforce. five major public universities in greater houston are teamed up with multiple energy industry partners, ranging from large oil and gas companies to startups on energy sector data analytics. given the emphasis of participating universities on **diversity** and equity and the diverse student populations they serve, this project broadens training opportunities for groups historically underrepresented in science, technology, engineering, and mathematics (stem). statisticians, computer scientists, geophysicists, and social scientists at the university of houston (uh) main campus, uh-downtown, uh-victoria, uh-clear lake, and sam houston state university are collaborating to develop year-long educational activities under the theme of energy transition, from traditional oil-and gas-related problems to renewable energy. the curriculum contains an array of important topics including fundamental science and engineering understanding, essence of statistics and machine learning methods, and practical skill sets of programming and data visualization. social science aspects on the energy transition and its implications for society are also included in the curriculum. the program consists of: (1) five-week summer boot camps with educational modules on statistics/machine learning, cs/programming, geophysics and earth sciences, public policy, and engineering; (2) advanced courses and micro-credential training offered by participating universities in the following fall semester; (3) semester-long team research projects on problems provided by industry partners in the spring semester; and (4) summer internships and/or conference presentation opportunities to conclude the program. each year, about 40 students participate in the program, totaling about 120 student participants over 3 cohorts. a framework in which research projects can be carried out is developed. the project also promotes interaction and collaboration between academia and industry in the region, opening up more opportunities for education and research collaboration. all project data is well documented and made freely available. the student and



program-level outcomes are formally assessed, with results disseminated through publication in peer-reviewed journals and conference presentations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NRI: Robust and Efficient Physics-based Learning and Reasoning in Degraded Environments

Awardee: Rutgers University New Brunswick

Amount: \$1,490,276.00

Abstract: this project will perform fundamental research into developing and integrating physics-driven reasoning and planning techniques to enable autonomous robots to manipulate unknown irregular objects and navigate in unstructured, dynamic environments. the developed techniques will be deployed on robomantis: a four-legged, wheeled robot that can assist in first-response missions. the project will fill the important gap between existing research on learning models of unknown objects from data and research on developing adequate simulation tools for robotic manipulation and locomotion by answering three fundamental questions: 1) how to efficiently simulate the effects of robotic actions on objects with uncertain models? 2) how to use physics simulation tools to plan manipulation and locomotion strategies for navigating in unstructured terrains? and, 3) how to learn physical models of objects on the fly? the project builds on top of progress in computer vision, physics simulation, and planning, towards developing an efficient toolset for robotic navigation in rubble. the main technical objectives of this project are to: 1) develop physics simulation tools that can be used for efficiently inferring models of both rigid and non-rigid objects and for robust planning, 2) develop optimization tools for learning models of objects from limited vision and interaction data, 3) develop manipulation and navigation algorithms that can leverage the learned models, and 4) demonstrate the fully integrated system on a diverse range of tasks related to search and rescue operations, such as manipulating unknown objects in clutter and

navigating in rubble. the project will adopt a bayesian approach where models of objects that are typically found in piles of rubble, such as debris and rocks, will be inferred from a few rgb-d images providing partial views of the scenes, and also from their responses to forces applied by the robot during locomotion and manipulation actions. hypotheses of various models will be used to simulate the effects of the exerted forces on the objects. models that best reproduce the observed effects of the forces will be given the highest probabilities. the inferred models will then be used to plan robust manipulation and locomotion actions that allow the robot to clear its way and advance through a pile of debris. the project brings together an interdisciplinary team of investigators who have expertise in computer vision, physics simulation and planning. implementations of the developed solutions will be provided to the research community as open-source software packages. this will be coupled with the generation of educational material, especially programming assignments on manipulation challenges that require physics reasoning, which will be shared with the academic community. the material will aim to attract undergraduate students early in their studies to stem by using hands-on experience that can be provided with the use of robotics, while also exposing them to foundational methods and data-driven tools. when appropriate, efforts will be made to introduce the research, in particular the hardware demonstrations, to k-12 students to cultivate their early interests in robotics, which touches all aspects of stem. in the process, the pis will aim to leverage **\*\*diversity\*\*** programs at rutgers university to recruit and support underrepresented groups. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Just add water? Investigating RNA stability in desiccated soil bacteria.

Awardee: University of Arizona

Amount: \$1,466,520.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public

law 117-2). dryland soils are home to complex microbiomes that mediate processes crucial to human and planetary health, including water sustainability, soil fertility, food security, bio\*\*diversity\*\*, and variability in atmospheric co2 concentrations. drylands are particularly sensitive to the effects of drought; about 20% of global drylands are classified as "degraded" or "marginal," with an annual cost of ~\$300 billion. soil microbes persist in dry soil by entering desiccation-induced microbial dormancy. the mechanisms that allow dryland microbes to enter and exit desiccation-induced dormancy are poorly understood. this research project investigates how different groups of bacteria tackle the problem of surviving desiccation. the soil bacteria that will be investigated are abundant mediators of soil carbon cycling and agricultural health in drylands. thus, studying the mechanisms of desiccation tolerance in soil bacteria can influence decisions about how to prevent or rehabilitate degraded dryland ecosystems. the results can also lead to new methods to measure how agricultural practices focused on reducing irrigation will affect the microbes that regulate soil fertility. the project aims to attract, train, and retain undergraduates that are historically excluded in stem fields as part of a larger vision to build a diverse american stem workforce. the research aims will be conducted by students conducting authentic course-based research on drought?a topic of global and local importance. a mentorship training program will educate graduate students in effective mentorship and provide them with authentic mentorship experience. microbes in dry soils face extreme stress from increases in temperature and drought that lead to severe soil drying. although non-spore forming soil bacteria in drylands can persist without water for months at a time through desiccation-induced dormancy, the molecular systems that control the tolerance and resiliency to prolonged desiccation are largely unknown. specifically, the effects of drying on rna?the labile molecular bridge between genetic information and functional protein?are virtually unexplored. the hypothesis that water availability regulates rna stability, which in turn controls desiccation tolerance will be tested. to test this hypothesis, the primary investigator and a team of research students will quantify the relationship between desiccation tolerance and rna stability in cultures of diverse soil bacteria by 1) measuring the desiccation tolerance of non-spore forming soil bacteria; 2)

relating desiccation tolerance to mrna activity after drying; and 3) calculating the gene-resolved rna half-lives in desiccated and rehydrated soil bacteria. determining the molecular controls of bacterial desiccation tolerance is vital to understand dryland vulnerability ahead of visible aboveground changes and will inform development of soil inoculants better suited to drought-impacted agricultural systems. the primary investigator and student research teams will explain how the stability of different rnas influence desiccation tolerance in diverse soil bacteria with course-based research activities. the primary investigator will apply an innovative graduate student mentorship training program that connects historically excluded graduate and undergraduate students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Culturally Responsive, Affective-Focused Teaching of Science and Mathematics

Awardee: University of Florida

Amount: \$1,448,590.00

Abstract: students and professionals who identify as black, indigenous, or people of color (bipoc) continue to be underrepresented in stem fields. broadening participation in stem requires a change in how k-12 stem teachers engage and educate students who identify as bipoc. research has demonstrated that cultural and social justice connections can lead to positive academic outcomes for students who identify as bipoc in science and mathematics. this project will provide a field-based science and mathematics teacher education program that supports teaching focused on students' affective development through culturally responsive practices. in this project, affective development is defined by students' abilities to incorporate their science and mathematics learning into their own unique personal value systems. the project's field-based teacher education program takes place over a two-year period and models how culturally responsive and affective instruction can occur in the stem classroom to engage students. the project participants include 48 secondary science and

mathematics teachers who work with about 5300 students in a district with some of the most persistent and pronounced educational equity issues in the state of florida. the associated research will have implications for theory and practice that can be extended to improve stem educator development in schools and districts throughout the country. this aligns with nsf's commitment to advancing k-12 student and teacher learning in the stem disciplines through research-based design and development of innovative models. using design-based implementation research, this project will accomplish the following objectives: (1) transform the practices of a district-wide set of 48 secondary science and mathematics teachers by equipping them with culturally responsive, affective-focused practices and leadership skills; (2) construct tools and resources that will serve as open-access professional development materials shared widely via learning management tools; and (3) develop an evidence-based and adaptable theory of change to share widely with the stem education community. the research plan draws on both qualitative and quantitative research methods to study the experiences and changes of science and mathematics teachers and their students as they experience continuously refined versions of the teacher education model. in particular, this project focuses on studying teacher and student outcomes, including teachers' culturally responsive, affective-focused practices and self-efficacy, their understanding of student values and cultural backgrounds, and their attitudes toward cultural \*\*diversity\*\*; growth in students' affective development and stem achievement, their interest in stem careers, and stem identity development. answers to the research questions will provide empirically-driven means for developing both the practical tools and the theoretical models of change toward stem teacher transformation and positive impacts for students who identify as bipoc. the discovery research prek-12 program (drk-12) seeks to significantly enhance the learning and teaching of science, technology, engineering and mathematics (stem) by prek-12 students and teachers, through research and development of innovative resources, models and tools. projects in the drk-12 program build on fundamental research in stem education and prior research and development efforts that provide theoretical and empirical justification for proposed projects. this award reflects nsf's

statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SCC-IRG Track 2: The "Community Tech Workers": A Community-Driven Model to Support Economic Mobility and Bridge the Digital Divide in the U.S.

Awardee: Regents of the University of Michigan - Ann Arbor

Amount: \$1,435,769.00

Abstract: information and communication technologies allow individuals to apply for benefits like health care and housing, to have groceries delivered to their homes, to schedule/attend healthcare appointments, and to apply for employment. however, digital inequalities in terms of access, use, and self-efficacy reflect offline socioeconomic inequalities and pose a serious threat to today's increasingly tech-reliant society. the digital divide is a multidimensional phenomenon that refers to three levels of differences: first, in who has access to the internet; second, who has skills to use the internet; and third, how the internet is actually used. many efforts to bridge the digital divide have failed because they only address the first level (e.g., providing public wifi, computers, computer labs) without continued onboarding and training support. this project aims to address digital disparities in southeast michigan by leveraging and building the digital literacy of local experts (level 2) to provide digital support to communities (levels 2 and 3). inspired by the transformative community health worker model, this work proposes "community tech workers" (ctw), a community-driven, "train the trainer" approach that promotes digital literacy in communities. participants include a public housing authority in detroit's eastside neighborhood, a refugee resettlement agency that serves refugees in a public housing community in ypsilanti, an advisory board consisting of local workforce development agencies and industry representation, and a steering committee of individuals who are involved in outreach, education, and interventions related to increasing digital proficiency and public health. the research will (1) develop and validate a survey instrument measure to assess community digital

capacity; (2) develop an initial ctw training program; (3) assess the training, learning experience, and impact of the ctws within each community; and (4) capture and evaluate the economic value of the ctw model. the survey instrument will extend existing assessments for measuring individual digital capacity to create a novel instrument that measures digital capacities at a community grain size. this instrument will be validated across two communities, and then be used to measure the impact of the ctw activities on the two communities over time. ctw training activities will be evaluated via interviews with participants and observations of the training sessions. recommendations for a credentialing system to document ctw proficiency and for a marketplace system to promote employment opportunities will be elicited via participatory co-design sessions, information which can be used to inform integration with or development of job recommendation and gig work applications. finally, data on costs will be collected to generate a cost-benefit analysis of the ctw model, to explore its further scalability. secondary outcomes of the work include providing local residents with free training to obtain the necessary skills to become a ctw, and in the future, temporary employment for selected tech workers and connections to local it employment opportunities. incorporating the model across multiple communities will help uncover generalizable requirements for creating equitable socio-technical infrastructures that support community digital capacity and expand local opportunities. this systemic perspective on the development and deployment of the ctw model aligns well with the goal of the nsf smart and connected communities (s&cc) program, which is to accelerate the creation of the scientific and engineering foundations that will enable smart and connected communities to bring about new levels of economic opportunity and growth, safety and security, health and wellness, accessibility and inclusivity, and overall quality of life. this project is also supported by the improving undergraduate stem education program, which seeks to support projects that have high potential for broader societal impacts, including improved **\*\*diversity\*\*** of students and instructors participating in stem education, professional development for instructors to ensure adoption of new and effective pedagogical techniques that meet the changing needs of students, and projects that promote institutional partnerships for collaborative research and

development. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Building a Youth-Led Learning Community through Automating Hydroponic Systems

Awardee: Boston College

Amount: \$1,414,733.00

Abstract: in this project, youth will apply scientific and computational science concepts and practices by learning to create and build automated systems where they can grow their own food. these specialized growing systems will utilize hydroponics where plants are grown without soil. computational science is an interdisciplinary area that combines skills and knowledge from science, computation, computer science, engineering, and mathematics to solve problems. the prevalence of computational science in industry and everyday lives necessitates the development of a stem workforce knowledgeable to solve complex real-world problems. researchers will train high school youth to program low-cost micro-controllers to collect data and use that data to automate hydroponic systems. to support the high school youth's interest in obtaining a post-secondary degree, they will be mentored by first-generation college students from alumni of boston college's college bound program and lasell university's pathways to **\*\*diversity\*\***. this project will study ways to design an internal learning environment that promotes youth skills and interest in pursuing stem careers. utilizing a design-based research framework and drawing upon a mixed-method data collection approach including observations, surveys, interviews, and youth generated artifacts, the project team will explore how and in what ways the use of physical computing coupled with computational science improves youth interest and knowledge to pursue stem careers. survey data will be analyzed by first evaluating the measurement quality of the latent variables using confirmatory factor analysis and then using latent variable growth modeling to assess changes in repeated measures for four time points. the research and evaluation work will track 500 youth and their families over

time and evaluate what aspects of the program are critical to youth success and stem career self-efficacy and awareness. this work offers an approach to support youth in examining careers across fields of agriculture, computation, and science teaching. this project is funded by the innovative technology experiences for students and teachers (itest) program, which supports projects that build understandings of practices, program elements, contexts and processes contributing to increasing students' knowledge and interest in science, technology, engineering, and mathematics (stem) and information and communication technology (ict) careers. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Increasing STEM Persistence by Supporting Apprentice Research Experiences (AREs) as a Model for Institutional Change in Community Colleges

Awardee: Wake Technical Community College

Amount: \$1,399,976.00

Abstract: this project aims to serve the national interest by iteratively assessing and improving the stem academic research and training (start) program, an apprenticeship research experience (are) at wake technical community college. the project will contribute to understanding the effects of are - especially uncommon and understudied at 2-year colleges - on community college students?

persistence in college and in stem careers. this project will develop a sustainable model for co-curricular apprenticeship-style mentored undergraduate research programs and help build the case for state and donor funding for undergraduate research experiences and internships at community colleges across north carolina. the project will enhance a current program, recruit students from populations underrepresented in stem, and further develop relationships with numerous research partners. by supporting students with paid internships, the project will increase access to stem careers for low-income students. training modules for mentors and students will also be developed. the project offers a distinct opportunity to recruit underrepresented minorities and first-generation college students into stem research and prepare them for successful academic and professional careers.

the project goal is to develop a sustainable and scalable undergraduate research and internship program model for 2- and 4-year colleges to partner in undergraduate research. such partnerships are expected to foster student success in transfer and persistence in bachelor's degree programs in stem. funds will support approximately 50 student interns each semester resulting in 400 paid internships over the course of the project. this project will develop a community of inquiry (coi) framework-based model for strengthening undergraduate research experiences in the community college context. the project will utilize a randomized controlled trial that meets the "what works clearinghouse" standards, and includes research questions on the impact of participation in start undergraduate research on student outcomes, e.g. retention and persistence in college and in stem fields, academic confidence, student identity and awareness, and scientific literacy and research skills. furthermore, the research questions examine the impact of start on the college, e.g. the impact on the **diversity** of student participation in stem fields, the skills and comfort of mentors in engaging in mentoring activities, and the institution's support for mentors and research. the external evaluator and project faculty will prepare manuscripts of findings for publication and disseminate them via national conferences, reaching audiences of both practitioners and researchers. academic partners include north carolina agricultural and technical state university, the university of north carolina at chapel hill, and north carolina state university. by

creating undergraduate research and internship opportunities for community college students the project is a model to build the stem pipeline. funding for this project comes from the advanced technological education program through the program description on advancing innovation and impact in undergraduate stem education at two-year institutions of higher education (pd 21-7980) which promotes innovative and evidence-based practices in undergraduate stem education in the community college sector. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EDGE CMT: Origin and diversification of butterfly color patterns

Awardee: Cornell University

Amount: \$1,390,000.00

Abstract: when we look across the **\*\*diversity\*\*** of life, we see many complex traits that are unique to certain groups of organisms. feathers in birds, hair in mammals, and flowers in angiosperms, for example. it is a major question in biology how these kinds of novel traits first appear. what is the genetic basis of newness? recent work across many species has shown that novel traits such as these are largely generated by old genes that have been repurposed for new roles. novelty appears to emerge through a reshuffling of older genetic building blocks, which are proposed to be ancient subnetworks of interacting genes. but where do these gene networks come from in the first place? and how are they rewired to generate complex new traits? with this funding, reed and colleagues are beginning to address these questions by looking at the origin of color in butterflies. they are characterizing the gene networks that underlie color pigmentation in butterflies, and they are determining how specific genetic changes caused these networks to be repurposed from ancestral roles in processes such as neural development, to make butterfly wing patterns. this work serves as a case study to help biologists understand the developmental genetic mechanisms that underlie the

genesis and diversification of complex biological traits. the project also includes training in biology research skills of graduate and undergraduate students from diverse backgrounds, the development and dissemination of instructional videos for genomic methods, and the establishment of a web-based resource for functional genomics in butterflies. a core concept in modern biology is that novel morphological traits originate from gene regulatory networks that predate the traits themselves. surprisingly, however, little is known about the specific genetic mechanisms that underlie the origin and repurposing of such gene networks. with this funding, reed and colleagues develop the regulatory network encompassing the butterfly color pattern gene *optix* into a model for exploring the regulatory architecture of trait diversification. *optix* is a homeobox transcription factor that plays a deeply ancestral role in neural and retinal development in both invertebrates and vertebrates. in butterflies, however, this gene underwent a radical co-option event where it gained a novel function as a master regulator of wing pigmentation, including playing key roles in adaptation and mimicry. thus, the researchers have a situation in lepidoptera where they can pinpoint the phylogenetic timing of a major *optix* co-option and repurposing event, where this gene appeared as a *de novo* regulator of color patterns. reed and colleagues are leveraging this opportunity to take a multi-species comparative approach to characterize the history of the *optix* regulatory network as it gained its novel adaptive function in color pattern regulation. using *optix* as the focal point, they are characterizing the cis-, upstream, and downstream regulatory dynamics of regulatory co-option, and construct a comprehensive case study of how a new gene regulatory network can emerge from the genome to generate new morphological features ? in this case, color itself. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Applying Student Knowledge for Success in Cybersecurity and Data Science

Awardee: New Jersey Institute of Technology

Amount: \$1,384,756.00

Abstract: this project will contribute to the national need for well-educated scientists, mathematicians, engineers, and technicians by supporting the retention and graduation of high-achieving, low-income students with demonstrated financial need at kean university, the new jersey institute of technology, fairleigh dickinson university, brookdale community college, and union county college. in particular, it responds to areas of national need in cybersecurity and data science by increasing the number of students graduating in computer science (cs) and information technology (it). moreover, the project will build regional workforce strength and contribute to the knowledge base on the role of student competence and belonging in ensuring persistence to degree attainment. over its five-year duration, a total of 256 students will benefit, receiving scholarships to complete cs or it degrees. project components include scholarship support for students, undergraduate research and/or professional experience opportunities prior to graduation, and

generation of new knowledge through research on economic realities for students and impact on career trajectories in cybersecurity and data science. students in this program will be prepared to enter the scientific workforce or graduate school as competent, highly trained individuals with a background in teamwork and research. furthermore, they will contribute to increased professional **\*\*diversity\*\*** in the fields of cs and it, and serve as role models to members of their communities.

the students recruited for this program will participate in workshops, take advantage of cohort experiences, and interact closely with faculty who will provide i) academic advising, ii) guidance for navigating higher education and postgraduate opportunities, and iii) supervision of teamwork, research, and working professional experiences. through undergraduate research opportunities and experiences from participation in faculty research programs and/or existing summer research and internship programs, these individual and cohort experiences will provide a basis for overall intellectual growth and promote increased student confidence, retention, and timely degree completion. these academic outcomes are in turn expected to allow students to successfully navigate common attrition points including financial hardship and professional identity development for post-graduate employment and continued education. the project's academic environment includes student-faculty advising and undergraduate research activities, using the affinity research group (arg) model and peer-mentoring. the use of teamwork, collaboration and student-motivated question and answer sessions will positively support research in the field of computer science and information technology regarding educational impact and retention, particularly for minorities, female, and first-generation students. this project is funded by nsf's scholarships in science, technology, engineering, and mathematics program, which seeks to increase the number of low-income academically talented students with demonstrated financial need who earn degrees in stem fields. it also aims to improve the education of future stem workers, and to generate knowledge about academic success, retention, transfer, graduation, and academic/career pathways of low-income students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review

criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: George Washington University

Amount: \$1,371,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: WINTRE-MIX: Winter Precipitation Type Research Multi-scale Experiment

Awardee: SUNY at Albany

Amount: \$1,369,548.00

Abstract: during near-freezing weather conditions, a **\*\*diversity\*\*** of surface precipitation types are possible, including: rain, drizzle, freezing rain, freezing drizzle, wet snow, ice pellets, and snow. such near freezing precipitation affects wide swaths of the united states and canada, impacting aviation, road transportation, power generation and distribution, winter recreation, ecology, and hydrology.

this award is for a field experiment, named the winter precipitation type research multi-scale experiment (wintre-mix) with the overarching goal of improving understanding of how a variety of processes influence the variability and predictability of the type and amount of precipitation that falls during winter weather events. the project has direct societal impact through the potential for improved forecasting of these events. additionally, the project will have significant student involvement, public outreach events, and citizen science participation. the wintre-mix campaign will be conducted in southern quebec, canada and northern ny and vt in the united states. the canadian national research council convair-580 research aircraft and the university of illinois mobile radars will be deployed along with a host of surface-based instrumentation in february and march of 2022 to make observations that can be used to determine the thermodynamic, dynamic, and microphysical processes that interact to determine near-freezing precipitation type. more specifically, the project has three overarching scientific questions that will be addressed using observations, analysis, and modeling: 1) how do mesoscale dynamics modulate near-freezing precipitation, 2) how do microscale processes modulate near-freezing precipitation, and 3) how do multi-scale processes combine to determine the predictability of near-freezing precipitation? this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: WINTRE-MIX: Winter Precipitation Type Research Multi-scale Experiment

Awardee: SUNY at Albany

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Matched Words: diversity

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Title: Democratizing Access to the Emerging Interdisciplinary Tech Workforce for Low-Income Science Majors

Awardee: Temple University

Amount: \$1,323,467.00

Abstract: this project will contribute to the national need for well-educated scientists, mathematicians, engineers, and technicians by supporting the retention and graduation of

high-achieving, low-income students in the college of science and technology (cst) at temple university. in particular the project intends to provide 96 scholarships to support 32 unique scholarship recipients to support the completion of stem degrees in chemistry, biology, physics, mathematics, and earth and environmental sciences coupled with a minor in information science. the driving force behind the project team's efforts is to democratize access to economic opportunities in the technology-focused stem workforce for high-achieving, low-income students. lack of knowledge and skills in information sciences can be a barrier to workforce competitiveness and to economic mobility for low-income students. to overcome this barrier, the project leaders have identified intentional, multidisciplinary academic pathways that provide high-achieving, low-income students with the ability to focus on their chosen primary stem major, such as biology or earth science, in combination with specialized study in information science. such integrated academic pathways align with emerging needs for scientists to have more knowledge and skills in information science to collect, represent, analyze, and discover meaningful models by applying computational solutions to large data sets. the project hypothesizes that providing financial support to explore pathways for integrated study of stem and information science, supported through cohort-based curricular and co-curricular activities, can ultimately lead to higher stem degree attainment and workforce entry among low-income students. through this project, researchers will develop and implement a model program that supports students from low-income backgrounds to complete academic degree programs with clearly identified academic pathways that promote degree attainment for undergraduate stem majors and add value through integrated study of information science. the approach builds on evidence-based practices that have been shown to positively impact individual student outcomes; program elements are designed to emphasize connections across disciplines, integrate socially relevant applications of content knowledge, connect to professional practices, and develop identity and community through service-learning projects. additionally, the program is also designed to broaden participation of underrepresented groups in computing, with program elements that implement evidence-based approaches for **\*\*diversity\*\***,

equity, and inclusion in stem education. the project will advance knowledge about the perceptions of stem majors in choosing to pursue integrated academic pathways, as well as the impact on academic and workforce preparation for stem students who complete such pathways. this project is funded by nsf's scholarships in science, technology, engineering, and mathematics program, which seeks to increase the number of low-income academically talented students with demonstrated financial need who earn degrees in stem fields. it also aims to improve the education of future stem workers, and to generate knowledge about academic success, retention, transfer, graduation, and academic/career pathways of low-income students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: ADVANCE Partnership: Building Community Understanding of the Institutional Compensation System

Awardee: Rochester Institute of Tech

Amount: \$1,314,681.00

Abstract: this project aims to significantly expand knowledge of best practices for faculty compensation to a broader community in higher education and provide critical insights to guide compensation practices. salary outcomes and pay practices are closely related to the quality of work life and inform our knowledge of what (and who) is important to the organization. in this domain, institutional structures and systems of power are influential. women consistently earn less than men, even when controlling for demographic and background variables; a wage gap that increases for women of color. in higher education, this gap persists among faculty, particularly at institutions with the highest levels of research. this project's objective is to improve institutional understanding and influence actions regarding pay equity through broader comprehension of compensation structures. project activities have three aims: first, engage administrative units (human resources, institutional research, **\*\*diversity\*\***/inclusion, legal, and academic affairs) in a collaborative relationship supported by university leadership. second, enhance pay decision-makers' understanding of and basis for pay decisions, and their ability to communicate to individuals how their pay is determined. third, increase faculty knowledge of institutional pay practices while emphasizing the importance of inclusion and institutional values. expected outcomes from this work include improvements in institutional policies and practices, faculty perceptions of pay equity, leadership skills of pay decision-makers, and institutional engagement beyond the project partners. the project involves collaborations with three university partners villanova, drexel, and gallaudet, the american

association of university women (aaup), and the nsf includes hub and the aspire alliance. the three partner-universities will undertake actions to: promote an inclusive work environment and informed faculty community that understands its financial model about compensation; align university resources with institutional values to promote enhanced equity; and support systemic, sustainable change through institutionalization of compensation interventions. the project will employ a multi-frame organizational analysis approach, integrating structural, human resource, political, and symbolic aspects of organizational theory, to better understand each partner-university. the partner cohort will explore multiple dimensions of justice regarding salary ? distributive, procedural, interpersonal, and informational ? through workshops, coaching sessions, and organizational action plans. ongoing formative assessment will include input from women of color and deaf and hard-of-hearing women. the project's reach will expand to additional institutions through the partnerships with the american association of university women, nsf includes hub, and the aspire alliance. expected outcomes include implementation of compensation-related accountability measures, improved faculty understanding of pay practices, increased comprehension of equity among salary decision-makers, and infrastructure changes to support ongoing progress. the nsf advance program is designed to foster gender equity through a focus on the identification and elimination of organizational barriers that impede the full participation and advancement of diverse faculty in academic institutions.? organizational barriers that inhibit equity may exist in policies, processes, practices, and the organizational culture and climate.? advance "partnership" awards provide support for projects that scale-up evidence based systemic change strategies to enhance gender equity for stem faculty regionally or nationally. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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## System

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Matched Words: diversity

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Title: Global Sustainability Scholars for Sustainable Oceans: building a network of transdisciplinary scientists and practitioners that represent humanity?s future.

Awardee: University of Colorado at Boulder

Amount: \$1,312,490.00

Abstract: humanity faces profound challenges in the 21st century. from a rapidly rising population, a warming climate, increased demand for food, fiber, and water, and a rapid loss of bio\*\*diversity\*\*

and ecosystem services, we face environmental problems that are more pervasive and serious than at any time in our history. the global ocean plays a critical role in the earth system affecting atmospheric, geochemical, ecological, and social systems in a multitude of interconnected ways. to predict changes, understand their impacts on natural and social systems, and develop approaches that allow us to adapt to and mitigate the impacts, requires more integrative approaches to the study of ocean systems, and this, in turn, will require large-scale cooperation across disciplinary, cultural, and national boundaries. accordingly, the next generation of sustainability leaders will require a broad set of skills to engage in inter- and trans-disciplinary teams to solve the complex environmental issues that face humanity. this project seeks to develop the next generation of international trans-disciplinary sustainability science leaders through a collaborative fellowship program that connects undergraduates, graduate students and post-doctoral researchers with today's trans-disciplinary sustainability science leaders. using a cohort model, the participants work with international, transdisciplinary research teams on ocean sustainability projects funded by the belmont forum, over the course of several field seasons. through these research opportunities and training experiences, the program seeks to provide the participants with trans-cultural, trans-disciplinary, and trans-national cooperative opportunities which will be essential in generating and applying knowledge to actions that speed the transition toward a more globally sustainable future. the program seeks to help the participants be nimble and fluent across research disciplines, and to develop collaborative leadership, communication, and negotiation skills. the project will provide opportunities for students and researchers from underrepresented groups to engage in transdisciplinary, team-oriented, international science with direct relevance to some of the most challenging issues in ocean sustainability. engaging over several consecutive field seasons, will further build community that is likely to last well beyond the lifetime of the project and help generate the diverse workforce of the future. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Sustaining The Utqiagvik Aerosol Record of Decades (STUARD)

Awardee: University of California-San Diego Scripps Inst of Oceanography

Amount: \$1,299,527.00

Abstract: the arctic is warming faster than any other place on earth, with sea ice declining rapidly and sources of sea spray and aerosol emissions derived from living organisms (biogenic) are consequently changing. utqiagvik is at the forefront of this change, abutting one of the largest areas of sea ice loss. these atmospheric aerosols could have far-reaching impacts to both the climate, environment and resident community. because this change has happened largely in the last decade, now is an important time to document changes and continue a data record that will allow for a characterization of the new arctic. the longest and most complete record of airborne fine particles (or ?aerosol?) and their properties in the american arctic is that of utqiagvik, where nsf, the national oceanic and atmospheric administration and the department of energy have contributed to making this unique location serve as a regional record of changes in atmospheric aerosol properties. that record has served as the basis for hundreds of publications on questions from atmospheric chemistry to climate science to ecology and bio\*\*diversity\*\* conservation, which clearly demonstrate the broad, cross-disciplinary scientific value of these measurements. this research will extend the baseline measurements of this arctic aerosol record, including a continuation of the 15-year record of submicron inorganic components, re-instituting the 2-year record of organic components collected a decade ago, enhancing the chemical analysis with sulfur isotopes to improve interpretation of emission sources, continuing particle number size distribution measurements, and re-starting cloud condensation nuclei measurements. re-starting sampling for organic components provides a comparison to that of 2008-2010, documenting the myriad of source changes in the last decade. observations for continuing size distribution records and re-starting cloud condensation nuclei measurements provides the link from the chemical record of sources to the physical impacts on

climate and the environment. this project will also allow analysis and archiving of the last 7 years of inorganic filters that were collected and the next 5 years, extending the inorganic aerosol composition record to almost 30 years. in addition to making the data widely available for a breadth of research, a journalist will publish articles in local news media to broaden the awareness of utqiagvik's historic role as an arctic observatory. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: CUNY Graduate School University Center

Amount: \$1,298,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: Collaborative Research: Digitization TCN: Extending Anthophila research through image and trait digitization (Big-Bee)

Awardee: University of California-Santa Barbara

Amount: \$1,288,241.00

Abstract: declining populations of bees impact plant-pollinator interactions in both natural and agricultural systems. while bees and other insects pollinate most wild plants, and are critical to sustain a large proportion of global food production, they are decreasing in both numbers and **\*\*diversity\*\***. our understanding of the factors driving these declines is limited because we lack sufficient data on the distribution of bee species, and on the behavioral and anatomical traits that may make them either vulnerable or resilient to human-induced environmental changes, such as habitat loss and climate change. fortunately, wild bees have been collected by researchers and deposited in natural history collections for over 100 years, retaining a wealth of associated attributes that can be extracted from specimen images. this project will digitally capture data and images from



these historic specimens, develop tools to measure bee traits from these images, and generate a comprehensive bee trait and image dataset to measure changes through time. this will increase our understanding of specific traits that put bee species at risk of decline - a critical need for both sustaining our agricultural economy and the conservation of our natural resources. in addition, the large image datasets created by this project can be used for new artificial intelligence identification tools that will help improve our future pollinator observation and monitoring efforts. the big-bee thematic collection network (big-bee tcn) will create over one million high-resolution 2d and 3d images of bee specimens, representing over 5,000 worldwide bee species, including all of the major pollinating species of the united states. the big-bee network includes 13 institutions and partnerships with us government agencies. novel mechanisms for sharing image datasets will be developed and datasets of bee traits will be available through an open data portal, the bee library, for research and education. the big-bee project will engage the general public in research through community science via crowdsourcing trait measurements and data transcription from images. in addition, training and professional development for natural history collection staff, researchers, and university students in data science will be provided through the creation and implementation of workshops focusing on bee traits and species identification. all data resulting from this award will be shared with and publicly available through the national digitized biocollections resource, idigbio.org. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Frameworks: Convergence of Bayesian inverse methods and scientific machine learning in Earth system models through universal differentiable programming

Awardee: University of Texas at Austin

Amount: \$1,278,970.00

Abstract: understanding and quantifying parameter sensitivity of simulated systems, such as the

numerical models of physical systems and mathematical renderings of neural networks, are essential in simulation-based science (sbs) and scientific machine learning (sciml). they are the key ingredients in bayesian inference and neural network training. seizing on the opportunity of emerging open-source earth system model development in the julia high-level programming language, this project is endowing these open-source models with automatic differentiation (ad) enabled derivative information, making these converging data science and simulation-based science tools available to a much broader research and data science community. enabling a general-purpose ad framework which can handle both large-scale earth system models as well as sciml algorithms, such as physics-informed neural networks or neural differential equations, will enable seamless integration of these approaches for hybrid bayesian inversion and bayesian machine learning. it merges big data science, in which available data enable model discovery with sparse data science, and the model structure is exploited in the selection of surrogate models representing data-informed subspaces and fulfilling conservation laws. the emerging julia language engages a new generation of researchers and software engineers, channeling much needed talent into computational science approaches to climate modeling. through dedicated community outreach programs (e.g., hackathons, minisymposia, tutorials) the project team will be working toward increasing equity, **diversity**, and inclusion across the participating disciplines. the project is developing a framework for universal differentiable programming and open-source, general-purpose ad that unifies these algorithmic frameworks within julia programming language. the general-purpose ad framework in julia leverages the composability of julia software packages and the differentiable programming approach that underlies many of the sciml and high-performance scientific computing packages. compared to most current modeling systems targeted for hpc, julia is ideally suited for heterogeneous parallel computing hardware (e.g., cuda, rocm, oneapi, arm, powerpc, x86 64, tpus). the project is bringing together expertise in ad targeted at earth system data assimilation in high performance computing environments with sciml expertise. the project team is working with the julia computing organization and package developers to ensure sustainability of the

developed frameworks. the project's earth system flagship applications consist of (i) an open-source, ad-enabled ocean general circulation model that is being developed separately as part of the climate modelling alliance (clima), and (2) an open-source, ad-enabled ice flow model. each of these application frameworks is being made available to the community for science application, in which derivative (gradient or hessian) information represent key algorithmic enabling tools. these include sciml-based training of surrogate models (data-driven and/or model-informed), parameter and state estimation, data assimilation for model initialization, uncertainty quantification (hessian-based and gradient-informed mcmc) and quantitative observing system design. academic and industry partners are involved, who are using the frameworks for developing efficient power grids, personalized precision pharmacometrics, and improved eeg design. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: RoL: The Evolution of the Genotype-Phenotype Map across Budding Yeasts

Awardee: University of Wisconsin-Madison

Amount: \$1,250,014.00

Abstract: how organisms' external characteristics or traits are encoded in their genomes and how they change over time represent important and largely unanswered biological questions. this project will address these questions by studying the metabolisms and genomes of the more than 1,000 known species of budding yeasts and their evolution. some of these yeast species are important opportunistic pathogens, while others are of great industrial relevance as producers of foods, beverages, medicines, and biofuels. this project will span multiple scales of biological organization (from molecules to cells, species, and beyond) and ~400 million years of evolution to yield fundamental insights into how traits are encoded in genomes, how new functions evolve, and how

the relationship between traits and genomes itself evolves. the project will support the wild yeast and computational genomics programs, two established and highly successful educational and training programs that immerse early-stage undergraduate students, including those from underrepresented backgrounds, in authentic, discovery-driven research. using draft genomes for nearly all known budding yeast species and state-of-the-art genome-editing tools that are broadly active in diverse species, this project will predict the connection of every metabolic gene in every yeast species? genome to its function(s), as well as examine the evolution of every known metabolic gene, pathway, and trait across the budding yeast subphylum saccharomycotina. through genome-scale evolutionary analyses and targeted functional experiments on key representative taxa spanning budding yeast genomic and metabolic **\*\*diversity\*\***, this project will functionally characterize how between-taxa variation at the level of genotypes gives rise to variation at the level of phenotypes. in particular, the project will chart how variation at the level of dna, rna, proteins, and metabolites sequentially transforms genetic variation into biochemical functions and physiological traits with an emphasis on functionally characterizing gaps and correcting discrepancies in the predicted genotype-phenotype map. this project is jointly funded by the evolutionary processes program in the division of environmental biology and the genetic mechanisms program in the division of molecular and cellular biosciences of the directorate for biological sciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Dimensions US-China: Collaborative Research: Quantifying the Impact of Eutrophication on the World's Grassland Soil Microbial Biodiversity and Functioning

Awardee: University of Oklahoma Norman Campus

Amount: \$1,250,000.00

Abstract: human activities are increasing the amount of biologically limiting nutrients, such nitrogen

(n) and phosphorus (p), flowing into ecosystems on every continent, and this increased nutrient supply is causing dramatic impacts such as bio\*\*diversity\*\* loss. microbes comprise most of the bio\*\*diversity\*\* on earth, and the \*\*diversity\*\* of microbes in the soil is a critical link in maintaining the health of our ecosystems. however, we have little understanding of how alteration of global nutrient supplies are affecting soil microbial \*\*diversity\*\*. the proposed work will quantify how increased nutrient supplies affect soil microbial \*\*diversity\*\* and how these changes affect the functioning of grassland ecosystems around the world. the research will leverage a worldwide network of scientists, the nutrient network (nutnet), who are replicating an identical nutrient-addition experiment at more than 100 grassland sites across 26 countries. using this global research platform, this project will explore different ?diversities? of the soil microbes by counting their identities (taxonomic \*\*diversity\*\*, td), their evolutionary relationships (phylogenetic \*\*diversity\*\*, pd), the genes encoded in their dna (genetic \*\*diversity\*\*, gd), and what they are doing (functional \*\*diversity\*\*, fd). the scientists on this research team will not only determine how these different dimensions of \*\*diversity\*\* respond to the nutrient change but also why they are changing. are microbial communities changing because some microbes can grow better (abiotic filtering), compete or cooperate with other microbes or plants (biotic interactions), or are good or bad at migration (dispersal), or appear by chance (drift)? this project will develop new mathematical models to predict how nutrients change the \*\*diversity\*\* of soil microbes and their functions in different regions in the future. broader impacts of this project include (i) increased public engagement and literacy in stem via k12 education that will reach over 4,000 k-12 students including from under-served schools using nutnet plots set up for education at cedar creek and activities at oklahoma; (ii) enhanced research infrastructure of the global nutnet collaboration, which benefits the greater research community via published data, provision of samples, and space for additional projects; and (iii) advanced training in international cross-disciplinary collaboration for project post-docs and students, that will generate a more competitive workforce to engage in systems-level problem solving for agriculture, environment, ecology and climate research. the project will use high throughput

metagenomics technologies and integrative mathematical and statistical modeling to analyze soil grassland microbial **diversity** responses to experimental eutrophication along global gradients in climate, plant **diversity**, and edaphic conditions. the research will test theory-based predictions about the responses of soil microbes to nutrient supply across scales of space and time, generating novel insights into: (i) global patterns of soil microbial **diversity** (td, pd, gd, fd) along broad gradients of climate, plant **diversity**, and edaphic conditions; (ii) the context-dependence and interactive effects of n and p supply on grassland soil microbial communities, nutrients, and soil c storage; (iii) the importance of plant, microbe and soil elemental stoichiometry for controlling the responses of microbial **diversity** and functioning to nutrient supply, as well as the role of plant-microbe interactions in mediating plant responses to nutrient addition; (iv) the relative importance of stochastic (e.g., dispersal) and deterministic (e.g., abiotic filtering, biotic interactions) processes controlling responses by each of the dimensions of microbial **diversity** to nutrient addition across global environmental and geographic gradients; (v) the importance of **diversity** and community assembly in controlling soil microbial ecosystem functioning, and the influence of environmental factors (e.g., soil, plant, climate, geography); (vi) potential ?biomarkers? (key taxa or genes) of grassland soil functions; (vii) novel metagenomics-enabled ecosystem models for global simulation of grassland soil c dynamics; and (viii) model-inferred impacts of nutrient addition on soil c dynamics across biogeographic gradients in climate, plants and edaphic conditions. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: LIGO Instrument and Data Characterization

Awardee: Louisiana State University

Amount: \$1,210,000.00

Abstract: this award supports research in relativity and relativistic astrophysics and it addresses the

priority areas of nsf's "windows on the universe" big idea. the last several years were very exciting in gravitational wave astronomy, with the first detection of gravitational waves in 2015 from a collision of black holes 1.3 billion years ago, and with more than 50 detections published in 2021; the lsu group has been a critical contributor to these discoveries. the group's activities in the next years will focus on aspects of improvement of the advanced ligo detectors and the characterization of data from the advanced ligo interferometer. these efforts are fully integrated with those of the ligo scientific collaboration (lsc) and are closely related with the activities of the ligo livingston observatory, since that observatory is located only 30 miles from the lsu campus. in doing its research, the group will train students and a postdoc who will add to the quality and **\*\*diversity\*\*** of the stem workforce, as well as share the research with the general public. the lsu group will pursue research activities in two main topics, all coordinated with the lsc and key to the improvement of detection rates of gravitational waves with the advanced ligo detectors. the first topic is about characterizing the advanced ligo detector and applications to future designs; the group will help diagnosing and improving the detector's noise in the frequency domain due to the sensing and control of the alignment degrees of freedom, and the feedback control of the suspended masses. the group will model the performance of the system, compare models with actual performance, and then apply the models and the experience to the conceptual development of such systems for upgraded detectors. the second topic is analyzing data from advanced ligo detector; the group will identify instrumental artifacts, in particular those related to the group's expertise on scattering sources. the group will eliminate the cause of the transients when possible, and find out the artifacts that most affect the low latency searches for astrophysical signals in ligo data. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: PlantSynBio: Identification and Design of Transcriptional Activation

## Domains Across Plant Species

Awardee: Duke University

Amount: \$1,204,813.00

Abstract: every plant begins life as a seed with one cell and one genome. in order for a plant to grow, the cells must divide and turn into different kinds of cells by turning on different genes. leaf cells turn on leaf genes; root cells turn on root genes. this process of turning genes on and off requires specialized proteins called transcription factors. transcription factors also allow plants to turn genes on or off to respond to stresses like drought or pests and pathogens. transcription factors turn genes on using specialized regions called "activation domains." the first part of this project will use technologies we developed to identify activation domains on all the transcription factors of one widely studied plant species, arabidopsis. the data we collect will power our computational models for predicting activation domains in other plants. the final portion of this project will build synthetic transcription factors that can be used to engineer gene regulation in other plants. this research will create useful and powerful tools for plant biologists and plant breeders. this collaboration between three research teams creates a unique interdisciplinary training environment for undergraduates, graduate students, and postdoctoral research fellows. our team is committed to building a supportive environment that fosters equity, **\*\*diversity\*\*** and inclusion. the three pi's come from backgrounds that have been traditionally excluded from science. two of the pi's are building on the success of their nsf career awards.

in plants, transcription factors control gene regulatory programs for development, growth and stress responses. transcription factors have two functions: 1) to bind dna sequences in the genome directly with a dna binding domain (dbd) or through a partner dbd-containing protein and 2) to recruit transcriptional machinery. dbds have been well characterized and can be predicted directly from amino acid sequence. in contrast, the regions of transcription factors that bind coactivator complexes, activation domains, remain poorly characterized and cannot be predicted from amino acid sequence. for example, in arabidopsis, there are 1,717 transcription factors, but only 8 known activation domains. as a consequence, when a



new genome is sequenced, models for predicting dbds can identify putative transcription factors, but there are no analogous models for predicting if these transcription factors are activators or repressors. this project will use high throughput screening methods to identify activation domains on all arabidopsis transcription factors. these data will train deep learning neural networks to predict activation domains from amino acid sequence and predict activation domains in other diverse plant species. the final portion of this project will create and validate synthetic transcription factors for engineering gene regulation in plants. these tools will expand the synthetic biology toolbox for targeted hypothesis testing of metabolic processes, engineering regulatory networks, advancing agriculture and contributing to solutions that could address environmental problems. this award was co-funded by the plant genome research program in the division of integrative organismal systems and the systems and synthetic biology cluster in the division of molecular and cellular biosciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: University of Utah Particle Astrophysics Research Group Grant (VERITAS, HAWC, CTA)

Awardee: University of Utah

Amount: \$1,200,423.00

Abstract: high-energy gamma-radiation represents one of the key messengers of the extreme universe, in particular providing insight into the cosmic ray accelerators that produce the highest energy particles observed. the award supports the activities of researchers at the university of utah for on-going participation in observations and analysis of data from the high altitude water cherenkov (hawc) and veritas observatories, and the future cherenkov telescope array (cta) observatory. students and postdoctoral researchers supported by this grant will explore the origin of the high-energy gamma-radiation emitted by black holes, neutron stars, and supernova remnants. in addition, the researchers will develop ultra-high-resolution visible-light observations to accurately measure the diameters and create images of nearby stars using the veritas stellar intensity interferometry observatory. the award supports an extensive training program for undergraduate students who do not otherwise have access to extensive research facilities, and activities that explore the connections between astronomical dark skies, urban planning, bio\*\*diversity\*\* and microclimate, workforce \*\*diversity\*\*, and economic opportunity through the university's consortium for dark sky studies. recent advances in multi-wavelength analyses developed by the researchers provide a framework to explore possible astrophysical origins of galactic cosmic rays and the observed local positron flux. this includes studies of archival and new veritas observations of promising tev halo regions identified from current all-sky catalogs published by the fermi satellite observatory, and the hawc northern-sky surveys. next steps will realize improved gamma-ray

observations with the newly-developed wide-field of view schwartzchild-couder telescope and result in integrating these elements, the multi-messenger maximum likelihood analysis framework (3ml), and matched run method analysis tools to the gammapy analysis framework, for use by the future cta observatory. completing the program is a survey of stellar diameters measured in the u/v optical bands via intensity interferometry observations with the veritas telescopes that will permit development of a suite of analysis tools for imaging of o/b/a stars, cepheid variables, and binary systems. this project advances the goals of the nsf windows on the universe big idea. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: RESEARCH-PGR: Extracellular RNA Produced By Plants: What, Where, How, Who, and Why?

Awardee: Donald Danforth Plant Science Center

Amount: \$1,200,000.00

Abstract: this project investigates the role of secreted rna in the immune system of plants. the innes and meyers laboratories recently discovered that the leaves of plants accumulate rna in the spaces between cells and on their surfaces. although we usually think of rna as a molecule that can direct cells to synthesize specific proteins (e.g., the mrna in covid vaccines directs our cells to make sars-cov2 spike protein), some rnas serve other functions. analysis of the base sequences of plant extracellular rnas revealed that these rnas are diverse in sequence, but do not appear to encode proteins. the discovery of extracellular non-coding rna in plants raises two fundamental questions that this project will address: 1) how do plants secrete rna? and 2) what is the function of this rna? it takes a large amount of energy for cells to secrete rna, thus this secreted rna must benefit the plant in some way. this project will test the hypothesis that secreted rna functions to protect plants from infection by fungi and bacteria. if this hypothesis is correct, the proposed research will enable

generation of crop plants with improved immune systems that are more resistant to disease. such crops are needed to feed a growing global population in a sustainable manner, while reducing the environmental impacts of agriculture. the innes and meyers laboratories recently discovered that the apoplast of arabidopsis leaves contains abundant long non-coding rnas, including circular rnas, as well as small rnas. these rnas are bound to protein particles, which protects them against degradation. notably, this extracellular rna (exrna) is highly enriched in the post-transcriptional modification n6-methyladenine (m6a). these discoveries raise fundamental questions about plant biology: are there specific exrnas that are broadly conserved across plant species? how are exrnas secreted, and are post-transcriptional modifications central to this process? and why do plants produce exrnas? do they play a fundamental role in plant-microbe interactions? to answer these questions, exrna will be purified from the apoplast and leaf surfaces of seven diverse species: arabidopsis, soybean, tomato, lettuce, pineapple, rice, and maize, which were chosen based on their phylogenetic **diversity**, genomic resources, importance as crops, and **diversity** in physiology. these exrnas will be analyzed using both rna-seq and srna-seq, which will allow identification of rnas that are conserved between species. to assess whether m6a or other modifications are required for secretion, transgenic plants that express exrnas that lack modification sites will be tested for their secretion efficiency. to investigate additional requirements for exrna secretion, the exrna content in arabidopsis and rice plants with mutations in known rna binding proteins and secretory pathway genes will be analyzed. lastly, to assess whether exrnas contribute to immunity, mutants compromised in exrna secretion will be tested for resistance to fungal and bacterial pathogens. this award was co-funded by the plant genome research program and the plant biotic interactions program in the division of integrative organismal systems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SCC-CIVIC-FA Track A: A Community-Based Framework to Develop Shared Micromobility for Affordable-Accessible Housing (SMILIES)

Awardee: University of Arkansas

Amount: \$1,200,000.00

Abstract: this project presents smilies (shared micromobility for affordable-accessible housing): a community-engaged pilot project to improve accessibility to jobs and essential services for residents of affordable housing communities by leveraging the explosive growth of shared micromobility services (smm). smm includes community usage of bikes and scooters, including electric ('e') versions. affordable-accessible housing is increasingly scarce in the u.s., particularly in small and mid-sized cities in rural areas. as these cities offer only limited public transportation options, low-income residents living in those areas may struggle to access jobs and essential services. thus, transportation solutions that consider but do not rely on transit to improve the accessibility of low-income workers in small and mid-sized cities in rural areas should be investigated. smm is emerging as a popular mode for recreation in large metropolitan areas but has yet to be leveraged as an innovative solution for jobs-housing transportation in affordable housing communities. the proposed smm pilot project generated through community engagement will fill this critical gap by quantifying the impact of smm on accessibility to jobs and essential activities for affordable housing communities. this contribution is significant because it would introduce strategies and policies to guide local governments, community champions, and smm operators in efficient management of smm services while ensuring the benefits are available and accessible to low-income residents, ultimately promoting social equity. the overall objective of this project is to design and evaluate an smm system for affordable housing communities through a community-engaged research-centered pilot project. this objective will be accomplished through a community-based participatory action research (cbpar) methodology, supported with quantifiable models to estimate the impacts of smm on household travel and costs as well as the latent demand for smm services. the cbpar team for this project includes diverse stakeholders from universities, public planning and transportation

agencies, local businesses, and smm vendors. the proposed research is transformative as it will leverage community engagement to first design a community-centered smm system and then conduct real-world pilot deployments under community-defined conditions. the pilot is to be deployed in fort smith, arkansas, a mid-sized city with high incidents of poverty and racial **\*\*diversity\*\***, and a history of transportation challenges centered on access to jobs and essential services attributable to a lack of public transit. this project is part of the civic innovation challenge, which is a collaboration of nsf, department of energy vehicle technology office, department of homeland security science and technology directorate and federal emergency management agency.

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SCH: Explainable Learning of Heart Actions from Pulse to Broaden Cardiovascular Healthcare Access

Awardee: University of Maryland, College Park

Amount: \$1,200,000.00

Abstract: cardiovascular disease is the most prevalent cause of death. early treatment can effectively reduce the risk of sudden cardiac death, but a many cardiac issues show no obvious symptoms in the early stage and would benefit from long-term continuous cardiac monitoring to capture the intermittent and asymptomatic abnormalities of the heart. this disproportionately affects low-income and disadvantaged populations, who have limited access to affordable preventive care. an electrocardiogram (ecg) is a non-invasive gold standard for diagnosing cardiovascular diseases. although it is currently possible to obtain an instant ecg test through a special smartwatch or special attachment to a smartphone, these current options require continuous user participation and are impractical to meet the needs of long-term continuous monitoring. this project investigates a new artificial intelligence (ai) powered health solution to automated and continuous cardiac monitoring by

inferring ecg from the readily available continuous measurements, such as those sharing the same principles as in many wearable devices. the research from this project will provide insights on how to transfer the ecg-based rich knowledge base to the diagnosis of cardiovascular diseases from wearable sensors. in order to broaden participation and impact, the project will integrate research and educational activities. these include supporting the workforce development in such in-demand technical areas as machine learning and smart health, and actively engaging students in hands-on and exploratory interdisciplinary research, especially those from the under-represented groups. the project will contribute to promoting national health, welfare, and prosperity. the key research issues of inferring ecg from photoplethysmogram (ppg), which can be monitored continuously without constant user attention, include: (1) how to apply biomedical insights to model the relations between ecg and ppg; (2) how to carry out explainable learning for inferring ecg from ppg; (3) how to make a transformative expansion of public health knowledge based on the newly developed bridge between ecg and ppg; and (4) how to address a variety of diverse and practical conditions, including population **\*\*diversity\*\***, disease progression, and noise/distortions in real-world ppg sensing sources. the investigator team plans to carry out the core inference from ppg to ecg in several stages, starting with modeling the biophysical relation between ecg and ppg and representing both waveform families through the well-understood basis in the fourier family as a proof-of-concept. the team plans to utilize data next to refine the representation using dictionary learning, and incorporate a deep model when extensive data can be leveraged to provide a refined inference. the bridge between ecg and ppg enabled by explainable ai can bring unprecedented opportunities to expand smart health knowledge to benefit public health. the investigator team will work closely with a medical expert to explore ai-enabled understanding and promotion of cardiovascular health in exercise physiology, and transferring rich ecg medical knowledge base to the more user-friendly ppg domain. the team plans to embrace the opportunity of cross-disciplinary collaboration to evaluate the new capabilities in practical settings as well as promote participation and feedback from a diverse population. this award reflects nsf's statutory mission and has been



deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Frameworks: Convergence of Bayesian inverse methods and scientific machine learning in Earth system models through universal differentiable programming

Awardee: Massachusetts Institute of Technology

Amount: \$1,200,000.00

Abstract: understanding and quantifying parameter sensitivity of simulated systems, such as the numerical models of physical systems and mathematical renderings of neural networks, are essential in simulation-based science (sbs) and scientific machine learning (sciml). they are the key ingredients in bayesian inference and neural network training. seizing on the opportunity of emerging open-source earth system model development in the julia high-level programming language, this project is endowing these open-source models with automatic differentiation (ad) enabled derivative information, making these converging data science and simulation-based science tools available to a much broader research and data science community. enabling a general-purpose ad framework which can handle both large-scale earth system models as well as sciml algorithms, such as physics-informed neural networks or neural differential equations, will enable seamless integration of these approaches for hybrid bayesian inversion and bayesian machine learning. it merges big data science, in which available data enable model discovery with sparse data science, and the model structure is exploited in the selection of surrogate models representing data-informed subspaces and fulfilling conservation laws. the emerging julia language engages a new generation of researchers and software engineers, channeling much needed talent into computational science approaches to climate modeling. through dedicated community outreach programs (e.g., hackathons, minisymposia, tutorials) the project team will be working toward increasing equity, **\*\*diversity\*\***, and inclusion across the participating disciplines. the project is

developing a framework for universal differentiable programming and open-source, general-purpose ad that unifies these algorithmic frameworks within julia programming language. the general-purpose ad framework in julia leverages the composability of julia software packages and the differentiable programming approach that underlies many of the sciml and high-performance scientific computing packages. compared to most current modeling systems targeted for hpc, julia is ideally suited for heterogeneous parallel computing hardware (e.g., cuda, rocm, oneapi, arm, powerpc, x86 64, tpus). the project is bringing together expertise in ad targeted at earth system data assimilation in high performance computing environments with sciml expertise. the project team is working with the julia computing organization and package developers to ensure sustainability of the developed frameworks. the project's earth system flagship applications consist of (i) an open-source, ad-enabled ocean general circulation model that is being developed separately as part of the climate modelling alliance (clima), and (2) an open-source, ad-enabled ice flow model. each of these application frameworks is being made available to the community for science application, in which derivative (gradient or hessian) information represent key algorithmic enabling tools. these include sciml-based training of surrogate models (data-driven and/or model-informed), parameter and state estimation, data assimilation for model initialization, uncertainty quantification (hessian-based and gradient-informed mcmc) and quantitative observing system design. academic and industry partners are involved, who are using the frameworks for developing efficient power grids, personalized precision pharmacometrics, and improved eeg design. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SCC-CIVIC-FA Track B UNUM: Unification for Underground Resilience Measures

Awardee: New York University

Amount: \$1,199,949.00

Abstract: the importance of extreme events from climate change, weather, and accidents continue to have critical impacts on infrastructure. underground infrastructures are interconnected within one another and with above ground infrastructure. these interdependencies often have cascading impacts on electric power, water, transportation and communication with extreme social and economic impacts. increasing community resilience depends upon identifying underground infrastructure data and data sharing. such underground infrastructure data are not readily known, available, or interoperable. furthermore, they are typically under multiple jurisdictions. the unum project provides a collaborative mechanism for data sharing among government, industry, utilities, and community groups with different data security requirements. two pilot areas are used within new york city, midtown east (manhattan) and sunset park (brooklyn), contrasting in the types of underground conditions, stakeholders, and demographic and economic **\*\*diversity\*\***. in stage 1, commitments to participate in data sharing were obtained from over 40 stakeholders through a data repository managed by a city agency that provide the foundation for stage 2. this stage 2 project has broader impacts in providing a roadmap and two testbeds for a data model, data needs, sharing, and security protocols for underground infrastructures transferable to other areas to improve their resilience.

goals and scope of research and methods and approaches: unum phase 2 expects to develop a methodology to standardize underground infrastructure and geological data sharing so that all subsurface utility information is made interoperable: capable of being brought together on a common basemap for integration and analysis. this will better enable (1) to identify hazard and disaster vulnerabilities, (2) devise strategies to reduce accidents and emergencies, and (3) to harden infrastructure in case of natural disasters and other large-scale threats like sea level rise and global warming. based on relationships and agreements with utilities established in unum stage 1, unum stage 2 will collect infrastructure data related to water and sewer networks (nyc dep), transit (mta), electric power (con edison and national grid), etc. subsurface utility data will be transformed into a common format, registered to nyc's photogrammetric basemap, and securely stored. the data will conform to the muddi data model now in advanced development by the open geospatial

consortium, and will be closely related to underground infrastructure asce 38 and 75 standards for engineering quality and accuracy. the unum team will co-develop with community groups art and engineering activities to improve community-based infrastructure literacy. this project is part of the civic innovation challenge which is a collaboration of nsf, department of energy vehicle technology office, department of homeland security science and technology directorate and federal emergency management agency. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Access to Innovative Education: Providing Learning Opportunities and Scholarships for Neurodivergent Students in STEM

Awardee: Landmark College

Amount: \$1,199,832.00

Abstract: this project will contribute to the national need for well-educated scientists and computer scientists by supporting the retention and graduation of high-achieving, low-income students with demonstrated financial need at landmark college. this institution is one of just two colleges in the u.s. that focuses exclusively on serving students who have a learning difference, including learning disabilities such as dyslexia, attention deficit hyperactivity disorder (adhd), and/or autism, collectively referred to as neurodiverse (nd) students. over its six-year duration, this project will provide scholarships to 36 undergraduate students who are pursuing either an associate?s or a bachelor?s degree in life sciences and/or computer science. first-year students will receive up to four years of scholarship support, and transfer and associate degree students will receive up to two years of scholarship support. the project aims to increase student persistence in stem fields by linking scholarships with effective supporting activities, including mentoring, undergraduate research experiences, internships, career preparation, and participation in robust cohort activities. with the

help of mentors and cohort activities, the scholars will outline their career goals and steps toward achieving those goals. scholars will be drawn from the landmark college student body, which consists of 100% nd students, so this project has the potential to diversify participation in stem fields and to learn how mentoring and individual development plans support retention and graduation of this student population. the project focuses on how effective mentoring leads to better outcomes for nd students in stem fields and how to form a stronger stem identity leading to positive experiences in internships and undergraduate research. the project proposes concrete strategies for increasing the number of nd students who are stem-ready for the opportunities in today's workforce. the overall goal of the project is to increase **diversity** and degree completion of nd undergraduates in stem fields. this project builds on landmark college's current institutional student supports. psychosocial, non-cognitive factors, such as academic perseverance, social skills, learning strategies, and academic mindsets, have generally been demonstrated to influence student persistence in stem. however, little is known about how these factors affect neurodiverse students at bachelor's and associate degree-granting liberal arts colleges. this project will investigate the effects of psychosocial factors on nd student persistence in stem and, more specifically, will explore how cohort support components support autistic students. this project investigates the possibility that the peer support class promotes increased student responsibility and cohort cohesion. this project will also investigate the possibility that the scholars develop a healthy disability identity and an identity in a stem field of study while persevering in their major because of participating in the mentoring activities of the project. this project has the potential to advance understanding of psychosocial factors on nd student persistence in stem and early career access. this project will be evaluated via a mixed method approach using information from the cohort activities and mentoring activities. results will be made available on the landmark college website, as well as through regional and national conferences and publications. this project is funded by nsf's scholarships in science, technology, engineering, and mathematics program, which seeks to increase the number of low-income academically talented students with demonstrated financial need who earn degrees in

stem fields. it also aims to improve the education of future stem workers, and to generate knowledge about academic success, retention, transfer, graduation, and academic/career pathways of low-income students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: The Simpson Neutron Monitor Network

Awardee: University of Delaware

Amount: \$1,194,735.00

Abstract: this three-year collaborative project is focused on building of a network of ground-based cosmic-ray monitors, called neutron monitors (nms), operated by a consortium of three u.s. academic institutions, namely universities of new hampshire, delaware and wisconsin-river falls. invented by prof. john simpson in 1948, following his experience on the manhattan project, nms have been used to detect and measure radiation in space, starting almost ten years before the space age. they are stationed on the ground all over the globe, providing continuous measurements of cosmic radiation for over a half century. nms measure the trends and changes in the radiation levels in space, which is critical information for travel by astronauts to the moon and mars. they can also detect intense, short-term bursts of radiation from the sun that reach the ground. all this activity is driven entirely by what the sun is doing. nms are robust and reliable and have assumed a new importance in recent years when used in conjunction with the international fleet of spacecraft and with neutron monitors in other countries. now, all the nms sponsored by the u.s. are being linked into what will be the simpson neutron monitor network, which will make it more efficient to coordinate operations and science. during this three-year collaborative project, the consortium will carry out this research, teasing new information out of these heritage instruments and providing researchers around the world with up-to-date radiation climate data. cosmic rays entering the earth's

atmosphere are messengers informing us about large-scale heliosphere structure, local space environment and solar activity. they have already passed through and interacted with the interplanetary magnetic field, and they carry information of its detailed structure. some of these cosmic rays possess enough energy to reach the ground. a nm is a ground-based particle detector that records the nucleonic component in particle showers. this directly correlates with the number of high energy cosmic rays striking the earth's atmosphere. the analysis of these data is used to build an understanding of the sun's influence on the solar system. because of the large detector volume exploited by ground-based stations, neutron monitors remain the state-of-the-art instrumentation for measuring rigidity  $>1\text{gv}$  cosmic rays. the programmatic linking of these instruments run by the universities of new hampshire, delaware and wisconsin-river falls will secure a continuity of quality data for the global community, as called out in the national space weather plan and congressional legislation. the data from these instruments are used by many, including, space weather predictors, industry, space scientists, homeland security and hydrologists. the nm stations span a wide range of latitudes, from the south pole to the arctic regions. the contributors to the nm signal include cosmic rays from the galaxy that are heavily modulated by solar activity and from the sun itself in the form of high energy bursts of protons. the variability of these agents reveals conditions in interplanetary space, general solar activity and the fundamental processes that produce cosmic rays throughout the universe. with today's computing resources, we better understand how these instruments detect radiation, and the consortium will thus be able to extract new information from these workhorse devices. this will shed new light on how the distribution of cosmic rays varies with time, geography and particle energy. the consortium will study how to permanently secure the operations of the monitor network and intelligent ways of expanding the network to complement those at existing sites. the education and outreach goals of the project include a research position for a postdoc, a wide variety of opportunities and experiences for undergraduates, as well as opportunities for high school and elementary school students. the research and epo agenda of this collaborative project supports the strategic goals of the ags division in discovery, learning,

**\*\*diversity\*\***, and interdisciplinary research. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: A Data-Driven Employer-Academia Partnership for Continual Computing Curricular Change

Awardee: University of Alabama Tuscaloosa

Amount: \$1,188,256.00

Abstract: this project aims to serve the national interest by improving the supply of well-prepared computer science professionals capable of addressing the needs of american employers in the public and private sectors. this project intends to build a national partnership between employers and academia to help identify and mitigate gaps between the competencies of computing graduates and the expectations of potential employers. the project will survey computer science educators and practitioners to develop a model that defines the competencies expected by potential employers. the project team then plans to test the model at three institutions of higher education in alabama ? the university of alabama, tuscaloosa, tuskegee university, and shelton state community college. finally, the project team intends to develop tools and methods for institutions to identify and implement competency-based educational approaches for computer science across the nation. the project plans to use three interconnected strands of evidence-based activities to institute transformational change in the involved communities. first, a national strand will engage u.s. faculty in developing competency-based curricula informed by industry practitioner feedback. second, a local pilot strand intends to create transformative curricular change based on student competencies using an evidence-based change model in the three alabama institutions. sociologists and computing faculty on the team will help to understand, predict, and reduce barriers to competency-based employment of computing graduates from marginalized communities in the heart



of the impoverished alabama black belt. the unique perspective relative to **\*\*diversity\*\***, equity, and inclusion needs should serve as a model for other computing departments. the third strand will develop competency-based surveys for practitioners and academics to identify and refine specific competencies that are hoped to drive continual curricular change. outcomes, including the change process, national workshops, and experiences from the local process will help with transferability in the computing education community. in addition to informing curricula, the project will provide valuable data for educational researchers to help close the gap between employers and higher education. finally, as the competency approach to curricular design is relatively new in computing and engineering disciplines, lessons from this project will have the potential to transform curricular review and design in other stem disciplines. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the institutional and community transformation track, the program supports efforts to transform and improve stem education across institutions of higher education and disciplinary communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RTG: Computational Mathematics for Data Science

Awardee: Emory University

Amount: \$1,188,174.00

Abstract: computational and data-enabled science has become the third pillar of science, completing theory and experimentation. its success has been fueled by breakthroughs in scientific computing, the explosion of available data, and our ability to formulate mathematical models and calibrate them to measured data. recent success stories range from numerical weather prediction, which has seen tremendous achievements in accuracy over the past years, to speech recognition, which has dramatically improved in the last decade by systematically learning from data. the aim of this project

is to implement a comprehensive vertically integrated research training group (rtg) on the central theme of computational mathematics for data science. in addition to being areas of fundamental and strategic importance to the united states (e.g., for the development of new medicines, technologies, and defense capabilities), both computational mathematics and data science are areas that can have a tremendous societal impact and will attract a broad range of students. the rtg themes of this project include applications ranging from statistical data assimilation to machine learning, which are among the most transformative technologies of our times and have captured substantial public interest with many potential applications from drug discovery to driverless cars. despite many advances, there still is a pressing need for more mathematical theory and rigor, which provides ample research opportunities for all levels of mathematicians, from undergraduate students, graduate students, postdocs, and senior scientists. this project will support 3 graduate students per year, 1.5 undergraduate students per year and at least 1 postdoc per year. at its core, data science uses mathematical methods and computational approaches to extract knowledge and information from data. harnessing the data revolution requires new mathematical breakthroughs in the form of theory, models, and computational algorithms. breakthroughs are particularly needed to enable mathematicians and application scientists to analyze and synthesize larger and more complex datasets in an effective, reliable, and explainable manner. to this end, the research conducted in this project will unify and further develop the mathematical theory and computational tools used in applications ranging from data assimilation to machine learning. this comprehensive approach will be based on knowledge from, and make novel contributions to mathematics, computational science, and data science. particular focus will be on the mathematics of deep learning and data assimilation and their application in impactful areas of medicine (cardiac modeling, medical imaging), the weather and environment (hurricane storm surge modeling), and disease outbreak modeling. common threads in these areas are their mathematical foundations, most importantly differential equations, optimization, linear algebra and advanced techniques from computational science, such as parallel and distributed computing. this rtg program is anchored

around year-long research themes that include one or more of the above mentioned core research themes. training will be multi-faceted, to include education, potential career skills and experiences, soft skills, scientific integrity, and promoting an appreciation for \*\*diversity\*\*. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Leveraging the Power of Reflection and Visual Representation in Middle-Schoolers' Learning During and After an Informal Science Experience

Awardee: Gulf of Maine Research Institute

Amount: \$1,186,630.00

Abstract: this project addresses a longstanding problem in informal science education: how to increase the likelihood of consequential science, technology, engineering, and mathematics (stem) learning from short duration experiences such as field trips. although informal learning experiences can greatly contribute to interest in and knowledge of science, there is a shared concern among educators and researchers that students may have difficulty recalling and using scientific information and practices emphasized during these experiences, even though doing so would further their science learning. nonetheless, science learning is rarely, if ever, a "one-shot deal." children acquire knowledge about science cumulatively across different contexts and activities. therefore, it is important that informal science learning institutions identify effective practices that support the consolidation of learning and memory from exhibit experiences to foster portable, usable knowledge across contexts, such as from informal science learning institutions, to classrooms, and homes. to this end, this research in service to practice project seeks to harness the power and potential of visual representations (e.g., graphs, drawings, charts, maps, etc.) for enhancing learning and encouraging effective reflection during and after science learning experiences. the project promises to increase learning for the 9,000+ 5th and 6th grade students from across the rurality and growing

**\*\*diversity\*\*** of the state of maine who annually participate in labventure, a 2.5-hour exploration of the gulf of maine ecosystem at gulf of maine research institute. the research will provide new and actionable informal science learning practices that promote engagement with visual representations and reflection, and science understandings that can be applied broadly by informal science institutions. this project is funded by the advancing informal stem learning (aisl) and the discovery research prek-12 (drk-12) programs. it supports the aisl program goals to advance new approaches to, and evidence-based understanding of, the design and development of stem learning in informal environments. it supports the drk-12 program goal of enhancing the learning and teaching of stem by prek-12 students and teachers. the project is grounded in the idea that visual representations, including drawings, can both enhance science learning and encourage reflection on doing science that can support extension of that learning beyond a singular informal science experience. the project uses design-based research to address the following research questions: (1) does reflection during an informal science learning experience promote students' retention and subsequent use of science information and practices that are part of the experience? (2) does interpreting and constructing visual representations, such as drawings, improve students' understanding and retention of information, and if so, how and when? and (3) does combining visual representations and narrative reflections confer benefits on students' science learning and engagement in science practices both during the informal learning experience, and later in their classrooms and at home? these questions will be pursued in collaboration with practitioners (both informal educators and classroom teachers) and a diverse team of graduate and undergraduate student researchers. approximately 600 student groups (roughly 3000 individual students) will be observed during the labventure experience, with further data collection involving a portion of these students at school and at home. the project will yield resources and video demonstrations of field-tested, empirically based practices that promote engagement with visual representations and reflection, and science understandings that can travel within students' learning ecosystem. in support of broadening participation, the undergraduate/graduate student researchers will gain wide understanding and

experience connecting research to practice and communicating science to academic and nonacademic audiences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: DMREF/GOALI/Collaborative Research: Physics-Informed Artificial Intelligence for Parallel Design of Metal Matrix Composites and their Additive Manufacturing

Awardee: Georgia Tech Research Corporation

Amount: \$1,177,594.00

Abstract: this designing materials to revolutionize and engineer our future (dmref) research enables physics-informed artificial intelligence (ai) design of metal materials reinforced with ceramic particles (metal matrix composites) and their additive manufacturing (3d printing). such materials can exhibit superior mechanical performances at higher temperatures relative to the same metal material without ceramic reinforcements. additive manufacturing provides unprecedented fabrication capability for high performance, lightweight structural components made from metal matrix composite materials. however, the design of metal matrix composites and their additive manufacturing is largely performed with expensive, time consuming trial and error methodologies; quality assurance of such parts is similarly challenged. ai-guided design and qualification of materials and their manufacturing can significantly lower the time and cost barriers to such technologies. the basic research performed in this program will fill critical gaps to enable ai discovery and optimization of these materials and their manufacturing toward reducing deployment times and costs by half, to meet the materials genome initiative vision. the outreach programs and **\*\*diversity\*\***, equity, and inclusion plans include ai manufacturing course curricula spanning kindergarten - graduate which include example problems and tools developed from this program. atlanta and salt lake city high school teachers and students from underrepresented minority populations will receive hands-on experience and instruction in these curricula. the research

maintains and expands robust programs supporting fundamental research in alloys, ceramics, and their composites; support modalities for free-flowing interactions among universities (georgia tech and utah), start-up ventures (goali partner elementum 3d), and national laboratories (air force research laboratory); expand investments in automated materials manufacturing research to ensure the u.s. is the leader in the field by 2030; all using, when appropriate, computational methods, data analytics, machine learning, and autonomous experimental 3d characterization. this research program enables physics-informed artificial intelligence (ai) - driven parallel design of metal matrix composites and their additive manufacturing. the concept of ai that discovers and optimizes new materials and their additive manufacturing (am) in parallel promises to further revolutionize am but is yet to be realized. basic research is to enable autonomous ai discovery and optimization of materials and their manufacturing toward reducing deployment times and costs by half, to meet the materials genome initiative vision. five critical data-driven algorithmic gaps will be filled: 1) data analysis-interpretation-curation algorithms to enable automatic, pedigreed data curation from requisite process-structure-property data sources. 2) algorithms that automate data cleaning and concatenation of databases so that ai can modify and append the data spaces when new data sources or data features are incorporated into a research problem. 3) algorithms that automate data feature mapping across multiple length and time scales to complete process-structure-property data ontologies. 4) data feature engineering algorithms that improve the ai performance. 5) process-structure-property machine learning models that learn global relationships across multiple nested submodels. physics-based models and experiments will be advanced to predict and verify their utility in discovering and optimizing metal matrix composites and their additive manufacturing at multiple length and time scales. high throughput one-dimensional, two-dimensional, and three-dimensional characterization data analyses will be automated. goali partner elementum 3d will provide a techno-economic baseline study of commercializing a new metal matrix composite for additive manufacturing to be used as an overall assessment metric for the advancements made in this program. the development of a new am test artifact will benefit researchers around the globe.



the protocols and standards developed for automating data workflows can benefit materials science and engineering researchers around the world by increasing access to high-throughput and high-fidelity data sources, including machine learning models and ai knowledge systems, for all kinds of materials and manufacturing processes. this project is jointly funded by the division of civil, mechanical and manufacturing innovation (cmmi) in the directorate for engineering (eng), the division of information and intelligent systems (iis) in the directorate for computer and information science and engineering (cise), and the division of materials research (dmr) in the directorate for mathematical and physical sciences (mps). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: Bees of the World - Phylogenomics, Biogeography, and Evolution of Host-Plant Associations

Awardee: Washington State University

Amount: \$1,176,747.00

Abstract: bees are vitally important to agriculture, food security, and the preservation of natural ecosystems due to their pollination services. over 85% of the 325,000 flowering plant species on the planet depend on animal pollination and the vast majority is carried out by bees. in the u.s.a. alone

bees are responsible for the commercial production of 130 crop plants, generating over \$11 billion in annual revenue. the value of bees to nature and human well-being is abundantly clear. the partnership between bees and flowering plants formed over 100 million years ago, and since that time, bees have radiated globally into an astounding 20,000+ different species, many of which are specialist pollinators of particular plant species or families. the study of bee bio\*\*diversity\*\* is urgently needed because there is growing evidence that some bee species are in decline and baseline knowledge of bee \*\*diversity\*\*, distribution, and family relationships is incomplete. the bees of the world project has the potential to significantly improve knowledge of bee bio\*\*diversity\*\* and to establish a guide to interpret key traits of bees, such as their host-plant associations. by utilizing recent advances in dna sequencing technology, a comprehensive tree-of-life for bees will be generated for the first time, providing a framework from which to study bee \*\*diversity\*\* and their relationships with plants. to disseminate results and general bee knowledge, the project will engage in multiple outreach efforts with professional and non-professional audiences. activities include creation of a virtual bee course, teaching of a molecular methods workshop, and, in collaboration with the natural history museum of utah, development of exhibits and youth education activities focused on pollinators. the project will use cutting edge molecular and analytical methods and engage a global network of collaborators to assemble a comprehensive phylogenomic dataset for bees. the project aims are to: (1) resolve remaining uncertainties in higher-level bee phylogeny and classification, (2) incorporate fossils to reconstruct the global biogeographic history of bees, revealing the origin and spread of bee \*\*diversity\*\* over time, and (3) analyze patterns of host-plant use across bees and for targeted clades at lower taxonomic levels, revealing how host-plant specialization has evolved and impacted rates of diversification in bees. to resolve the phylogeny of bees with improved confidence, the research team will use next-generation dna sequencing approaches and novel laboratory methods to sequence bee species from across the globe. the project will generate low coverage genomes for most bee genera and ultraconserved element (uce) data for over 3,000 species, filling in sampling gaps. the resulting bee phylogeny will serve as a

framework to study bee classification, biogeography, and host-plant evolution. comprehensive databases of bee fossil, distribution, and host-plant information will be created and made available to other researchers. combining results from each component of the project will provide a comprehensive understanding of how bees have diversified and dispersed over time and how their partnership with plants has shaped their evolutionary trajectory. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Accessible Computational Thinking in Elementary Science Classes within and across Culturally and Linguistically Diverse Contexts

Awardee: University of Maryland, College Park

Amount: \$1,172,781.00

Abstract: currently, students who are white, affluent, and identify as male tend to develop a greater interest in and pursuit of science and computing-related careers compared to their black, latinx, native american, and female-identifying peers. yet, science, computing, and computational thinking drive societal decision-making and problem-solving. the lack of cultural and racial **\*\*diversity\*\*** in science and computing-related careers can lead to societal systems and decision-making structures that fail to consider a wide range of perspectives and expertise. teachers play a critical role in preparing students to develop these skills and succeed in a technological and scientific world. for this reason, it is crucial to investigate how teachers can help culturally and linguistically diverse students develop a greater understanding of and interest in science and computers. this research project aims to enhance elementary teacher education in science and computational thinking pedagogy through the use of culturally relevant teaching, i.e. teaching in ways that are relevant to students from different cultural and linguistic backgrounds the project will support 60 elementary teachers in summer professional development and consistent learning opportunities during the

school year to learn about and enact culturally relevant computational thinking into their science instruction. in doing so, the project aims to increase both the quantity and quality of computing experiences for all elementary students and support nsf's commitment in broadening participation in the stem workforce. the project will also produce resources, measures, and tools to support elementary teachers to do this kind of work, which will be shared with other stem researchers and teacher educators. the goal of this research project is to design and promote teaching practices that integrate computational thinking in the elementary science classroom in culturally relevant ways. this project will seek to empower practicing elementary teachers' approaches to meaningfully and effectively integrate and adapt computational thinking into their regular science teaching practice so that all students can access the curriculum. it will also explore the impact of these approaches on student learning and self-efficacy. the scope of this project will include working with multiple highly distinct school settings in maryland, arizona, and washington dc across three years, reaching approximately 60 elementary teachers and 1,200 students. to achieve the project objectives, the research team will leverage concurrent mixed methods approaches that include teacher and student interviews, reflections, observations, descriptive case study reports as well as regression and multilevel modeling. the project's findings will inform the field's understanding of: (a) teachers' conceptualization of computational thinking; (b) the barriers elementary teachers encounter when trying to integrate computational thinking with culturally relevant teaching practices; (c) the types of support that are effective in teacher professional development experiences and throughout the school year; and (d) the development of a cohort of teachers that can maintain integration efforts in different districts. the discovery research prek-12 program (drk-12) seeks to significantly enhance the learning and teaching of stem subjects by prek-12 students and teachers, through research and development of innovative resources, models and tools. projects in the drk-12 program build on fundamental research in stem education and prior research and development efforts that provide theoretical and empirical justification for proposed projects. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the

foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MRI: Acquisition of an ultrahigh resolution mass spectrometry system to enable metaproteomics experiments to support microbiome research

Awardee: Colorado State University

Amount: \$1,167,241.00

Abstract: an award is made to colorado state university (csu) to purchase state-of-the-art instrumentation to study the microbiome. the instrument will be housed in and managed by the csu analytical resources core bioanalysis and omics center (arc-bio) at the fort collins campus, which ensures that this shared resource is equally available to all csu students ? including students at the csu campus in pueblo, co, a federally designated minority serving institution. the requested instrument will be used to support a hands-on undergraduate research experience in microbiological sciences. the pi team, highly regarded leaders in microbiome and analytical sciences, will disseminate knowledge derived from this instrument through both formal and informal methods, including development of graduate and undergraduate coursework and lectures, laboratory tours, graduate committee membership, and undergraduate employment and training. a hands-on workshop involving the graduate student microbiome club and the student bioinformatics club is planned to introduce metaproteomic concepts and nurture a well-educated user base for this instrument. these educational activities offer improved stem educational opportunities at every academic level within csu in a manner that reflects csu's **\*\*diversity\*\***. training in modern mass spectrometry helps to ensure a globally competitive stem workforce valued by both academic and corporate employers. the ?microbiome? can be defined as a community of microorganisms in a particular environment (e.g. human, animal, soil, etc.). microbiome studies are primarily facilitated using 16s rrna or metagenomics sequencing to identify the bacterial components present in a given microbial community. however, this type of analysis cannot measure functional changes to microbial

communities (e.g. what are the bacteria doing?). proteins represent the biologically functional output of genes, and proteomics is the analytical technique used to characterize an organism's functionality. by extension, metaproteomics approaches provide thousands of measurements of protein composition and concentration from a community of organisms. metaproteomics has historically been limited by mass spectrometry technology and computational challenges. significant advancements have been achieved in both of these areas, opening the potential for more researchers to incorporate metaproteomics approaches in their studies. researchers at csu are interested in understanding the functional and structural basis of microbiome biology and ecology, with application to research fields including human, animal, plant and soil biology, ecology, and biofuels. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Wyoming

Amount: \$1,159,167.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.



Matched Words: diversity

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Title: Collaborative Research: GCR: Growing a New Science of Landscape Terraformation: The Convergence of Rock, Fluids, and Life to form Complex Ecosystems Across Scales

Awardee: University of Arizona

Amount: \$1,158,103.00

Abstract: the u.s. and the world today face the increasingly urgent question of how to better understand and manage complex physical-biological systems in order to address pressing problems such as: restoration of degraded landscapes, sustainable management of ecosystem services, including water cycling and supply, ecosystem nutrition, bio\*\*diversity\*\*, carbon sequestration in the face of global change, and eventually, terraforming planets beyond earth. at the root of these problems is the fundamental question of landscape terraformation: how does life expand and sustain itself, in increasingly complex and symbiotic forms, across landscapes at multiple scales to transform bare rock into complex multi-function ecosystems? this growing convergence research team of earth scientists (hydrologists, geochemists), biologists (evolutionary genomicists, ecosystem ecologists), and social scientists (anthropologists who study cultures of science) will leverage a unique and powerful ?convergence instrument? -- university of arizona?s landscape evolution observatory, consisting of three large experimental hillslopes at biosphere 2 -- to both reveal key mechanisms of landscape terraformation and catalyze new ways of interdisciplinary thinking to empower and diversify this next generation of scientists to achieve convergence research. the central investigation of this work is of how small scale hydrological, geochemical, ecological and evolutionary processes interact to create emergent landscape-scale terraformation, across three stages of biological complexity: from simple lithotrophic microbial communities (including microbial crusts), to non-vascular plants (mosses without roots), to vascular plants with roots and sophisticated hydraulic architectures. experiments will test model representations of water flow through landscapes, its effects on the transformation of rock via weathering at different scales, and

thence, feedbacks which modify those landscapes and their biological habitability. at the same time, the composition and function of organisms as they colonize barren landscapes and develop symbiotic associations (especially for n fixation) will be manipulated to select from biological **\*\*diversity\*\*** in genes, traits, and functions, in order to identify the biological feedbacks which simultaneously transform hydrological and geochemical processes. in the process, convergence research will be studied, understood, and reflected through a novel, social science-based ?cultures of convergence science? investigation of the entire team in an ethnographic inquiry designed to identify practices conducive to successful convergence research. this proposal is supported in part by the critical zone collaborative network program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Investigating the genetic correlation hypothesis of signal-preference evolution

Awardee: Cornell University

Amount: \$1,145,645.00

Abstract: the genetics of behavior is a frontier in many respects, and its understanding is fundamental to many areas of biology, including conservation, sustainability and human health. this work explores the genetic correlations that may exist between male calling behavior and female mate choice in *laupala kohalensis*, a cricket species in hawaii, and how this correlation impacts the expression of male behavior and the associated female preference for calls. undergraduate, graduate and post-doctoral students supported by this project will gain research experiences in integrating behavioral and genetic/genomic studies related to animal behavior questions in natural populations. rigorous cross-training in these areas has tremendous potential for making transformative progress in the study of behavior. students will gain experiences in experimental design, field collecting, animal husbandry, behavioral measurements, dna manipulations, sequencing and bioinformatics. students working on the project will also gain outreach experiences, including projects with hawaii volcanoes national park, where we will develop public exhibits to teach about the unique hawaiian bio\*\*diversity\*\* and their scientific importance, as well as studies of the interactions between invasive species and hawaiian bio\*\*diversity\*\*. public lectures will be planned to participate in the science in the park series. our work also provides leadership on how to study behavior at multiple levels of analysis and to value the role of non-model organisms in the study of behavioral \*\*diversity\*\* and genetics. our work will provide vital genome sequence data from a non-model genome, specifically that contains genes involved in rhythmic behaviors with many analogs across diverse forms of life.

theoretical work supports the concept that genetic correlations underlying diverse behaviors are vital to healthy population function such that these genetic structures can be engaged rapidly during changing environments. while theory demonstrates its deep relevance, the presence of genetic correlation is empirically not well-established. our proposal offers a strong empirical system, sound methodology and exciting technological advancements aimed at producing a complete study of genetic correlation in the species *laupala kohalensis*. the present proposal uses a design that contrasts contributions to

genetic correlation from female preference and the physical location of genes underlying male and female behaviors in natural populations. the genetic correlation will be further probed in a selection experiment on male song, and its indirect effect on female acoustic preference. the proposed work will capitalize on a powerful experimental design to produce genome wide sequence data that can characterize the response to selection, in order to identify the genes underlying these behaviors and test the hypothesis that the responding intraspecific genetic variation shares the same genetic basis found between species. in the process of doing this research, we will also estimate natural levels of linkage disequilibrium across the genome in *laupala kohalensis* in relation to the location of acoustic behavior genes. understanding the genetics and identifying the genes underlying these traits will provide a much-needed empirical basis on which to judge numerous theoretical models. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Investigating the genetic correlation hypothesis of signal-preference evolution

Awardee: Cornell University

Amount: \$1,145,645.00

Abstract: the genetics of behavior is a frontier in many respects, and its understanding is fundamental to many areas of biology, including conservation, sustainability and human health. this work explores the genetic correlations that may exist between male calling behavior and female mate choice in *laupala kohalensis*, a cricket species in hawaii, and how this correlation impacts the expression of male behavior and the associated female preference for calls. undergraduate, graduate and post-doctoral students supported by this project will gain research experiences in integrating behavioral and genetic/genomic studies related to animal behavior questions in natural populations. rigorous cross-training in these areas has tremendous potential for making transformative progress in the study of behavior. students will gain experiences in experimental

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award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Syracuse University

Amount: \$1,135,333.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: Examining Training Environments and Career Outcomes of Interdisciplinary STEM PhD Students

Awardee: Ohio State University

Amount: \$1,134,496.00

Abstract: this collaborative project with ohio state university as the lead institution and indiana university and cornell university as partners examines the career outcomes across employment sectors of interdisciplinary graduate students, the environments in which they are trained, and how those environments relate to career outcomes. the investigators will use and expand an emerging infrastructure of data and measures to conduct a rich, multilevel analysis of individual career paths in the transition from graduate training to the workforce in the context of supply and demand factors that exist throughout a researcher's career. the investigators will (1) study how the characteristics of interdisciplinary researchers compare to disciplinary researchers and how the structure of the teams and networks in which they train compare, (2) develop a range of novel measures of early career outcomes to study how outcomes relate to training environments of disciplinarians and interdisciplinarians, and (3) study how outcomes vary across disciplines and by market demand. the project will enable young researchers to be better informed about the career outcomes of interdisciplinary researchers and provide actionable information to improve the training environments for these researchers. the project will be implemented using the emerging umetrics



infrastructure, and the data and metrics that the investigators develop on interdisciplinarity will flow back into the umetrics data infrastructure and made accessible for other researchers through the virtual enclave run by the institute for research on innovation and science at the university of michigan. the research will include three tasks. task 1: develop rich multi-faceted measures to identify interdisciplinarity among stem doctoral students and researchers. a wide range of integrated data resources will be used to operationalize ?interdisciplinarity?. investigators will generate field-based measures, citation-based measures, field transition measures, and text-based measures that will be cross-validated to trace the interdisciplinarity of research trajectories post graduation. task 2: describe the environments in which interdisciplinary graduate students train. investigators will describe a range of dimensions of training environments and how they relate to interdisciplinary research, including advisors, teams, team size and composition, team **\*\*diversity\*\***, and funding mechanism. task 3: estimate a wide range of career outcomes for interdisciplinary phd recipients and the role of supply and demand in shaping outcomes. data will examine whether interdisciplinary research is mostly induced by discoveries in new fields that open new avenues of research or whether the need for interdisciplinary research induces these discoveries. the project will expand an evolving data infrastructure for investigating stem workforce development. the project is supported by the ehr core research program that funds fundamental research focused on stem learning and learning environments, broadening participation in stem fields, and stem workforce development. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SCH: Enhanced detection of impending problem behavior in people with intellectual and developmental disabilities through multimodal sensing and machine learning

Awardee: Vanderbilt University

Amount: \$1,103,997.00

Abstract: children with intellectual and developmental disabilities (idd) are at increased risk of showing ?problem behavior? that place them at risk of getting hurt, removed from the classroom, or hospitalized. approximately 1 in 6 children and adolescents in the united states are diagnosed with idd and half of them experience some form of problem behavior. therapists trained in applied behavior analysis, or aba, can help determine why problem behavior happens and how to prevent it. these therapists watch children, try to evoke problem behaviors by changing a child?s environment, then try things that might change behavior, and see if the behavioral data changes. because problem behavior can be triggered during this process, this strategy sometimes put them or their patient at risk. it also takes a lot of time. wearable technology and advanced computational strategies could help increase the safety and helpfulness of strategies to prevent problem behavior. specifically, small sensors worn in clothing or on the wrist could provide data about a child?s body, or ?physiological responses,? like heart rate or sweat. machine learning can then be used to determine what combination of body signals imply a problem behavior is about to happen. this project has two stages. in the first stage, the team will design new sensors that detect biological signals such as sweating, motion, and heart rate. the team will then measure how well these sensors work. this includes asking people with idd what they think about the sensors. based on that input, the team will change the sensors and then use them in a larger study. the goal is to test whether the system can predict problem behavior, how well it works when used in the real-world with real therapists, and what users think about the system. results of this study will help researchers and practitioners understand if this kind of wearable technology is helpful and acceptable as part of supporting people with problem behavior and idd. this project proposes to integrate transdisciplinary expertise in cutting-edge wearable sensing, affective computing, machine learning, and behavioral and clinical science to enhance and transform existing models of behavioral intervention for problem behaviors in children and adolescents with idd. problem behaviors, including self-injury, aggression, property destruction, and wandering not only can cause serious injury or death, but also interfere with the ability to participate in school, home, and other community

settings. in the context of problem behavior and idd, this project will fundamentally advance the scientific and the technological methodologies of multimodal wearable sensing-based design of predictive machine learning models. the two research thrusts are: (1) design of multimodal sensor framework; and 2) real-time precursor prediction. across these thrusts, the project will make fundamental scientific and technological advancements in: (i) a low-power, open-access, user-centric wearable sensor framework that can sense physiological responses and gestures to be used for affective computing; and (ii) a set of novel, clinically grounded, semi-supervised machine learning models to predict problem behavior that can be used by behavioral interventionists in real-time. an important novelty of this research that separates it from existing work in the field is that the team proposes to address the detection of problem behavior through its precursors, rather than the behaviors themselves, with the goal of increasing the safety and efficiency of sessions. these scientific and technological advancements will be created within a state-of-the-art clinical and behavioral science framework. the proposed work will foster interdisciplinary research in engineering and health sciences. the team proposes a number of outreach and educational activities that will have broader impact in stem education: i) involve individuals with asd directly in the research through the frist center for autism & innovation?s neuro\*\*diversity\*\* corps; ii) provide interdisciplinary training opportunities for early stage clinical scientists; iii) provide research opportunity to high school, undergraduate, and graduate students; iv) provide research opportunity to high school teachers; v) bring research into the classroom; and vi) disseminate the research through seminars, presentation, and publication. emphasis will be placed on recruiting candidates from minority and underrepresented groups to improve \*\*diversity\*\* in stem. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EVOLUTIONARY CONFLICT AND PHENOTYPIC DIVERSITY IN SOCIETIES

Awardee: Georgia Tech Research Corporation

Amount: \$1,100,989.00

Abstract: biological organisms display remarkable **diversity** in form and function. for example, individuals frequently belong to distinct functional classes, such as the male and female sexes. however, because individuals within species generally possess the same set of genes, the development of distinct classes is expected to be constrained. the goal of this research is to study the constraints on the development of distinct classes in social insects. social insects represent excellent study systems because insect societies are composed of distinct functional classes such as the queen, worker, and male castes. in addition, social insects, such as bees, wasps, ants, and termites, have great ecological and economic importance. this research will analyze the physical forms, gene functions, and genome sequences of social insects to understand the importance of the shared genome on the development of distinct classes. the research will also include several broader impacts that will extend the influence of this research to educational activities aimed at training and educating the public. this research is significant because it will provide insight into the genetic mechanisms associated with the development of distinct functional classes and the causes of organismal **diversity** within species. phenotypic **diversity** is a hallmark of metazoan taxa. however, phenotypic evolution is constrained by intralocus conflict, which occurs when individuals within species possess traits that have a common genetic architecture. this research will explore intralocus conflict in social insects and determine if conflict has constrained phenotypic evolution in societies. study of genetic conflict in societies is particularly interesting because individuals may experience both intralocus caste conflict, which occurs between the castes, as well as intralocus sexual conflict, which occurs between the sexes. this research will test intralocus conflict theory. first, the research team will determine genetic correlations for morphological traits in queens, males, and workers. second, intralocus conflict will be studied at the molecular level by testing predictions about genetic correlations for gene expression phenotypes. finally, evidence for intralocus conflict will be detected by examining population genomic variation. this program will also promote

teaching, training, and learning. research will be incorporated into university classes, city-wide activities, and disseminated in the popular media. overall, this research program will result in one of the most thorough empirical investigations of intralocus conflict theory and provide insight into the mechanisms affecting phenotypic **\*\*diversity\*\***. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: RESEARCH-PGR: Extracellular RNA Produced By Plants: What, Where, How, Who, and Why?

Awardee: Indiana University

Amount: \$1,100,000.00

Abstract: this project investigates the role of secreted rna in the immune system of plants. the innes and meyers laboratories recently discovered that the leaves of plants accumulate rna in the spaces between cells and on their surfaces. although we usually think of rna as a molecule that can direct cells to synthesize specific proteins (e.g., the mrna in covid vaccines directs our cells to make sars-cov2 spike protein), some rnas serve other functions. analysis of the base sequences of plant extracellular rnas revealed that these rnas are diverse in sequence, but do not appear to encode proteins. the discovery of extracellular non-coding rna in plants raises two fundamental questions that this project will address: 1) how do plants secrete rna? and 2) what is the function of this rna? it takes a large amount of energy for cells to secrete rna, thus this secreted rna must benefit the plant in some way. this project will test the hypothesis that secreted rna functions to protect plants from infection by fungi and bacteria. if this hypothesis is correct, the proposed research will enable generation of crop plants with improved immune systems that are more resistant to disease. such crops are needed to feed a growing global population in a sustainable manner, while reducing the environmental impacts of agriculture. the innes and meyers laboratories recently discovered that

the apoplast of arabidopsis leaves contains abundant long non-coding rnas, including circular rnas, as well as small rnas. these rnas are bound to protein particles, which protects them against degradation. notably, this extracellular rna (exrna) is highly enriched in the post-transcriptional modification n6-methlyadenine (m6a). these discoveries raise fundamental questions about plant biology: are there specific exrnas that are broadly conserved across plant species? how are exrnas secreted, and are post-transcriptional modifications central to this process? and why do plants produce exrnas? do they play a fundamental role in plant-microbe interactions? to answer these questions, exrna will be purified from the apoplast and leaf surfaces of seven diverse species: arabidopsis, soybean, tomato, lettuce, pineapple, rice, and maize, which were chosen based on their phylogenetic **\*\*diversity\*\***, genomic resources, importance as crops, and **\*\*diversity\*\*** in physiology. these exrnas will be analyzed using both rna-seq and srna-seq, which will allow identification of rnas that are conserved between species. to assess whether m6a or other modifications are required for secretion, transgenic plants that express exrnas that lack modification sites will be tested for their secretion efficiency. to investigate additional requirements for exrna secretion, the exrna content in arabidopsis and rice plants with mutations in known rna binding proteins and secretory pathway genes will be analyzed. lastly, to assess whether exrnas contribute to immunity, mutants compromised in exrna secretion will be tested for resistance to fungal and bacterial pathogens. this award was co-funded by the plant genome research program and the plant biotic interactions program in the division of integrative organismal systems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EDGE CMT: Evolutionary developmental systems genetics of obligate sterility in ants

Awardee: Texas Tech University

Amount: \$1,100,000.00

Abstract: a major goal of biology is to understand the links between genomes and development and how evolution has tinkered with these mechanisms to produce the **\*\*diversity\*\*** of life. ants provide powerful study systems for exploring these and related topics because they show striking **\*\*diversity\*\*** within and between species. a defining feature of ant societies is the presence of a reproductive caste system where some individuals called queens specialize on reproduction and other individuals called workers specialize on other tasks. in most species, workers possess reduced reproductive organs and are capable of reproduction under certain circumstances (e.g., queen death), but in other species, workers completely lack reproductive organs. such obligate worker sterility has evolved at least 14 times across ants, yet little is known about the molecular mechanisms regulating the expression of this obligate sterility or whether the mechanisms are the same across each of the independent origins of sterility. the overall goal of this research is to elucidate the mechanisms underlying the expression and evolution of obligate sterility in ants and to further validate the effects of genes influencing the development of sterility in fruit flies. our research may provide novel insight into conserved genetic pathways regulating animal reproduction and reproductive health. further broader impacts of the research will be training students and researchers in approaches to study the genetic basis and evolution of development, working to improve public understanding of evolution and development, and working to increase student participation in science.

a major goal of biology is to understand the mechanisms linking genomes to phenotypes and how evolution generates and tinkers with these regulatory mechanisms to produce the **\*\*diversity\*\*** of life. one striking phenotype is the presence of an obligately sterile worker caste in social insects, which has evolved at least 14 times in ants, yet little is known about the underlying regulatory networks and whether this convergent phenotypic evolution involves convergent or parallel molecular evolution. the overall goal of this research is to use an integrative approach to elucidate the gene regulatory networks underlying the expression and evolution of obligate sterility in ants. ants provide a rare opportunity to study how infertility and sterility evolved within the context of their societies, connecting individual germline loss to colony-level gain of a

sterile worker caste. the germ-soma distinction within organisms is fundamental to multicellular life, and germline sequestration is a fundamentally important step in animal development. this research may contribute to understanding general principles and molecular pathways associated with animal development and the origin of cell types. moreover, the research may provide novel candidate genes and pathways regulating a range of complex phenotypes associated with reproduction, reproductive health, to be further studied in model organisms. further broader impacts of the grant include training students and postdoctoral researchers in approaches to study the genetic basis and evolution of development, working to improve public understanding of evolution and development, and working to increase student participation in stem fields. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Signal to Noise: How Complex Social Information Regulates Brain Genomics and Behavior

Awardee: University of Kentucky Research Foundation

Amount: \$1,042,815.00

Abstract: life experiences change individual behavior through complex interactions between environmental inputs and gene activity in the brain; it is unclear why certain experiences have lasting effects on behavior while other effects are easily reversed. this question is relevant to animal bio\*\*diversity\*\*, but also human health research, where one goal is to mitigate the behavioral impacts of experiences like social trauma. though dynamic brain gene activity underlies experience-induced changes in behavior, the exact mechanisms that regulate the persistence of an experience are unclear. for example, experience may chemically alter brain dna and therefore permanently change gene activity. however, a change in gene activity itself may be temporary, but lead to permanent changes in other factors that influence behavior, like brain structure. this study



uses experimental manipulations of gene regulating mechanisms to determine whether certain ones reliably predict the longevity of an experience. the subject of these studies is the honey bee (*apis mellifera*), a critical crop pollinator with a well-established relationship between social experience, brain gene activity, and aggressive behavior. teams composed of students and beekeepers will complete research objectives and organize a summit that introduces high school students to research results and academic, industry, and non-profit career opportunities in agricultural stem. in addition to filling critical knowledge gaps in the study of behavioral **\*\*diversity\*\***, this project will improve public science literacy and enhance partnerships among students and professionals inside and outside of academia. these steps contribute to an overall outcome of increased stem workforce **\*\*diversity\*\***, retention and career success.

in honey bees, adult defensive aggression and brain gene expression are persistently changed by social information accrued over the course of several days. to a degree, these phenotypes are also responsive to immediate information about threats to the beehive, enabling researchers to assess the circumstances under which persistent social experiences are updated by new information. persistent effects are correlated with changes in brain dna methylation and decreased lipid content in a peripheral endocrine tissue known to impact brain gene expression, the fat body. thus, the longevity of social experience could be a result of the gene regulatory impacts of brain dna methylation, endocrine signaling patterns, or both. researchers use intricate adult social manipulations to produce bees that display similar levels of aggression, but with different gene regulatory underpinnings (variation in brain dna methylation, fat body lipid content, or both). these bees will be used to examine which regulatory mechanisms predict the strength of response to new information, in terms of behavior, brain physiology (mitochondrial bioenergetics), and genome function (gene expression and chromatin accessibility measured using rna-seq, bisulfite-seq and atac-seq). larval bees also show persistent behavioral effects of their pre-adult environment. manipulations of larvae and measures of adult behavior will be used to determine whether the longevity mechanisms identified in adults also apply to a second life stage. this study addresses critical knowledge gaps in the relationship between brain genomics and behavioral

plasticity, including how peripheral systems and brain epigenetic mechanisms work together to regulate brain gene expression and behavior. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: DMREF: Symmetry-Guided Machine Learning for the Discovery of Topological Phononic Materials

Awardee: University of California-Santa Barbara

Amount: \$1,040,000.00

Abstract: non-technical description: fundamental understanding and control of heat conduction processes in materials are important for energy infrastructure, electronic devices, and renewable energy generation systems. this project focuses on a novel property of phonons ? vibrations of atoms that carry the heat in materials - called "topology". this property may allow new phenomena, such as heat conduction perpendicular to the temperature gradient direction and more efficient transport of heat waves on the material surfaces. to discover topological phonons, the research team will exploit a materials genome approach to search for materials hosting these special heat carriers. once candidates are identified, the research team will synthesize and characterize them, and the results will be used to refine the search algorithm. the research team plans to establish a public database storing the heat conduction properties of a large number of materials. this research will not only advance the fundamental understanding of how topology affects heat conduction in real materials, but also provide new routes to realizing unusual functionalities such as heat conductors that can be switched on and off. this project also supports educational activities to teach basic materials physics concepts to k-12 and undergraduate students through hands-on class projects and short courses. to promote **\*\*diversity\*\*** in the materials science workforce, the team also provides research opportunities to high school and undergraduate students from underrepresented

minority communities.      technical description: while the topology of electronic states has been a central theme in condensed matter physics for the past decade, topological phononic states have received much less attention. unlike their fermionic counterparts, topological states in the entire phonon spectrum can contribute to observable material properties, making topological phononic materials ideal testbeds for emerging new physics in topological bosonic systems, including phonon thermal hall effects, novel topological phonon-electron interactions and the resulting phenomena, such as unusual superconducting states. this project aims to systematically identify materials hosting intrinsic topological phonons in the thermal regime, where the topological phononic states explicitly modify intrinsic material properties, including thermal transport, electron-phonon interactions, and surface phonon modes. the research team will seek to accelerate material discovery by incorporating symmetry-guided machine learning based on euclidean neural networks. machine learning predictions will be verified using first-principles phonon simulation and topological invariance analysis. promising candidate materials will be synthesized as thin films and bulk single crystals and characterized using inelastic neutron and x-ray scattering, thermal transport, and surface-sensitive spectroscopy and scanning probe measurements. this research will advance fundamental understanding of topological bosonic systems and examine new thermal functionalities enabled by topological phonons.      this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Local-Scale Drivers and Responses of Thermospheric Weather above Antarctica

Awardee: University of Alaska Fairbanks Campus

Amount: \$1,034,406.00

Abstract: observations of the earth's upper atmosphere at the altitudes from above 100-km to a few hundred kilometers is subjected to highly variable forces as from the top (energy and momentum

transferred down from the solar wind interaction with geomagnetic field) as well as from the bottom ? from the lower atmosphere and mesosphere which generate gravity waves from the global atmospheric circulation driven mainly by the solar radiation. it is not easy to explore the upper atmosphere which lays below the satellite orbits, so only a remote technique instrumentation (such ground-based fabry-perot spectrometers, fps) is used for that kind of studies. latitudes of interests here are polar regions, specifically antarctica where two modern fpss are deployed at mcmurdo and south pole stations. this award will focus on the behavior and governing physics of the transition from the neutral fluid-like dynamics in the lower atmosphere to the plasma electrodynamics in the ionosphere and geospace domain above it. this transitional domain is frequently called the space-atmosphere interaction region (sair). knowledge of sair's properties and dynamics are important because they strongly impact many modern technological systems such as radio wave communication, navigation, and long-range radar applications. the primary goals of this research are identifying the role of waves and tides propagating upward from below and driving perturbation within the sair, and what is the role of forcing from above in driving high-latitudes thermospheric weather. the broader impact of this research is training the next generation of scientists through deep involvement of students and active support for \*\*diversity\*\* and inclusion. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Elucidating the interplay between two chromatin regulators HDA8 and ELP3 in dynamic control of primary and secondary metabolic networks

Awardee: Purdue University

Amount: \$1,002,041.00

Abstract: this project will yield knowledge on how plants coordinate metabolic networks to produce specialized metabolites that facilitate plant interactions with their environment, ranging from

attracting pollinators and seed dispersers to protecting themselves from biotic and abiotic stresses. to date, it remains largely unknown how metabolic networks are regulated to balance the needs for maintaining essential functions and producing specialized metabolites. this project will shed light on chromatin regulatory mechanisms that coordinate metabolic networks to produce volatile secondary metabolites, by testing the hypothesis that an interplay between two chromatin regulators controls the dynamic metabolic flux through primary and secondary metabolic pathways. the obtained knowledge has practical implications for both agriculture and ecology, with potential to improve plant reproductive success, plant defense and stress responses, crop nutritional value, and yield of high value phytochemicals. this project will provide multidisciplinary training for the next generation of scientists, including minorities and high school students, in stem research. preliminary studies using petunia hybrida flowers as a model system led to the hypothesis that histone deacetylase 8 (phhda8) works with the histone acetyltransferase phelp3 to regulate primary and secondary metabolic networks responsible for the biosynthesis and emission of volatile secondary compounds. to test this hypothesis, the following research objectives will be performed: (1) determining the impact of phhda8 and phelp3 on dynamics of primary and secondary metabolic networks via metabolic profiling; (2) deciphering the genome-wide targets of phhda8 and phelp3 in primary and secondary metabolic networks using functional genomics approaches; and (3) elucidating the molecular mechanisms coordinating phhda8 and phelp3 activities through biochemical approaches. this work will provide important mechanistic insights into the mode of action and interaction of histone acetylation proteins. the obtained knowledge will have a far-reaching impact on understanding chromatin level regulation underlying the chemical **diversity** found in nature and airborne communications in the plants. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Mentorship and Project-Based Learning to Support Computational Thinking and Computer Science Education Pathways for Underrepresented Students in Los Angeles

Awardee: University of California-Los Angeles

Amount: \$1,000,000.00

Abstract: educating black and latinx middle and high school students in the field of computer science with specialized skills is of high social and economic interest to the united states. computational thinking skills, such as persistence in working with difficult problems and collaborating with others to achieve a common goal, are foundational in preparing students for careers in computing and technology. this partnership between ucla and a neighboring middle and high school in south los angeles will explore how developing computational thinking skills may also enhance students' understanding of math concepts. to do this, the team will focus on supporting students of color through two critical aspects of education pathways through computer science: the delivery of knowledge by teachers and social influence near-peer mentors. this project builds upon a current partnership between the critical design and gaming schools (cdags) in south los angeles and the center for the transformation of schools (cts) at ucla that centers on effective interventions for 9th grade underrepresented students and expands the work to 300 students in 6th-12th grade. the project seeks to advance understanding of effective models for ct student development in schools that serve predominantly low-income students of color, as well as the types of educational pathways and partnerships that can remove barriers to learning and how ct development can be used as a means for promoting student learning in mathematics. the proposal investigates two critical factors in the cs preparation pathway: the delivery of knowledge by teachers and social influence near-peer mentors. the model will emphasize common instructional strategies to promote ct development and mentorship from ucla's center for excellence in engineering and \*\*diversity\*\* (ceed) an organization that will provide a pipeline of undergraduate mentors to work with teachers and student mentees at both schools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Adaptation: Adapting Successful Practices to foster an Inclusive, Respectful, and Equitable Environment (ASPIRE2)

Awardee: University of Texas at Dallas

Amount: \$1,000,000.00

Abstract: the university of texas at dallas (ut dallas) will be adapting successful practices to foster an inclusive, respectful, and equitable environment (aspire2) to significantly and systematically transform the campus in ways that will expand and enrich the **\*\*diversity\*\*** of its faculty in stem fields and beyond. through the aspire2 project, ut dallas will adapt and implement successful activities to foster a more inclusive campus climate, recruit more women in stem fields, (including women of color and women from underrepresented minority groups), and aid in the retention of all women faculty, in stem and across campus. the goal of the project is help ut dallas, a major research university, better reflect and represent the world in terms of gender and racial **\*\*diversity\*\***. by doing so, ut dallas can better serve its community, state and country, helping solve the national crisis of the disproportionate lack of tenured-system women, especially in stem fields. the outcomes of the aspire2 project are expected to bring about structural and cultural transformation and tackle persistent problems in innovative and intersectional ways. the aspire2 activities include: climate (training for deans, department/program heads, and faculty will be conducted; a department/program head council will be formed; an advocates and allies program will be developed; a biennial climate survey will be administered; and equity dashboards for the university and individual schools will be instituted), identification and recruitment (activities include future faculty career development workshops, paying careful attention to the composition of and training for search committees, and providing faculty liaisons to search committees), and retention and advancement (strengthening the existing faculty mentoring program, creating a women in stem employee resource group, and augmenting existing workshops for faculty promotion and tenure).

this project will enhance the climate on the ut dallas campus while broadening the participation and success among women faculty, particularly women of color and women from underrepresented minority groups. building on existing efforts, ut dallas is well-poised to create a more welcoming and inclusive environment by adapting previously vetted initiatives and strengthening the relationships across campus between administrators, faculty, and staff through the aspire2 activities. increasing faculty **\*\*diversity\*\*** will fuel new research collaborations while enriching teaching, learning and the overall student experience. the nsf advance program is designed to foster gender equity through a focus on the identification and elimination of organizational barriers that impede the full participation and advancement of diverse faculty in academic institutions. organizational barriers that inhibit equity may exist in policies, processes, practices, and the organizational culture and climate. advance "adaptation" awards provide support for the adaptation and adoption of evidence-based strategies to academic, non-profit institutions of higher education as well as non-academic, non-profit organizations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF RISE: Enhancement of Research Capability and Development of Early Career Faculty at Tuskegee University

Awardee: Tuskegee University

Amount: \$1,000,000.00

Abstract: the historically black colleges and universities research infrastructure for science and engineering (hbcu-rise) activity within the centers of research excellence in science and technology (crest) program supports the development of research capability at hbcus that offer doctoral degrees in science and engineering disciplines. hbcu-rise projects have a direct connection to the long-term plans of the host department(s) and the institutional mission and plans for expanding institutional



research capacity as well as increasing the production of doctoral students in science and engineering. with support from the national science foundation, tuskegee university intends to mentor five early career stem faculty by immersing them in four interconnected activities. the proposed interventions enhance research and education in advanced materials, provide research experiences at national laboratories, foster grantsmanship and provide training in career-life balance.

the goal of the tuskegee university (tu) rise proposal is to develop, implement and disseminate a model to increase the number of junior faculty with the expertise in materials science and engineering (mse) at tu who will in turn increase the production of phds in mse. five early career stem faculty will be immersed in the following four interconnected mentored interventions designed to bolster their expertise in mse research and develop skills in the preparation of competitive proposals for research funding while adopting positive work-like balance practices: intervention 1 (research) will enhance research and educational capabilities in advanced materials; intervention 2 (research) will provide research experiences at national laboratories; intervention 3 (grantsmanship) will foster grantsmanship through mentored support in all pre and post award processes; and 4) intervention 4 (work-life balance) will provide a workshop series on career-life balance. these interventions will allow tu junior faculty to become more competitive in attracting research grants from federal agencies and foundations and increase the number of underrepresented african american doctoral students. the processes and knowledge developed through interventions 1 & 2 in advanced materials will help in product development in areas such as biomedical, agriculture and polymer science. additionally, the knowledge that will be generated by the rise model is scalable and can be replicated at other hbcus to overcome the challenges faced by their junior faculty. the broader impacts also include improved research capabilities at tu in advanced materials and the production of many minorities and women with b.sc., m.sc. and ph.d. degrees. participating students will be trained in cutting-edge research and learn communication and interpersonal skills which will enable them to become role models for other students. moreover, these graduates will help bring much-needed **\*\*diversity\*\*** to the nation's advanced technological workforce. the human and

physical scientific infrastructure established by the rise grant will contribute to tu's long-term vision of reaching the carnegie classification as a doctoral granting institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: ADVANCE Adaptation: Project SAGES: Striving to Achieve Gender Equity in STEM

Awardee: SUNY at Albany

Amount: \$1,000,000.00

Abstract: the university at albany is a doctoral institution with a strong commitment to research excellence. it boasts a highly diverse undergraduate population and strives to excel as a diverse and

inclusive campus community; yet, women and women of color are underrepresented in the faculty ranks of stem departments. the goal of project sages is to create an environment in which women of all backgrounds and identities can thrive and develop their careers to their fullest potential. to accomplish this goal, project sages seeks to increase the number of women scientists in stem fields through proactive recruitment and unbiased hiring procedures and retain them by creating a climate and culture in which women feel supported, thrive, and advance in their careers from assistant to associate to full professor.

the aims of project sages are threefold: aim 1 seeks to increase the **\*\*diversity\*\*** of applicant pools for faculty searches in stem through a postdoctoral visitation program to identify competitive candidates for job vacancies and by education of search committees and decision makers on inclusive, unbiased search processes. to promote diverse applicant pools, search chairs will receive real-time feedback about pools to permit proactive measures if **\*\*diversity\*\*** does not meet national norms for the field. aim 2 seeks to improve the campus climate by subtly shifting departmental norms and cultures. departmental interventions will comprise awareness training for chairs, the formation of department climate committees, and ally training for men and women, all with the goal of creating a more inclusive environment. in addition, consistent and transparent policies and procedures will be implemented that meet the needs of a diverse faculty. aim 3 seeks to support women's research success. a networking program for women faculty and women of color and a pilot funding program will allow women in stem to build collaborative research teams. additional support is provided with a novel external sponsor program in which female assistant professors are paired with a prominent expert from another university who will provide ongoing guidance on best strategies for networking, funding, publishing, and achieving tenure. through these interventions, project sages aims to bring about sustained institutional transformation at the university at albany with the goal of achieving inclusive excellence in stem that better reflects the university's highly diverse student body. the interventions will lead to a more nurturing and family-friendly environment for women scientists of diverse identities and maximize their success through comprehensive professional support structures and an equitable tenure and

promotion process. outcomes from project sages will be disseminated through multiple outlets including a website. the nsf advance program is designed to foster gender equity through a focus on the identification and elimination of organizational barriers that impede the full participation and advancement of diverse faculty in academic institutions. organizational barriers that inhibit equity may exist in policies, processes, practices, and the organizational culture and climate. advance "adaptation" awards provide support for the adaptation and adoption of evidence-based strategies to academic, non-profit institutions of higher education as well as non-academic, non-profit organizations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Applying Student Knowledge for Success in Cybersecurity and Data Science

Awardee: Fairleigh Dickinson University

Amount: \$999,987.00

Abstract: this project will contribute to the national need for well-educated scientists, mathematicians, engineers, and technicians by supporting the retention and graduation of high-achieving, low-income students with demonstrated financial need at kean university, the new jersey institute of technology, fairleigh dickinson university, brookdale community college, and union county college. in particular, it responds to areas of national need in cybersecurity and data science by increasing the number of students graduating in computer science (cs) and information technology (it). moreover, the project will build regional workforce strength and contribute to the knowledge base on the role of student competence and belonging in ensuring persistence to degree attainment. over its five-year duration, a total of 256 students will benefit, receiving scholarships to complete cs or it degrees. project components include scholarship support for students, undergraduate research and/or professional experience opportunities prior to graduation, and generation of new knowledge through research on economic realities for students and impact on

career trajectories in cybersecurity and data science. students in this program will be prepared to enter the scientific workforce or graduate school as competent, highly trained individuals with a background in teamwork and research. furthermore, they will contribute to increased professional **\*\*diversity\*\*** in the fields of cs and it, and serve as role models to members of their communities.

the students recruited for this program will participate in workshops, take advantage of cohort experiences, and interact closely with faculty who will provide i) academic advising, ii) guidance for navigating higher education and postgraduate opportunities, and iii) supervision of teamwork, research, and working professional experiences. through undergraduate research opportunities and experiences from participation in faculty research programs and/or existing summer research and internship programs, these individual and cohort experiences will provide a basis for overall intellectual growth and promote increased student confidence, retention, and timely degree completion. these academic outcomes are in turn expected to allow students to successfully navigate common attrition points including financial hardship and professional identity development for post-graduate employment and continued education. the project's academic environment includes student-faculty advising and undergraduate research activities, using the affinity research group (arg) model and peer-mentoring. the use of teamwork, collaboration and student-motivated question and answer sessions will positively support research in the field of computer science and information technology regarding educational impact and retention, particularly for minorities, female, and first-generation students. this project is funded by nsf's scholarships in science, technology, engineering, and mathematics program, which seeks to increase the number of low-income academically talented students with demonstrated financial need who earn degrees in stem fields. it also aims to improve the education of future stem workers, and to generate knowledge about academic success, retention, transfer, graduation, and academic/career pathways of low-income students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Closing STEM Student Academic Performance Equity Gaps Through Student Research Exposure and Faculty Professional Development in Pedagogy and Curricular Innovation

Awardee: Riverside Community College District/Riverside City College

Amount: \$999,968.00

Abstract: with support from the improving undergraduate stem education: hispanic-serving institutions (hsi program), this track 2 implementation and evaluation project will implement evidence-based faculty development leading to an institutional culture supportive of **\*\*diversity\*\***, equity, and inclusion within stem disciplines at a minority serving community college. further, it will demonstrate the combined impact of such pedagogical and curricular practices with sustained, multi-faceted student supports, and enhanced exposure to undergraduate research experiences for building stem identity, leading to improved student academic performance and successful transfer to baccalaureate stem degree programs. annually, rcc serves more than 30,000 students. students from traditionally underrepresented ethnic backgrounds represent 73% of students enrolled at rcc, of which hispanic students are the majority group (63%). for the students of rcc, education, especially stem education, offers the promise of improving their social mobility and quality of life. however, these disciplines are among the most rigorous, and have high course failure and attrition rates. there are notable equity performance gaps in core stem course performance, persistence within stem, and transfer to four-year universities for hispanic, african american, and other underrepresented groups in higher education. we seek to change that through sustainable improvement in teaching and learning. to accomplish this goal, we are partnering with california state university san bernardino (csusb) to replicate work they have done with faculty development around inclusive and responsive stem pedagogy, and to expand targeted student support, mentorship and exposure to student research opportunities. two complementary sets of activity will be implemented: (1) peer-led faculty professional development focused on pedagogical and

curricular improvements in stem; (2) expansion of student experiential learning and research within and across stem disciplines, and through exposure to summer research experiences at a transfer destination university. those activities will result in (1) increased stem faculty knowledge, skills, and utilization of culturally sensitive, inclusive, and active learning pedagogy; (2) increased stem student retention, term-to-term persistence, course success, and transfer rate, and closing of student equity gaps; (3) contributions to the knowledge-base about **diversity**, equity and inclusion (dei) in stem.

the project will create a stem faculty learning community (flc) to develop and implement equity-minded, evidence-based practices proven effective for supporting hispanic and other underrepresented students to succeed in postsecondary stem education. research will contribute to the knowledge on stem education within minority serving institutions by employing a mixed-methods approach to holistically assess the project's implementation and outcomes at multiple levels. the project will measure changes in flc participants' awareness and implementation of high-impact practices and knowledge of dei issues in stem, and changes in students' stem-related identity, belonging, and career plans, as well as their academic performance and trajectory. the project results will be informed by and contribute to the literature on underrepresented minority student persistence and success in stem disciplines, as well as stem faculty professional development focused on high-impact teaching practices. results of this work will be disseminated to multiple audiences via disciplinary conferences, and presentations at conferences specific to community colleges and hispanic serving institutions. the hsi program aims to enhance undergraduate stem education, broaden participation in stem, and build capacity at hsis. achieving these aims, given the diverse nature and context of the hsis, requires innovative approaches that incentivize institutional and community transformation and promote fundamental research (i) on engaged student learning, (ii) about what it takes to diversify and increase participation in stem effectively, and (iii) that improves our understanding of how to build institutional capacity at hsis. projects supported by the hsi program will also draw from these approaches to generate new knowledge on how to achieve these aims. this award reflects nsf's statutory mission and has been deemed worthy of support



through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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these aims. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Adaptation: Empower through Inclusivity: Developing Pathways to Success

Awardee: South Dakota School of Mines and Technology

Amount: \$999,963.00

Abstract: an nsf advance adaptation award will allow the south dakota school of mines and technology (sdm) to initiate new programs and improve upon existing data collection and personnel policy to enhance gender, racial, and ethnic **\*\*diversity\*\***. sdm is a phd granting engineering science and technology university that is geographically isolated, surrounded by counties in the region considered frontier and remote (far) areas having populations of less than 7 people per square mile. its size (2700 students, 145 faculty), location, and stem focus provide challenges with respect to retention of a diverse faculty. our intent for this project will be to empower sdm faculty and research staff by shifting from a culture of attrition to a culture of development and engaging the majority populations of faculty at sdm to increase awareness of implicit biases, promote pathways to success for all faculty, and improve campus culture and climate. through careful curation and adaptation of successful advance initiatives, the project aims to enable a change in institutional culture. the project design is rooted in an understanding of the current climate and needs of the sdm faculty, including instructors and research professionals. the merit of the project is that it engages top-down support for programs that will have a marked impact on campus climate allowing for a transition from a culture of attrition to a culture of development. to improve retention of underrepresented groups, the project intends to include adaptation of three proven programs: advocates and allies (ndsu), facilitated mentoring circles (murray state), and mutual mentoring (umass). these programs are structured to include feedback to improve policy, involve expert advisors and evaluators, and are rooted in an enhanced plan for data collection and analysis. this project aims to directly address the

need to improve the participation of women in stem fields by providing programs to increase retention and career advancement at a science and engineering specialty school in an epscor state that serves a far region. planned activities will not only benefit women tenure-track faculty but will be made available to individuals in other career paths (instructional and research staff), to all genders, and to all ethnicities/races represented on campus. these efforts also will lead to improved educational opportunities for students to learn with a diverse faculty with members fully engaged in campus culture. best practices from sdm efforts will be made available to other institutions in the state, including the other five institutions in the board of regents system, three tribal colleges/universities, and two private universities. the nsf advance program is designed to foster gender equity through a focus on the identification and elimination of organizational barriers that impede the full participation and advancement of diverse faculty in academic institutions. organizational barriers that inhibit equity may exist in policies, processes, practices, and the organizational culture and climate. advance "adaptation" awards provide support for the adaptation and adoption of evidence-based strategies to academic, non-profit institutions of higher education as well as non-academic, non-profit organizations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RAISE: Spring & Wings: Resonance in insect and engineered flight with synchronous and stretch-activated actuation

Awardee: Georgia Tech Research Corporation

Amount: \$999,844.00

Abstract: this research advanced by interdisciplinary science and engineering (raise) project will develop a dynamical model to enhance understanding of insect flight as an integrated system and apply this information to robotic design. flight at the size of insects is very energetically challenging.

nonetheless, the evolution of flight spurred much of the evolutionary **\*\*diversity\*\*** of insects we see today. insects fly long distances, maneuver in crowded and gusty environments, and overcome the energetic limitations of flapping wing flight in ways that cannot yet be matched in human-engineered systems. insects couple springy exoskeletons to their wings to help store and return energy on every flap; however, to maximize energy return, insects would have to beat their wings at a steady rate. this project will explore how insects couple springs and wings together to manage energy requirements and flight control under a range of conditions. this project will also explore how the two distinct types of muscle contraction that insects use to power flight could both be achieved with the same underlying mechanics and muscle properties, enabling a mathematical framework for understanding how insects achieve such different types of flight. the project will use robophysical models with springy exoskeletons coupled to wings and insect-scale flapping robots to establish a general "spring-wing" framework. research at both collaborating institutions will include an immersive, vertically integrated undergraduate research program. student teams will receive mentorship and on-site research experience during the school year and will travel to their exchange location for interdisciplinary summer research. at least two graduate students and a post-doctoral fellow will also receive cross-disciplinary training. insect-scale flapping-wing flight demands both high-power actuation and low-latency control. to mitigate flight power requirements, most insects actuate their wings indirectly via muscles that deform a stiff, elastic exoskeleton. coupling elastic elements to the wings allows insects potentially to operate as a resonant system, which would reduce power costs but also would introduce control constraints, such as limiting wingbeat frequency modulation. to power flapping flight, insects evolved two distinct actuation strategies: synchronous flight, with time-periodic forcing of antagonistic muscles paced by the nervous system, and asynchronous flight, in which muscles set up self-excited oscillations due to strain-dependent activation. the project will establish an analytic framework for spring-wing systems, test if insects operate at their hypothesized resonant frequencies, and develop a dynamically scaled robophysical spring-wing flapper to explore how a single non-dimensional parameter, the weis-fogh number,

influences elastic energy storage and aerodynamic force control. the two muscle actuation strategies will then be combined, testing if synchronous flying insects that have evolved from asynchronous insects retain the necessary physiological signatures of self-excited (asynchronous) oscillations. a single dynamic system that can transition from the two regimes of stable flapping will be tested in the robophysical system and in an at-scale, bio-inspired flapping wing robot. finally, the tradeoffs of operating at or away from resonance in spring-wing systems will be investigated. the project bridges the biological and physical sciences, will expand understanding of physiological and biomechanical principles and trade-offs involved in flight, and should transform the current understanding of insect flight, with applications to robotics. undergraduate and graduate students and a post-doctoral fellow will participate in mentored, interdisciplinary research teams, and will present research results at national scientific meetings. research results will also be disseminated through a bio-inspired design workshop. this award is co-funded by the dynamics, control and systems diagnostics program in the division of civil, mechanical and manufacturing innovation, directorate for engineering, and the physiological mechanisms and biomechanics program in the division of integrative organismal systems, directorate for biological sciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: ADVANCE Adaptation: CSU STEPS for Gender Equity: Advancing Structures through Evidence-based Practices for Gender Equity

Awardee: Colorado State University

Amount: \$999,312.00

Abstract: colorado state university will tackle the significant nation-wide problem of inequity among faculty members in science, technology, math and engineering (stem) disciplines. specifically, this project aims to improve equity in recruitment, retention and promotion, with a focus on gender equity

that recognizes the other types of cultural, ethnic, physical, and economic backgrounds people have. the work thus targets improved **\*\*diversity\*\*** in stem disciplines. this problem is important because more diverse workforces are more effective at solving problems, and in a more just society, university faculty composition would reflect availability of doctoral graduates without bias. this problem has not already been solved because inequities are complex and embedded into the history of us society and academia. it is not intractable, however, and through carefully executing projects, colorado state aims to improve equity across the stem faculty. to address inequities, the project team aims to adapt a number of evidence-based best practices to particular situations at colorado state. the project targets four major changes. 1) a revised approach to recruiting new faculty. 2) improved unit climates through training allies to intervene when they notice inequities. 3) improved performance review processes with training and support for review committees. 4) enhanced leadership through education in equity who are both empowered to and accountable for making change. the expected outcomes of the project activities are improved climate and culture for all, and improved recruitment and retention leading to greater equity and **\*\*diversity\*\*** in stem units across campus.

the overarching goal of advance adaptation: csu steps for gender equity: advancing structures through evidence-based practices for gender equity is to transform university and unit structures and culture to improve climate and gender equity on stem faculties, with an intersectional focus on women with identities that historically have been marginalized. the specific aims are as follows: 1) enhance recruitment, 2) improve retention through training promotion and tenure committees, creating a cadre of equity-minded allies, and collecting qualitative data to understand departures and retentions, and 3) support and train unit leaders in equity efforts. thus, the scope of the project encompasses equity across all phases of faculty careers and on into leadership. the research methods include quantitative and qualitative approaches to evaluate success in providing participants with new skills, in improving department climate, and in retention outcomes. expected results include an increase in equitable recruitment and retention, improved climate, and a better understanding of the specific barriers faculty face. the project aims to

contribute to research literature in organizational change and equity. outcomes and findings will be disseminated at conferences, in academic publications, and in articles and talks for broad audiences. the nsf advance program is designed to foster gender equity through a focus on the identification and elimination of organizational barriers that impede the full participation and advancement of diverse faculty in academic institutions. organizational barriers that inhibit equity may exist in policies, processes, practices, and the organizational culture and climate. advance "adaptation" awards provide support for the adaptation and adoption of evidence-based strategies to academic, non-profit institution of higher education as well as non-academic, non-profit organizations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Engaging Teachers and Neurodiverse Middle School Students in Tangible and Creative Computational Thinking Activities

Awardee: Arizona State University

Amount: \$998,712.00

Abstract: students with disabilities, particularly those with autism, experience unequal outcomes in stem education and employment. despite frequently reported strengths and interests in stem disciplines, individuals with autism often do not receive the support?those related to communication, transitions, and flexibility?needed to succeed. in working with teachers, parents, and employers, this project will create pathways to position students with autism spectrum disorder for success in school and also the larger community. researchers from arizona state university and the neuro\*\*diversity\*\* educational research center (nerc) and practitioners at science prep academy (spa) and temple grandin school will collaborate on the development of learning activities and workshops that engage middle-school aged children, community members, and employers in activities that integrate music, technology, and computational thinking. for the employers and community members, participation



can lead to increased respect for neurodiverse children and job applicants and changes in stem field's hiring practices and workplace accommodations. teachers engaged in the process of co-designing the learning experience and additional teachers engaged in workshops will be able to learn new approaches for supporting learning. finally, this project aims to build pathways of support and facilitation for neurodiverse individuals that increase employment potential of students with autism in a more inclusive economy, where neuro\*\*diversity\*\* is a baseline rather than an exception.

the project is based on embodied learning and cooperative learning approaches that inform the team's development of telematic embodied learning (tel) activities: activities that engage participants in using movement and their bodies to understand concepts, and can be conducted in hybrid or remote teaching situations when students and teachers are in different locations. the project's iterative co-design process and practitioner model are designed to provide data on the kinds of support and training teachers would need to equip neurodiverse students with computer science concepts. the project's researchers will use a convergent mixed methods design to investigate the experiences of approximately 25 middle-school-aged children, 24 teachers, 15 parents, and 10 future employers through a combination of surveys, observations, interviews, and focus groups. the research aims to investigate how telematic embodied learning approaches enriched with computational media foster computational thinking; how teachers who participate in the tel workshops modify and diversify their teaching practices; how tel approaches can be adapted in other schools; and how tel approaches augment the learning of ct in computer science with developing socio-emotional skills impact future employment for neurodiverse children with autism. this project is funded through the cs for all: research and rpps program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity  
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Title: DISES: Resilient Socio-Environmental Systems: Indigenous Territories in the Face of Change

Awardee: University of Florida

Amount: \$998,682.00

Abstract: indigenous peoples are capable of conserving their natural environments in the face of significant development pressures. nevertheless, little is known about the conservation efficacy of their social-environmental practices. the study addresses this issue through a partnership with an indigenous nation to ascertain how they have been able to achieve cultural and bio\*\*diversity\*\* conservation, even with threats arising from resource extraction and large-scale infrastructure projects. thus, the study provides information critical to tropical forest conservation. research results on climate change mitigation strategies will be broadly disseminated among indigenous communities. since indigenous peoples manage 40 percent of protected areas globally, the potential conservation impact is great. the study builds local capacity by training eight indigenous research technicians, and it empowers indigenous communities by facilitating the design of territorial management plans that foster long-term indigenous resilience in the face of development pressures. in addition, the study supports a post-doctoral researcher and promotes \*\*diversity\*\* by training three graduate students from historically under-represented populations. this study enhances cross-cultural learning by partnering undergraduate students through online "virtual exchanges" and summer field courses. a robust science communication strategy ensures that study results will inform both academics and the general public about how indigenous social-environmental practices shape contemporary conservation strategies. this study focuses on the indigenous territory (it), an integrated socio-environmental system capable of maintaining sustainable interactions between a human population and the physical environment. its can be resilient to external threats by virtue of biocultural heritage: the language, knowledge, and practices indigenous peoples use to sustain the ecological integrity of their homeland environments. the study problem resides in our incomplete knowledge about how such resilience functions, and the goal is to fill this gap. specifically, we seek insight into the responses of its to development pressures that spark encroachments on indigenous lands but also make available the goods, services, and jobs of a market economy. at what point

does it resilience attenuate, precipitating the loss of biocultural heritage and ecosystem degradation? how do its sustain system integration as development pressures mount? the study team will address such questions with its indigenous partners, which is subject to threats from resource extraction and infrastructure development that are similar to those impacting the entire region. the study integrates ecology, socio-environmental modeling, human geography, and spatial sciences. it will collect data via ecological assays, scientific surveys, and key informant interviews. analytical techniques include both quantitative and qualitative methods. the study contributes to systems theory by conceptualizing the it as an integrated socio-environmental system, and it enhances an understanding of it resilience. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Advancing Research and Practice in Culturally-Relevant Computing in Upper Elementary Education

Awardee: University of Hawaii

Amount: \$996,552.00

Abstract: this project is motivated by the need to prepare elementary teachers to effectively integrate computer science (cs) education into their teaching. to address this need, this project will provide professional development focused on culturally-relevant computing. culturally-relevant computing values explicit connections between students' home cultures and the concepts and practices of cs. research has shown that culturally-relevant pedagogies help students from marginalized communities succeed in a variety of fields including stem-related areas. accordingly, the project's basis is that a sustained culturally-relevant computing professional development program will be an effective way to prepare educators to reliably produce valued cs and culture-based outcomes. the work will be done by a partnership between faculty and staff at the university of hawaii at manoa

(uhm) and the hawai'i state department of education (hideoe). the project will directly address concerns about the need to prepare teachers to integrate cs into their teaching while simultaneously promoting hawai'i's unique place, history, culture, and language. the project's practical and theoretical outputs regarding culturally-relevant computing and its pedagogical implications will be applicable to other cultures and contexts interested in equity and **\*\*diversity\*\***. with the goal of better understanding the role of culturally-relevant computing in supporting cs education, this research-practitioner partnership will provide professional development to upper elementary (grades 4 - 6) educators (n = 230) in hawai'i. specifically, the project pursues practice and research objectives aligned with calls to broaden participation in cs, better understand pedagogical factors supporting effective cs education, and examine how cs education can promote cs and culture-based education outcomes. the practice objectives of the project include: 1) developing culturally-relevant computing modules, 2) implementing a professional development program about culturally-relevant computing, and 3) forming a professional learning community about culturally-relevant computing. the project's research objectives will advance the field's theoretical and practical understanding of how culturally-relevant computing impacts educators' knowledge and beliefs about (a) the subject of cs, (b) their ability to teach cs, and (c) the relationship between cs and culture-based outcomes. methodologically, the project will follow a design-based research process coupled with an explanatory sequential mixed-methods design. taken together, this project will help researchers, practitioners, and policy-makers, better understand how culturally-relevant (sustaining) pedagogy can be leveraged to increase **\*\*diversity\*\***, equity and inclusion in stem-related fields such as cs. this project is funded through the cs for all: research and rpps program this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SCISIPBIO: Constructing Heterogeneous Scholarly Graphs to Examine Social Capital During

## Mentored K Awardees Transition to Research Independence: Explicating a Matthew Mechanism

Awardee: HEALTHPARTNERS Institute

Amount: \$995,110.00

Abstract: despite efforts at diversification, an outsized proportion of prestigious nih r01 awards go to a circumscribed group of individuals and institutions. how and why does this happen? the matthew effect, whereby success begets success, is thought to be responsible: applicants with even small advantage at the outset may have their advantage multiplied many times over following initial success. evidence is consistent with the presence of a matthew effect in r01 funding, yet no study has illuminated the specific nature of the advantage, nor detailed the means by which advantage is multiplied and accumulated. this project will answer questions about which aspects of social capital and scholarly achievement contribute most to r01 success, and whether gender or timing of scholarly events contribute, by examining the individual career trajectories of awardees of nih mentored career development awards (mk awards). project results will help design effective interventions to avert unintended funding disparities, while maintaining a rigorous peer review system. this will be the first empirical test of a matthew mechanism during transition to research independence and the first to leverage heterogeneous scholarly graphs (hsgs). the first aim is to capture complex relationships between each mk awardee, their scholarly achievement and social capital, and r01 success during their quest for research independence. existing bibliographic and nih award data will be combined in the construction of a ?global? hsg database - relating all mk awardees to their associated scholarly objects. the result will be a comprehensive graph structured database in which nodes represent all mk awardees and their associated scholarly objects (e.g., published articles, journals, primary academic institution, coauthors, coauthor?s scholarly objects), and edges represent relationships of various types (e.g., author of, cited by, affiliation, research topics). relationship context will be captured for all scholarly objects in the hsg through global, local, and hyper-local graphical feature extraction to comprehensively characterize mk awardees? scholarly profiles. second, survival models will be developed to predict r01 success for mk awardees

from latent and observed variables of scholarly achievement and social capital, and global, local, and hyper-local hsg features. the study offers a novel approach to studying complex social processes that marries social capital theory with heterogeneous scholarly graphs and network science methods. this study will go beyond previous studies in providing a multidimensional characterization of scholarly social capital (beyond coauthorship and citation) and will examine differential social capital accumulation as a mediator in mk to r01 transition. empirically-grounded predictive models will be designed to probe existing theory and yield insights on social capital's role in r01 funding success. this study will yield actionable knowledge to inform strategies aimed at improving efficiency awards and increasing the **\*\*diversity\*\*** of the awardee pool. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: PlantSynBio: Identification and Design of Transcriptional Activation Domains Across Plant Species

Awardee: University of California-Berkeley

Amount: \$993,862.00

Abstract: every plant begins life as a seed with one cell and one genome. in order for a plant to grow, the cells must divide and turn into different kinds of cells by turning on different genes. leaf cells turn on leaf genes; root cells turn on root genes. this process of turning genes on and off requires specialized proteins called transcription factors. transcription factors also allow plants to turn genes on or off to respond to stresses like drought or pests and pathogens. transcription factors turn genes on using specialized regions called "activation domains." the first part of this project will use technologies we developed to identify activation domains on all the transcription factors of one widely studied plant species, arabidopsis. the data we collect will power our computational models for predicting activation domains in other plants. the final portion of this project will build synthetic

transcription factors that can be used to engineer gene regulation in other plants. this research will create useful and powerful tools for plant biologists and plant breeders. this collaboration between three research teams creates a unique interdisciplinary training environment for undergraduates, graduate students, and postdoctoral research fellows. our team is committed to building a supportive environment that fosters equity, **\*\*diversity\*\*** and inclusion. the three pi's come from backgrounds that have been traditionally excluded from science. two of the pi's are building on the success of their nsf career awards.

in plants, transcription factors control gene regulatory programs for development, growth and stress responses. transcription factors have two functions: 1) to bind dna sequences in the genome directly with a dna binding domain (dbd) or through a partner dbd-containing protein and 2) to recruit transcriptional machinery. dbds have been well characterized and can be predicted directly from amino acid sequence. in contrast, the regions of transcription factors that bind coactivator complexes, activation domains, remain poorly characterized and cannot be predicted from amino acid sequence. for example, in arabidopsis, there are 1,717 transcription factors, but only 8 known activation domains. as a consequence, when a new genome is sequenced, models for predicting dbds can identify putative transcription factors, but there are no analogous models for predicting if these transcription factors are activators or repressors. this project will use high throughput screening methods to identify activation domains on all arabidopsis transcription factors. these data will train deep learning neural networks to predict activation domains from amino acid sequence and predict activation domains in other diverse plant species. the final portion of this project will create and validate synthetic transcription factors for engineering gene regulation in plants. these tools will expand the synthetic biology toolbox for targeted hypothesis testing of metabolic processes, engineering regulatory networks, advancing agriculture and contributing to solutions that could address environmental problems.

this award was co-funded by the plant genome research program in the division of integrative organismal systems and the systems and synthetic biology cluster in the division of molecular and cellular biosciences. this award reflects nsf's statutory mission and has been deemed worthy of support

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Title: Understanding When Diversity, Equity and Inclusion (DEI) Work "Counts" in Faculty Evaluation

Awardee: University of Maryland, College Park

Amount: \$987,764.00

Abstract: this study aims to increase **diversity** in stem academic workplaces by testing ?nudge? interventions to help **diversity**, equity, and inclusion (dei) work matter in promotion and tenure decision-making. nudges refer to deliberate changes to the decision-making context aimed at guiding people toward a particular behavior, which in this case is valuing dei work. many institutions

have tried to reform the tenure process to reward dei work, but there is little concrete evidence that any of these initiatives have shaped tenure decisions. despite widespread use in organizations and education, nudge science has rarely been applied to faculty evaluation decisions. the study will use an experimental vignette methodology (evm) in which faculty participants will make an explicit decision about a fictional applicant. faculty participants will be recruited from biology (specifically ecology and evolutionary biology) and engineering. knowledge from the project's findings will provide useful information to university leaders seeking to reform promotion and tenure to value dei work. many faculty members, including a disproportionate number of black, brown, and women faculty, engage in dei work, but consistently report that when it comes to tenure and promotion, they are not sure whether and how their dei work counted in decisions made. this work will examine whether three different "nudge" interventions (a) providing an equity charge encouraging participants to value dei work, (b) having the tenure candidate emphasize their dei efforts in separated sections of their cv and personal statement, and (c) having participants use a rubric in which dei is one of the criteria listed, are more influential than the others in shaping tenure decisions. an experimental vignette methodology (evm) will be used in which faculty participants will make an explicit decision about a fictional applicant. faculty participants will be recruited from biology (specifically ecology and evolutionary biology) and engineering. participants will be randomly assigned a dossier that includes the evaluation criteria, a curriculum vitae, and a personal statement. the main outcome variable is the recommendation from the participant regarding faculty tenure. this study is the first to use an experimental design to test faculty weighting of dei in tenure decisions in a stem field. this project will advance knowledge about which kinds of nudges are more likely to work within faculty evaluation settings, and whether interventions have a different impact depending on the perceived identities of the candidates. this project is funded by the ehr core research (ecr) program, which supports work that advances fundamental research on stem learning and learning environments, broadening participation in stem, and stem workforce development. this award reflects nsf's statutory mission and has been deemed worthy of support through

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Title: Preparing Leaders and Nurturing Tomorrows Scientists: Botany and Beyond (PLANTS III)

Awardee: Botanical Society of America

Amount: \$986,448.00

Abstract: the plants iii program will establish a series of annual workshops and activities to foster a mentoring network and community of interactions among faculty, and students, researchers, and career professionals in botany and allied disciplines with the goal of broadening participation in those disciplines. the botanical society of america (bsa) will lead this effort in support of a diverse and inclusive botanical community. by addressing plant awareness and cultivating a diverse and inclusive community of scientists, these activities can accelerate discovery, research and applied botanical sciences. these activites will engage the botanical community and professional botanical societies (e.g., bsa, the american society of plant taxonomists, the society of herbarium curators) in a collaborative effort to engage a diverse community of undergraduates, early career professionals, and faculty to affect a more inclusive scientific community. the program will provide financial

support for underrepresented students to engage with botany at multiple levels; provide several access points for students and faculty that have been historically excluded, to engage with the botanical sciences; and create a program and series of inclusive and accessible experiences that provide sustained personal and social connections supporting a diverse, inclusive and equitable botanical community. in addition, professional development workshops will provide faculty with evidence-based best practices of botanical science education, training for identifying barriers to equity and inclusion in a science classroom, and methods for engaging a **\*\*diversity\*\*** of students in the study of botanical science. all of these activities are critical to creating a diverse and inclusive 21st century workforce that will be charged with finding creative solutions to global challenges. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Evolution and genetic basis of locomotor activity patterns among Lake Malawi cichlids:  
Exploring a novel mechanism of habitat partitioning

Awardee: University of Massachusetts Amherst

Amount: \$985,559.00

Abstract: this project investigates a new hypothesis to explain how a high **\*\*diversity\*\*** of similar species can coexist in the same environment, that species partition their habitat temporally via divergence in the circadian timing of activity, day vs night. animals exhibit a range of activity levels and patterns over the course of a day, but how these behaviors are regulated at the genetic level remains poorly understood. further, closely related species can differ markedly in both levels and patterns of activity, but how variation in these behaviors may facilitate the co-existence of species within a single environment is largely unknown. this project addresses these two knowledge gaps, using cichlid fishes from lake malawi, africa. this cichlid system exhibits unparalleled **\*\*diversity\*\***, with well over 500 species evolving within the last ~1-2 million years. moreover, malawi cichlids

co-exist in extremely high diversities, with certain localities supporting over 40 species. how this occurs has long fascinated biologists, with most studies focusing on how species partition habitat spatially, for example across different depths. this research has the potential to provide novel insights into how bio\*\*diversity\*\* is maintained in the lake malawi cichlid system, and other groups characterized by high levels of bio\*\*diversity\*\*, with implications for conservation strategies. more broadly, this project will provide a better understanding of circadian biology, which may provide insights into the linkage between disrupted circadian rhythms in humans and disorders of the brain. building on past activities, the investigators will deliver summer workshops on evolution to underserved and underrepresented middle school students through partnerships with existing programs in massachusetts. they will recruit underrepresented high school and undergraduate students into their labs for supervised research. in addition, they will develop and deliver course-based undergraduate research experience laboratories for undergraduates at both institutions to expand access to research.

the circadian timing of activity is critical for organismal fitness, and species across the animal kingdom exhibit \*\*diversity\*\* in the timing of activity that ranges from strongly diurnal to strongly nocturnal. while the neural and molecular basis through which animals maintain a 24-hour circadian clock is well-studied, much less is known about how the timing of activity evolves. identifying the ecological and genetic factors associated with variation in activity patterns would therefore address a critical gap in our knowledge. this project will investigate these open questions by applying high-throughput behavioral analyses in lake malawi cichlid fishes ? an iconic and powerful model system for ecology and evolutionary research. malawi cichlids exhibit unparalleled \*\*diversity\*\* in an array of phenotypes, including behavioral traits. preliminary data associated with this proposal documented a surprisingly high magnitude of variation in locomotor activity patterns among species, offering a unique opportunity to investigate its evolution and genetic basis. to this end, the investigators will undertake experiments to examine the evolution of activity patterns in an explicit phylogenetic context, assess the degree to which these patterns are modulated by environmental factors including social interactions and food availability, and to

characterize the genetic/genomic architecture of locomotor activity. while each experiment will be informative on its own, the combined results will provide key insights into the evolutionary potential of circadian regulation of activity, significantly advancing the field, and establishing a robust foundation for future research. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: GRate ? Integrating data and modeling to quantify rates of Greenland Ice Sheet change, Holocene to future

Awardee: University of Washington

Amount: \$983,607.00

Abstract: the greenland ice sheet has experienced devastating melt in recent years. recent scientific reports highlight how vulnerable the greenland ice sheet is to arctic climate change and draw a dire picture of the impact of sea-level rise. in order to equip society with the best forecasts of sea level rise for planning, scientists need to improve the ability to simulate ? or model ? the response of ice sheets to climate change. for this project, scientists from different branches of ice-sheet research will work together to improve ice sheet modelling. the researchers will leverage recent scientific advances to model the entire greenland ice sheet in order to investigate long-term ice-sheet sensitivity to changes taking places in the ocean and atmosphere. the research group is committed to creating an inclusive environment where all team members can learn and excel. the team contains **\*\*diversity\*\*** in ethnicity, gender and rank, and will train six early career scholars, recruiting specifically from groups underrepresented in the geosciences, which is among the least diverse stem fields in the u.s. results will be made publicly available and will facilitate a broad range of future research about the arctic system, including ice sheet modeling, model spin-up, paleoclimate reconstruction/synthesis and glacier history. to elevate the capacity of outreach and education programs developed during their first project, the team will build on their ?scientists are superheroes? outreach program and leverage other, existing outreach frameworks, including making connections with greenlandic communities and with high school student intern programs at their universities linked to the young women?s leadership school (bronx, ny) and the spring valley (ny) branch of the naacp, coordinated by our dedicated project educator and outreach specialist.

reducing uncertainties in ice-sheet model predictions is crucial in society's handling of the sea level crisis. uncertainties related to ice-sheet instability arise from limited observations, inadequate model representation of ice-sheet processes, and limited understanding of the complex interactions between the atmosphere, ocean, and ice sheets. how atmospheric and oceanic forcing vary through time, and at what timescales each are capable of forcing rapid change, are critical for predicting future ice mass loss, but scientists have been observing ice sheet change for only a short period of time (decades). the pis propose to scrutinize greenland ice sheet change spanning from the beginning of the holocene (12,000 years ago) to 2100 ce, making it possible to evaluate the varying roles of atmospheric and ocean forcing on decadal-to-centennial timescales relevant for the future greenland ice sheet evolution. the pis will utilize their established multi-disciplinary collaboration to combine ice sheet modelling, climate forcing and reconstructions of past ice-sheet change. this will position the team to make predictions of future ice sheet change that are grounded in greenland ice sheet behavior during past climate swings that occurred prior to our brief window of modern observation. the work will lead to lasting products to serve the community's collective effort to better understand ice sheet change: 1) a state-of-the-art ice-sheet model optimized for simulations over long timescales, 2) a holocene-through-modern set of atmospheric and ocean state estimates optimized for forcing an ice-sheet model, and 3) a database of past-ice sheet configurations and paleoclimate records formatted for model-data comparison. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: An Evidence-Based Approach Towards Technology Workforce Expansion by Increasing Female Participation in STEM Entrepreneurship

Awardee: University of Wisconsin-Madison

Amount: \$983,486.00

Abstract: this is a collaborative project, with the university of wisconsin-madison as the lead institution and the university of maryland as the partnering institution, to explore the entrepreneurial proclivity of undergraduate women majoring in stem fields. the researchers propose a multi-method approach led by an interdisciplinary team to (1) identify factors that influence entrepreneurial proclivity and (2) develop and test interventions related to closing gender disparities in stem entrepreneurship. the research includes the analysis of a comprehensive administrative database to identify mechanisms for potential interventions and field experiments to achieve greater gender parity in entrepreneurial career choices for stem students. results of the field experiments will be integrated with the database to produce outcome measures. the project will produce empirical evidence to increase the understanding of student entrepreneurship and inform interventions that improve entrepreneurship participation for women in stem. the researchers will frame the research design and methods using the individual-opportunity nexus theory that knowledge is a precursor to entrepreneurship. there are four hypotheses: (1) greater entrepreneurial proclivity will be found in women in stem fields with higher curriculum **\*\*diversity\*\***, who have taken at least one business class, who are enrolled in stem courses with students with higher **\*\*diversity\*\*** in their courses, and who are enrolled in stem courses with students who have taken one or more business classes. (2) women stem students demonstrate higher entrepreneurial proclivity when they are exposed to relatable role models in entrepreneurship. (3) women stem students demonstrate higher entrepreneurial proclivity when entrepreneurship is presented as a gender-neutral field. (4) women stem students demonstrate higher entrepreneurial proclivity when they are exposed to entrepreneurial success stories. the researchers will make causal inferences about factors that influence entrepreneurial proclivity of women in stem by measuring self-reported activities, analyzing administrative data, and documenting student start-ups. the core of the project is based on data drawn from a data infrastructure that combines administrative data with results of an annual survey. the researchers will use those data to evaluate the mechanisms that influence the underrepresentation of women in entrepreneurship. they will augment the data infrastructure with a

field experiment to test hypotheses informed by existing literature and findings from their data analysis. this project is co-supported by the ehr core research program that funds fundamental research on stem learning and learning environments, broadening participation in stem fields, and stem workforce development and by the science of science bpinnovate program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Global estimates of energy pathways and stirring by internal waves and vortical mode

Awardee: NorthWest Research Associates, Incorporated

Amount: \$981,611.00

Abstract: the ocean primarily derives its energy from large-scale wind, tidal and solar forcing, but the ultimate distribution of heat and currents depends on how this energy is transferred from large-scale motions to small scales where it is dissipated. some of the energy forced by winds at the ocean surface escapes to the interior through density undulations, called near-inertial waves, that can span hundreds of kilometers. another significant energy source for waves comes from the tide when it encounters topography and produces internal waves, known as the internal tide. it is generally well understood that these two types of waves interact, catalyzed by other flow features, and transfer energy through an internal wave field into smaller scale motions and mixing. this study will parameterize the spectrum of internal waves in terms of the large-scale forcing and other catalysts, and the predicted stirring that results, producing the first global maps of these estimates. parameterizations of these stirring processes will benefit large-scale ocean general circulation models (ogcms), and a refined understanding and parameterization of the internal wave energy cascade and its implications for vertical mixing and dissipation will benefit climate models. recognizing that submesoscale, ogcm and climate modelers at the same meeting often do not

attend the same scientific sessions, the investigators will bring these two communities together by organizing a joint session at the 2024 ocean sciences meeting, focused on internal wave and submesoscale parameterizations in global models. one graduate student will be trained under this project (umassd). the ongoing efforts of the team demonstrates their commitment to education, outreach, **\*\*diversity\*\*** and inclusion. pi sundermeyer currently advises (among others) five women graduate students, and will seek to recruit women and/or under- represented/minority students under this project. pi sundermeyer has given several presentations on ocean processes to multiple classes in the sandwich, ma public school district. under the present project, he and the graduate student will work with middle and high school teachers in sandwich and new bedford public schools to develop ocean-related learning modules. pi early helped design and mentor in an nsf-reu program and co-founded the nwra early-scientist mentoring program; pi wortham is a science communication fellow at seattle pacific science center; pi lelong is a mentor with mpowir and active in the seattle chapter of swms. nwra participates every summer in discovery corps, the pacific science center's summer research program for high school and college students from under-represented communities. this proposal involves collaborations with ogcm modeler h. simmons and with mexican mathematician g. hernandez-duenas.

the internal wave field in the stratified interior of the ocean draws its energy primarily from winds and tides, with geostrophic motions and topographic scattering acting as catalysts. this energy cascades to small scales and directly stirs the fluid, generating vortical mode along the way, which then itself contributes to energy transfers and stirring. although observations indicate stirring rates of  $\mathcal{O}(1) \text{ m}^2 \text{ s}^{-1}$  at scales of  $\mathcal{O}(10) \text{ km}$ , gaps remain in our ability to predict diffusivity at these scales directly from the energy sources. the first major contribution of this study will be to clarify the roles of relevant processes in setting the shape and strength of the internal wave and vortical spectra. second, it will extend previous theoretical and numerical estimates of stirring from internal waves and vortical mode to more realistic conditions. by considering realistic stratification and forcing, this study will close a significant gap in our understanding of how the oceanic internal wave and vortical mode fields are formed, and how these

processes stir fluid at the submesoscale. the work here will also help close the energy budget for the ocean by quantifying the rate at which energy is extracted from various large-scale forcing, and cascaded downscale through the internal wave field. last, it will quantify the shape and magnitude of the vortical mode field that arises naturally as part of this cascade, a result that has remained largely elusive from field observations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Expanding a Statewide Pathway for CS Teacher Certification: A Curriculum Model for Secondary Education Teacher Candidates

Awardee: University of Alabama Tuscaloosa

Amount: \$978,930.00

Abstract: the university of alabama (ua) will form a researcher-practitioner partnership (rpp) among six alabama higher-education institutions (alabama state university, jacksonville state university, university of alabama at birmingham, university of alabama in huntsville, university of alabama, and university of south alabama), as well as other rpp partners (e.g., high school computer science educators across alabama, and the alabama state department of education). a national plan for expanding k-12 computer science (cs) teacher professional development must include (pre-service) future teacher candidates (tcs) well beyond the current models of only training in-service teachers. this project will contribute to a new approach for virtual online instruction that prepares pre-service tcs as credentialed future cs educators who will introduce their students to computational thinkingskills and concepts. participant tcs will be recruited from a diverse pool of candidates across the six partner institutions and topics of **\*\*diversity\*\***, equity, and inclusion will be a foundation of the two-course pathway. the project is driven by the following core csforall needs: scaling effective professional development (pd) efforts to a large cohort of new cs teachers--many of whom have little

to no formal cs preparation; establishing certification programs and preservice paths for teacher pd; establishing online and hybrid pd approaches, creating robust pd materials for teachers and facilitators; and assessing the effectiveness of pd models with respect to content knowledge, pedagogy, computational thinking, classroom equity, and student outcomes to address these needs, the implementation, research and evaluation of this project will focus on expanding our existing knowledge and impacts from a locally successful and recently completed implementation for training secondary mathematics tcs in cs within their existing mathematics teacher preparation program. the statewide expansion and implementation will widen the geographic coverage to tcs at our partner institutions and broaden the recruitment to all focus areas of secondary education (e.g., science, mathematics, career tech, and even social studies and other teaching fields in secondary teacher preparation). the specific goals of the project include: (1) recruiting and enrolling up to 90 secondary tcs to begin the cs preparation pathway in pursuit of a cs endorsement added to their secondary teaching discipline; (2) producing 72 cs credentialed secondary tcs, of which 27 will receive a course-specific certification for ap computer science principles (csp); (3) producing 45 full cs subject endorsed secondary teachers; (4) leveraging an rpp model that builds beyond a prior effort, this project will provide preparation opportunities that will enable tcs to be ready to teach cs upon graduation, including praxis preparation to become fully credentialed in cs; and (5) expanding and enacting the ua campus cs curriculum for all disciplines of secondary tcs across six higher-education partner institutions, providing an opportunity for openly sharing all developed resources and assisting the partner institutions in bootstrapping their own cs education efforts. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Determinants of amphibian genomic diversity: Integrating traits, phylogeny, and geography

Awardee: University of New Mexico

Amount: \$970,175.00

Abstract: genetic differences between individuals and populations of the same species are essential for organisms to adapt and survive in changing environments. surveying genomic variation within species, and determining what factors influence that variation, are thus important goals for managing wildlife populations and conserving bio\*\*diversity\*\*. amphibians are key contributors to many ecosystem processes, but they are one of the most threatened vertebrate groups. they are also lacking from many comparative studies of genomic variation because they have large, complex genomes. this project will investigate the factors that influence genomic variation within amphibians and will produce new genome-scale data for several dozen frog species sampled across the united states. broader impacts include training early-career scholars including a postdoctoral researcher, two graduate students, and six undergraduate students in field sampling, genomic sequencing, bioinformatics, and statistical analysis. the project will also contribute to research infrastructure by archiving searchable, multi-purpose amphibian specimens and tissues at the museum of southwestern biology for future uses. a new undergraduate course in bio\*\*diversity\*\* informatics will be developed to engage students with natural history collections and bio\*\*diversity\*\* databases, provide computational training, and offer hands-on research experiences through collaborative projects that leverage the amphibian genomic data produced by the project. this research addresses key questions about the determinants of genetic \*\*diversity\*\*, thereby advancing knowledge about the origins, distribution, and evolutionary history of global bio\*\*diversity\*\*. two complementary approaches to data collection encompass several complex factors that affect genetic \*\*diversity\*\* ? life history and ecological traits, phylogenetic history, population history, and current environmental variation ? and provide insights into the scale at which these factors influence \*\*diversity\*\* within species. the first approach will combine data repurposing, machine learning, and phylogenetic comparative methods to identify important predictors of genetic \*\*diversity\*\* for global amphibians using open-access museum, trait, and genetic sequence databases. these results will shed light on the importance of species traits, phylogenetic history, and geographic range



characteristics for predicting genetic **diversity** across hundreds of amphibian species. the second approach will produce new high-resolution, genome-scale data for more than 40 frog species in the united states, sampled strategically across geographic space to test predictions about the influence of population history and current environmental variation on genetic variation within species. by integrating traits, phylogeny, and geography, this research will uncover the determinants of amphibian genomic **diversity** and establish a framework to address this fundamental aspect of **bio-diversity** across different taxonomic and spatial scales. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Testing the most striking tropical marine biodiversity gradient on the planet: does it hold for sponges?

Awardee: University of Hawaii

Amount: \$959,716.00

Abstract: coral reefs are among the most species-rich ecosystems on the planet, occupying only about 1% of the seafloor, but housing more than a quarter of known marine **bio-diversity**. sometimes called the rainforests of the sea, coral reefs have great intrinsic biological, cultural and economic value. nearly a billion people across the planet rely on coral reef ecosystems as a significant source of their diet, and the annual economic benefits of coral reefs are estimated to be around \$9.9 trillion usd. thus, the global decline of coral reefs by an estimated 30-50% since the 1980s is of considerable concern as scientists struggle to understand whether species are being lost before they are even discovered. while coral reefs are spectacularly diverse, the majority of this **bio-diversity** actually lives hidden deep within the three-dimensional framework of the reef itself. this hidden (or cryptic) community of organisms are both dramatically understudied and fundamentally important for the persistence of coral reefs. sponges are a dominant group among

these cryptic organisms within the reef which provide food from the bottom of the food chain and help sustain coral reef bio\*\*diversity\*\*. despite the vital ecological role of sponges on coral reefs, little is known about their \*\*diversity\*\*, abundance or species ranges across the indo-pacific. for example, the most striking marine bio\*\*diversity\*\* gradient on the planet is described from several of the visibly dominant groups on coral reefs, including corals and reef fishes. from the global hotspot of species richness in the indo-pacific coral triangle there is a sharp eastward decline in species numbers to more remote oceanic islands in the central pacific, such as the hawaiian archipelago. however, no survey to date has evaluated whether the \*\*diversity\*\* of poorly known cryptic coral reef species, such as sponges, show the same pattern as the visible species that dominate the surface of the reef. summer training modules introduce at-risk pacific islander youth to coral reef bio\*\*diversity\*\* to recruit and train a new generation of sponge taxonomists. identification guides are being produced to help resource managers in establishing a baseline of sponge \*\*diversity\*\*, which allows resource managers to identify and protect native species, improves detection of alien species introductions and serves as a tool for monitoring changes in the ecosystem in response to human impacts. the work is being disseminated widely through scientific literature, public and professional presentations, popular press articles, and an educational display about sponges and coral reef biology in collaboration with the waik?k? aquarium. this important knowledge gap is addressed by analyzing an existing backlog of standardized sampling devices (arms) collected from throughout the pacific ocean to determine whether sponges that live largely unseen within the reef framework follow the same \*\*diversity\*\* gradient as has been previously reported for fish and corals. by integrating taxonomy with multi-locus dna barcoding and metabarcoding, this project is documenting species richness and bio\*\*diversity\*\* patterns among the cryptic sponge community across five ecoregions spanning over 10,000 km of the tropical pacific. these collections include many new species and are providing vouchered dna barcodes to existing reference databases that currently include fewer than 1% of sponge species across the planet. sponges are a rich source for pharmaceutical development, so discovery of new species also provides opportunity for exploration

of natural products from both the sponges and culturable microbes associated with them. by examining sponge species occurrence and **diversity** along both environmental and anthropogenic gradients in each ecoregion, the data also address whether coral reef sponges can serve as indicators of human impacts. collectively, these results are transforming our knowledge of tropical pacific sponge bio**diversity**, species ranges, and providing much-needed reference barcodes to global sequence databases. by determining whether sponges show the same indo-pacific richness gradient as reported in fishes and corals, this project is testing how well generalizations made from the visible subset of species that live on the surface of coral reefs apply to rest of coral reef bio**diversity**. this study is greatly advancing our knowledge of pacific coral reef sponges and will ultimately inform the scale over which vital ecological roles performed by this understudied taxon, such as the production of nutrients at the bottom of the food chain, are acting across the pacific. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Community Facility Support for Geochronology and Thermochronology at the Arizona LaserChron Center

Awardee: University of Arizona

Amount: \$959,118.00

Abstract: recent developments in geochronologic methods and instrumentation are revolutionizing many different aspects of earth science research. some of the most exciting advances are being driven by laser-ablation icp mass spectrometry (la-icpms), which generates u-th-pb ages and complementary geochemical information rapidly, with micron-scale spatial resolution, and with the precision necessary to address a wide range of problems in earth science. the arizona laserchron center (alc) is a community facility that utilizes la-icpms to determine u-th-pb ages, hf isotope ratios,

and trace element abundances from a variety of minerals that occur in sedimentary, igneous, and metamorphic rocks. we also utilize a dedicated scanning electron microscope that generates the high-resolution and high-magnification images necessary for state-of-the-art micro-analysis. primary goals of the alc are to (1) generate u-th-pb ages, hf isotope ratios, and trace element concentrations of the best precision, accuracy, and spatial resolution possible from la-icpms, (2) provide opportunities for researchers from around the world (and especially nsf-supported scientists) to use our instruments and expertise to address geologic problems, (3) drive the development of new techniques and applications of geochronology, thermochronology, and petrochronology, (4) build new cyberinfrastructure for data acquisition, analysis, and archiving, and (5) use every aspect of facility operation as an opportunity to enhance expertise and **\*\*diversity\*\*** among geochronologists and users of geochronology. research at the alc is conducted in a highly collaborative mode, with alc scientists providing assistance with all aspects of a project (from initial design of the study to final publication of results) and faculty members and students from other institutions visiting the lab to generate their own data and learn the theory and methodology of u-th-pb geochronology. funding from this award will enable the alc to facilitate the acquisition of geochronologic information in support of a large number of nsf-funded projects. these projects focus on generating new knowledge about the growth of continents, emergence of life, processes of mountain building, mechanisms and timing of volcanic eruptions, distribution of sediment through space and time, formation of mineral, energy, and water resources, and linkages between climate and tectonics. the alc will also continue to help drive the development of numerous new analytical techniques, applications, and instruments, as well as the cyberinfrastructure needed to utilize and integrate the information generated. educational activities will include hosting visits from several hundred faculty and student researchers per year, teaching short courses at annual meetings, developing materials that can be used in earth science courses, providing opportunities for non-scientists to learn about geochronology, creating new tools for displaying and interpreting geochronologic data, and driving the development of global databases that host u-th-pb geochronologic information. this award

reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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publication of results) and faculty members and students from other institutions visiting the lab to generate their own data and learn the theory and methodology of u-th-pb geochronology. funding from this award will enable the alc to facilitate the acquisition of geochronologic information in support of a large number of nsf-funded projects. these projects focus on generating new knowledge about the growth of continents, emergence of life, processes of mountain building, mechanisms and timing of volcanic eruptions, distribution of sediment through space and time, formation of mineral, energy, and water resources, and linkages between climate and tectonics. the alc will also continue to help drive the development of numerous new analytical techniques, applications, and instruments, as well as the cyberinfrastructure needed to utilize and integrate the information generated. educational activities will include hosting visits from several hundred faculty and student researchers per year, teaching short courses at annual meetings, developing materials that can be used in earth science courses, providing opportunities for non-scientists to learn about geochronology, creating new tools for displaying and interpreting geochronologic data, and driving the development of global databases that host u-th-pb geochronologic information. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: HSI Implementation and Evaluation Project: Western MA Engineering Pathways Program

Awardee: Holyoke Community College

Amount: \$956,458.00

Abstract: with support from the improving undergraduate stem education: hispanic-serving institutions (hsi program), this track 2 project called the western ma engineering pathways program, will contribute to the national need for a diverse engineering workforce by supporting the recruitment, retention, graduation, and transfer of underrepresented students in engineering programs at holyoke community college (hcc), the university of massachusetts at amherst, and

western new england university (wneu). over a four-year period, the project will identify students from partners holyoke high school and westfield high school who express an interest in engineering, develop and test innovative interventions, and support students along the academic pathway. early engagement with engineering concepts and ongoing comprehensive student supports will bolster stem identity, self-efficacy, and self-confidence among traditionally underrepresented students in the field. the western ma engineering pathways program has three goals: 1) create improved pathways to broaden the participation of students historically underrepresented in engineering, 2) revitalize hcc's engineering programs to be more responsive to a diverse student body and to regional employer demands, and 3) produce fundamental research on building an effective pathway for targeted students in the western massachusetts that can be implemented and sustained in a way that is replicable nationally. with support from project partners at the collaborative for educational services, the society for women engineers (swe), and the 50k coalition, project activities will attract and retain more students in engineering, especially students who identify themselves as women, latinx, or from other historically marginalized groups. the proposed project will investigate the differences between the experiences and decisions surrounding engineering education for women, latinx students, and students with multiple marginalized identities (mmi) in undergraduate engineering education. research questions will determine how high school and community college students make decisions around pursuing undergraduate engineering education; the ways in which latinx and female students, especially those with mmi, differ in their decision-making process from their peers; how institutional changes made to address the needs of latinx students, especially those with mmi, improve their outcomes and those of other undergraduate engineering students; and how equitable pathway design can be used to shift stakeholders' foci from institutional outcomes to student-centered outcomes. findings from this project will support equity and inclusion efforts at each partnership institution and will guide efforts at other hispanic-serving institutions seeking to increase latinx contributions to the future of engineering. the project team will work with the 50k coalition to share promising practices and stem education research findings on a national scale.

improved connection and interaction with local industry will provide employers with a voice in preparing future engineers and increasing **\*\*diversity\*\*** in their workforce. the hsi program aims to enhance undergraduate stem education, broaden participation in stem, and build capacity at hsis. achieving these aims, given the diverse nature and context of the hsis, requires innovative approaches that incentivize institutional and community transformation and promote fundamental research (i) on engaged student learning, (ii) about what it takes to diversify and increase participation in stem effectively, and (iii) that improves our understanding of how to build institutional capacity at hsis. projects supported by the hsi program will also draw from these approaches to generate new knowledge on how to achieve these aims. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Predicting plant functional trait variation across spatial, temporal and biological scales

Awardee: Virginia Commonwealth University

Amount: \$950,561.00

Abstract: variability is an inherent property of life on earth. as a result, understanding the causes and consequences of variability is central for understanding the nature of life itself. as mean temperatures increase around the world, many areas are simultaneously experiencing increasing climatic variability. yet, there is no theory that predicts the variability of natural systems. this research will develop a model for predicting the variability of plant function across scales of biological organization, from organisms to ecosystems. this research will focus on plant functional traits (morphological, physiological, and phenological characteristics) and environmental variability because functional traits link plant performance to ecosystem processes. further, gradients of environmental variability are ubiquitous in nature across all spatial and temporal scales, and underlie



prominent ecological and evolutionary hypotheses. in addition to developing new theories and generating new data essential for predicting species responses to increasing climatic variability, this project will address a national training need in data literacy, data science, and working with different scientific disciplines. to do so, undergraduate course content and training modules will be designed following open science principles. course content will leverage open biological and environmental data produced by nsf investments in research and infrastructure, including the national ecological observatory network (neon), the long-term ecological research (lter) network, integrated digitized biocollections (idigbio), and the global bio\*\*diversity\*\* information facility (gbif). additionally, this project will support the training and professional development of students from historically underrepresented groups in science, contributing to a diverse, skilled, and innovative stem workforce. specifically, this research will quantify emergent properties of functional trait variation by decomposing trait-trait and trait-environment relationships; testing the environmental heterogeneity and climatic variability hypotheses; and linking trait variation at the organismal scale to patterns of species distributions. at a continental scale, this project will leverage data from neon sites across latitude encompassing the eastern united states and puerto rico to quantify plant trait variation across spatial, temporal and biological scales. this project will also characterize scaling between plant functional trait variation, environmental heterogeneity, and climatic variability across temperate and tropical mountains, where abiotic gradients in temperature and precipitation are steep in space and time. measurements of plant abundance, growth, functional traits, and satellite observations of vegetation indices will form one of the few explicit tests of the environmental heterogeneity and the climatic variability hypotheses across spatiotemporal scales. ultimately, this research will resolve major disparities in the measurement, quantification, and modeling of functional trait variation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Pollen-stigma interactions: events and players that set off the path to reproductive success

Awardee: University of Massachusetts Amherst

Amount: \$950,000.00

Abstract: pollination in flowering plants is the requisite process for fertilization. the production of seeds and fruits, preservation of plant species and generating **\*\*diversity\*\*** all rely on pollination success. this project focuses on understanding how pollen and stigma, the pollen receptive surface on the pistil (the female reproductive organ) interact to initiate pollination. the first event on the stigma is for the pollen to germinate, thereby generating a pollen tube which penetrates the stigma and elongates inside the pistil to deliver sperm to the egg. the mechanisms underlying the activation of dormant pollen grains are poorly understood. the process requires the pollen cytoplasm to distribute to a small area where a pollen tube emerges from the grain and grows into the pistil to start a fruitful journey. this project focuses on obtaining a molecular understanding of these earliest pollination events. water transfer between the stigma and pollen to activate the pollen grain, cytoplasmic reorganization in the pollen to engineer the tube extrusion and tube growth process, and the enzymes that modify the pollen and stigma cell walls to facilitate tube extrusion and its penetration of the pistil will be examined for their contribution to the success of the early pollination events. the project will train undergraduates, master?s, ph.d. students, and post-graduate level scientists, feeding the pipeline for the research workforce and future leaders in science. a collaboration with girls inc. of the valley (holyoke ma) will bring high school girls for a summer experience centered on the project research area.

important advances have been made in recent years in the molecular and cellular understanding of the reproduction process in flowering plants, especially in how the sperm-bearing pollen interact with tissues in the pistil to enable fertilization to produce seeds. important but under-explored are the earliest events which occur upon pollen landing on the receptive surface of the pistil, the stigma, to set off the pollination process. this project focuses on obtaining a molecular and cellular understanding of these early events. specifically, the project explores how the stigmatic papilla cells mobilize water from the stigma to

hydrate a dry and dormant pollen grain to activate germination, which involves the extrusion of a polarized outgrowth from the grain and its development into a pollen tube. it also examines how the pollen grain mobilizes its cell surface signaling and cytoplasmic components to orchestrate pollen tube extrusion and penetration of the stigma. considerable cell wall degradation and modification activities occur in both the pollen and the pistil to enable the germination and tube growth process. therefore, how cell wall degradative enzymes contribute to these processes will also be examined. the research uses arabidopsis as the model system and relies on combined molecular, transgenic, cell biological and biochemical approaches. the project will provide students from undergraduate to postdoctoral levels with a broad range of scientific knowledge and experience in research approaches that can be broadly applied. a summer workshop related to plant reproduction will be developed for high school students from neighboring inner cities. the cellular dynamics and function cluster in the division of molecular and cellular biosciences is co-funding this award. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: RoL: The Evolution of the Genotype-Phenotype Map across Budding Yeasts

Awardee: Vanderbilt University

Amount: \$949,986.00

Abstract: how organisms' external characteristics or traits are encoded in their genomes and how they change over time represent important and largely unanswered biological questions. this project will address these questions by studying the metabolisms and genomes of the more than 1,000 known species of budding yeasts and their evolution. some of these yeast species are important opportunistic pathogens, while others are of great industrial relevance as producers of foods, beverages, medicines, and biofuels. this project will span multiple scales of biological organization

(from molecules to cells, species, and beyond) and ~400 million years of evolution to yield fundamental insights into how traits are encoded in genomes, how new functions evolve, and how the relationship between traits and genomes itself evolves. the project will support the wild yeast and computational genomics programs, two established and highly successful educational and training programs that immerse early-stage undergraduate students, including those from underrepresented backgrounds, in authentic, discovery-driven research. using draft genomes for nearly all known budding yeast species and state-of-the-art genome-editing tools that are broadly active in diverse species, this project will predict the connection of every metabolic gene in every yeast species? genome to its function(s), as well as examine the evolution of every known metabolic gene, pathway, and trait across the budding yeast subphylum saccharomycotina. through genome-scale evolutionary analyses and targeted functional experiments on key representative taxa spanning budding yeast genomic and metabolic **\*\*diversity\*\***, this project will functionally characterize how between-taxa variation at the level of genotypes gives rise to variation at the level of phenotypes. in particular, the project will chart how variation at the level of dna, rna, proteins, and metabolites sequentially transforms genetic variation into biochemical functions and physiological traits with an emphasis on functionally characterizing gaps and correcting discrepancies in the predicted genotype-phenotype map. this project is jointly funded by the evolutionary processes program in the division of environmental biology and the genetic mechanisms program in the division of molecular and cellular biosciences of the directorate for biological sciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Citizen Science Teachers: Noyce Residency Scholars Program for Western New York

Awardee: SUNY at Buffalo

Amount: \$946,530.00

Abstract: this project aims to serve the national need of increasing the number and retention of diverse and effective science teachers in high-need school districts in western new york. with a citizen science focus, this project will explore innovative strategies for preparing science teachers through civic engagement, study of local environments, and transformational approaches sustained in partnership with schools and communities. this focus will be paired with a context-specific, community-based teacher residency approach, a model that research has demonstrated to produce teachers who reflect greater demographic **diversity** and have notably longer retention as teachers. taken together, a citizen science focus and residency approach may yield project outcomes that shed light on recruiting, preparing, and retaining high-quality science teachers that reflect the demographic **diversity** of students in p-12 schools. this project at the university at buffalo includes partnerships with buffalo public schools and niagara falls city schools. the project's overall goal is to recruit, prepare, and retain 20 science teachers across five cohorts of science career changers and undergraduate biology, chemistry, physics, and earth science majors. it is expected that project will contribute to a deeper understanding of how a civic engagement approach to local environments, when paired with a community-based approach to field experiences, can yield high quality, culturally, and linguistically-diverse teachers who have a positive impact on science engagement and learning in p-12 schools. using surveys, interviews, and data about participation, retention, and academic performance, this project will examine the effectiveness of the project's interventions in preparing and engaging science teachers, and in placing and retaining these teachers in high-need schools. project outcomes will be analyzed by building a series of statistical models, such as cross-sectional sem models and longitudinal models. quantitative data will be triangulated with qualitative data to provide a more rigorous assessment of project impact. project findings will be disseminated in journals, at conferences dedicated to stem teacher preparation as well as venues open to increasing the **diversity** of the ranks of stem teachers, and through online reports and monographs. findings can inform teacher education programs across the country regarding diversifying teachers in p-12 schools, with a particular focus on science teachers. this

project also supports research on p-12 students? science learning experiences and the impact of civically engaged science instruction facilitated by teachers from diverse backgrounds. this track 1: scholarships and stipends project is supported through the robert noyce teacher scholarship program (noyce). the noyce program supports talented stem undergraduate majors and professionals to become effective k-12 stem teachers and experienced, exemplary k-12 teachers to become stem master teachers in high-need school districts. it also supports research on the persistence, retention, and effectiveness of k-12 stem teachers in high-need school districts. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Genomics of speciation and evolution of ecological traits in a geographic radiation of island kingfishers

Awardee: University of New Mexico

Amount: \$942,923.00

Abstract: how and why species diversify is a central question of biology and the process of speciation is how all bio\*\*diversity\*\* is created. islands provide an excellent setting in which to study speciation in wild populations due to their discrete geography and well-characterized geologic record. the indo-pacific, from southeast asia to polynesia, is the cradle of speciation theory and home to numerous geographic radiations of widespread, rapidly evolving species complexes. this project will synthesize genomics and state-of-the-art trait datasets to reveal processes that promote rapid radiations in nature. specifically, it will use a widespread, species-rich genus of island kingfishers (aves: todiramphus) as its study system. this project aims to make broadly applicable and generalizable predictions about the speciation process. the outcomes of this project will be a model for future speciation research in the pacific and serve as a springboard for pioneering new ways of studying complex phenotypes and their interactions with nature. this project will engage the

public through virtual and face-to-face experiences. the researchers will create virtual collections experiences (vces) that highlight the associated natural history collections at the museum of southwestern biology and the field museum. these online tools will reveal how data are collected from specimens and used to address the project's research objectives. the vces will be developed as education modules for grades 9-12, complete with lesson plans and student learning outcomes. the researchers will develop a highly multisensory exhibit at the field museum, playing on the project's themes of color evolution that will reach an estimated 500,000 people in chicago. an educational workshop will be held at the museum of southwestern biology that will provide hands-on training and experience in bio\*\*diversity\*\* science to native american and hispanic students from unm and new mexico's rural-area institutions. it will showcase professional opportunities in stem with a focus on museum-based bio\*\*diversity\*\* science. speciation genomics addresses the roles of ecology, gene flow, and genomic architecture in the formation of species. this project proposes an integrative study of systematics, biogeography, plumage diversification, and ecological adaptation to test multiple hypotheses of the factors that promoted rapid diversification in a diverse and widespread radiation of island kingfishers. todiramphus kingfishers occur across the entire indo-pacific and their diversification rate rivals those of 'classic' adaptive radiations. this study system provides replicated instances of sympatry and isolation, as well as divergent ecologies required for a synthetic study of diversification. the project will generate diverse datasets including whole genomes, ecological niche models, and phenotypic traits, to study how these factors facilitated rapid radiation on islands over the last 10 million years. the proposed research will leverage this unique geographic context to provide novel insights into the multifaceted process of speciation by (a) quantifying the presence and extent of gene flow and how novel changes in genomic architecture influenced diversification; (b) assessing how extrinsic traits (plumage coloration, biogeography, and relative niche conservatism) promoted or inhibited species divergence in the clade; and (c) through a novel test of the abundance-niche-center hypothesis in the context of genomic and phenotypic \*\*diversity\*\*. this award reflects nsf's statutory mission and has been

deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Texas Tech University

Amount: \$938,970.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Quorum Sensing Control of Bacterial Biofilm Formation and Dispersal

Awardee: Princeton University

Amount: \$934,613.00

Abstract: biofilms, bacterial communities formed on solid surfaces, are a predominant form of bacterial life on earth. biofilms are crucial for the environment, industry, and medicine. biofilms can be beneficial, for example in the microbiome and in bioremediation, but biofilms can also be harmful, for example during infection and because biofilms foul many types of surfaces. biofilm dispersal is



crucial for bacterial spread and for disease transmission, but very little is known about this important process. one aim of this project is to determine the mechanisms that coordinate biofilm dispersal. another aim of this project is to determine how communication between bacterial cells helps maintain biofilms. an exploration of the role of phages in driving biofilm formation and dispersal will also be a focus of this work this work will advance the progress of science by revealing the mechanisms that provide bacterial biofilms their resilience and they will reveal biofilm vulnerabilities. highly talented students will be trained by working on this project. efforts to increase **\*\*diversity\*\*** among those who participate in science research and efforts to expand public access/public understanding of science are central to the project and will be accomplished through a variety of nation-wide science outreach efforts. the overall goals of this research are to explore the mechanics, spatial and temporal cell-cell communication processes, and signal transduction networks that enable bacteria to build and subsequently disassemble multicellular biofilm communities. an exploration of the role of phages in driving biofilm formation and dispersal will be a focus. the studies will span biological scales - from the molecule, to the protein, to the network, to the cell, to the community. at a basic science level, the work will define the mechanisms bacteria use to uniquely detect and respond to kin and non-kin in communities, how genes and mechanics interact to drive community morphology, and how inter-domain interactions influence multicellular community dynamics. at a practical level, these investigations could lead to synthetic strategies to manipulate biofilm formation and dispersal, quorum-sensing-mediated communication, and phage infection of bacteria. consequently, the results should reveal the principles underpinning the evolution and maintenance of traits that are not essential under laboratory conditions but are crucial and precisely regulated in nature. with this knowledge in hand, the field should be able to rapidly move forward to develop synthetic strategies to prevent or promote quorum sensing, to prevent or promote single-species and mixed-species biofilm formation, and to prevent or promote biofilm dispersal, as required. such applications will have industrial, agricultural, and medical relevance. the pi is highly involved in service as chair of department, as a teacher, as an editor, broadly in national

educational and outreach initiatives, and through her service to not-for-profit foundations and government funding agencies. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Accessible Computational Thinking in Elementary Science Classes within and across Culturally and Linguistically Diverse Contexts

Awardee: Arizona State University

Amount: \$931,058.00

Abstract: currently, students who are white, affluent, and identify as male tend to develop a greater interest in and pursuit of science and computing-related careers compared to their black, latinx, native american, and female-identifying peers. yet, science, computing, and computational thinking drive societal decision-making and problem-solving. the lack of cultural and racial **\*\*diversity\*\*** in science and computing-related careers can lead to societal systems and decision-making structures that fail to consider a wide range of perspectives and expertise. teachers play a critical role in preparing students to develop these skills and succeed in a technological and scientific world. for this reason, it is crucial to investigate how teachers can help culturally and linguistically diverse students develop a greater understanding of and interest in science and computers. this research project aims to enhance elementary teacher education in science and computational thinking pedagogy through the use of culturally relevant teaching, i.e. teaching in ways that are relevant to students from different cultural and linguistic backgrounds the project will support 60 elementary teachers in summer professional development and consistent learning opportunities during the school year to learn about and enact culturally relevant computational thinking into their science instruction. in doing so, the project aims to increase both the quantity and quality of computing experiences for all elementary students and support nsf's commitment in broadening participation in

the stem workforce. the project will also produce resources, measures, and tools to support elementary teachers to do this kind of work, which will be shared with other stem researchers and teacher educators. the goal of this research project is to design and promote teaching practices that integrate computational thinking in the elementary science classroom in culturally relevant ways. this project will seek to empower practicing elementary teachers? approaches to meaningfully and effectively integrate and adapt computational thinking into their regular science teaching practice so that all students can access the curriculum. it will also explore the impact of these approaches on student learning and self-efficacy. the scope of this project will include working with multiple highly distinct school settings in maryland, arizona, and washington dc across three years, reaching approximately 60 elementary teachers and 1,200 students. to achieve the project objectives, the research team will leverage concurrent mixed methods approaches that include teacher and student interviews, reflections, observations, descriptive case study reports as well as regression and multilevel modeling. the project?s findings will inform the fields? understanding of: (a) teachers? conceptualization of computational thinking; (b) the barriers elementary teachers encounter when trying to integrate computational thinking with culturally relevant teaching practices; (c) the types of support that are effective in teacher professional development experiences and throughout the school year; and (d) the development of a cohort of teachers that can maintain integration efforts in different districts. the discovery research prek-12 program (drk-12) seeks to significantly enhance the learning and teaching of stem subjects by prek-12 students and teachers, through research and development of innovative resources, models and tools. projects in the drk-12 program build on fundamental research in stem education and prior research and development efforts that provide theoretical and empirical justification for proposed projects. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Developing Authentic and Fair Computer Science Assessments

Awardee: University of Washington

Amount: \$913,449.00

Abstract: this project aims to promote equitable design of computer science (cs) assessment in secondary and post-secondary education in the united states and globally, increasing the **\*\*diversity\*\*** of students engaging in cs learning through reduced test bias. in this study, we aim to address difficulties in assessing computer programming by investigating critical characteristics of programming tasks using both response process and product data. findings will have direct practical implications for developing authentic, fair and valid assessment of learners with different demographic backgrounds. through advancing our understanding of the cognitive processes underlying programming thereby informing ways to better teach, learn, and assess programming skills, we expect the project to impact the broader cs education community through shareable data sets to the general public, assessment innovations in large cs classrooms, actionable insights on test bias for cs instructors, and the engagement of undergraduates of diverse gender, race, and ability. the research team from the university of washington also intends to integrate scientific discoveries from this study into the university's publicly available course materials. the planned dissemination will maximize outreach to various outlets such as the nsf-supported exploring computing education pathways that brings together state leaders shaping u.s. k-12 cs education curricula, practices, and standards. this project consists of foundational research on assessing, learning and teaching computer programming skills. the project will capitalize on the ability of recording the coding process via keystroke logs to extract and summarize vast amounts of fine-grained information captured by observing program edits. we aim to study the relations between process and task characteristics, identifying patterns that are indicative of proficiencies and suggest fluency or dysfluency. such identification will, in turn, allow for designing instructional, learning, or assessment materials that are targeted at specific needs of learners. we plan to triangulate different types of student data to address research questions around detecting meaningful behavioral

patterns from timing and process data when students are engaged with computer programming, relations between tasks characteristics and programming process, student knowledge, attitudes, experience and proficiency, as well as the extent to which task design contribute to the performance patterns detected for students that vary along gender, ethnicity, and native language. the project will use controlled experiments and cognitive interviews to collect quantitative and qualitative data. multiple instruments will be used for data collection, such as the ets major field test-computer science. in terms of data analysis, the project will leverage various analytical and modeling techniques from the fields of psychometrics, statistics, machine learning, and educational data mining. findings from this project will offer empirically-tested guidelines on which task characteristics to account for when designing fair and valid assessments across different demographic groups. this project is funded by the ehr core research (ecr) program, which supports work that advances fundamental research on stem learning and learning environments, broadening participation in stem, and stem workforce development. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Transitions: Modeling microbial community metabolic interactions under extreme conditions

Awardee: Duke University

Amount: \$899,031.00

Abstract: this goal of this research is to determine how microbes living in extreme conditions communicate metabolically. microbial extremophiles are remarkable examples of life's resilience, thriving in hot springs at boiling temperatures, in brine lakes saturated with salt, and in deserts once thought to be sterile. this project uses extremophiles that live in high salt as a test system to map and model how nutrients flow through microbial communities, enabling resilience during times of food scarcity. the metabolism of salt-adapted microbes is poorly understood but produces chemicals

and enzymes of interest to biotechnology. the proposed research is therefore expected to reveal general principles of biological resilience and present novel approaches for future industrial applications of extremophile metabolic products. these activities will enable a transition in the pi's research direction from molecular experiments in pure laboratory cultures to field ecology and metabolic modeling. the goal of the education plan is to foster inclusive learning experiences that span disciplinary lines. together with students and postdocs from her group, the pi will form "co-learning teams" in which the team leader learns, alongside students in the field, how to sample and collect data. in these vertically integrated teams, the perspective that everyone is learning together is expected to lessen power dynamics and promote a positive research culture where all team members feel welcome and valued.

the proposed research tests the hypothesis that hypersaline microbial communities interact to maintain stability despite changes in salinity and nutrient availability. hypersaline-adapted archaea, or halophiles, provide a unique model for investigating the metabolic interactions in microbial communities. member species share a common hypersaline habitat but exhibit extensive **diversity** in how they generate energy. nutrients are intermittently available in hypersaline lakes during seasonal variation, resulting in severe energy stress. in response, halophiles have evolved a wide array of possible metabolic solutions to survive on the same pool of scarce resources. hypersaline microbial communities have great potential to reveal general principles of community resilience to environmental perturbation. however, knowledge regarding the mechanisms of community interactions remain largely uncharacterized. in the proposed work, the pi and collaborators address these questions by pursuing the following objectives: (a) constructing constraint-based models for hypersaline communities to explain and predict metabolic interactions; (b) sampling the great salt lake microbial communities over temporal and spatial gradients to test model predictions; (c) testing model predictions in synthetic communities grown in the lab under ecologically relevant conditions. to accomplish these aims, a comprehensive professional development plan is proposed, including intensive study in metabolic modeling and training in field ecology during trips to the great salt lake. the proposed models are

expected to enable highly accurate predictions of flux distributions in microbial communities. this research enables the pi to launch a new and exciting research direction, building on prior work that discovered mechanisms of transcriptional regulation of metabolic networks in archaeal extremophiles. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Transitions: Modeling microbial community metabolic interactions under extreme conditions

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Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Rensselaer Polytechnic Institute

Amount: \$898,999.00



Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and \*\*diversity\*\* of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SBIR Phase II: Bilingual Literacy Assessment and Skill Tracker

Awardee: LangInnov

Amount: \$898,537.00

Abstract: the broader impact/commercial potential of this small business innovation research (sbir) phase ii project is related to the underserved, emergent bilingual population in us school systems. in spite of their growing size (approximately 20 percent of the total us population), emergent bilinguals still do not have adequate support to succeed in academic settings and are often victims of a subtractive bilingualism process that favors the acquisition of english at the expense of the home language. the lack of adequate bilingual resources has led to a disproportionate misplacement of emergent bilinguals in special education as well as an increased drop-out rates in bilingual populations, in general, and latino communities in particular. to address these problems, a recommendation system powered by machine-learning algorithms that will generate a personalized bundle of fun, bilingual literacy activities linked to a fully-automated bilingual assessment is proposed. the unique characteristic of this solution is that the personalized activities are generated

automatically based on assessment results and activity performance. the goal of the activities is to develop the skills identified by the assessment as needing improvement, both in english and in the home language of the child. this small business innovation research phase ii project addresses the educational needs of the growing, school-age, emergent bilingual population (i.e. children in the school system whose home language is not english or only english), as well as the loss of cultural **\*\*diversity\*\*** and linguistic acumen for society as a whole. the main research objectives involve: a) designing game-like bilingual activities that can get the young child?s attention, b) developing age-appropriate and culturally-sensitive content for the bilingual activities, c) refining the speech recognizer to work well with children's speech in both spanish and english, and d) implementing the latest trends in data-analysis and machine-learning technologies to develop a recommendation system that proposes personalized activities tailored to each child?s needs based on assessment results and activity performance. the research and development plan aims at developing an innovative product that stands out from existing solutions. the key differentiator features are: 1) its focus on bilingual children and its adaptability in accepting bilingual answers for the activities, 2) its capacity to help children develop speaking skills due to the integration of automatic measures of speech performance, and 3) its recommendation engine that suggests personalized bilingual activities for each student tailored to their specific needs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity  
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Title: Collaborative Research: MIM: The impact of the fungal microbiome in metal tolerance and soil biogeochemical transformations

Awardee: Michigan State University

Amount: \$898,475.00

Abstract: some metals are essential nutrients for life, while some are non-essential or even harmful

to living organisms. fungi and bacteria are microorganisms that often live in a close association and play a key role in transforming and detoxifying metals in the environment. in spite of this importance, there is relatively little understanding of how the interactions between bacteria and fungi influence the transformation and/or detoxification of metals. the goal of this project is to address this knowledge gap by identifying how fungal-bacterial interactions affect metal transformation. this will be achieved through a novel multidisciplinary research approach employing advanced, state-of-the-science analytical techniques. knowledge gained through this project will allow the engineered control of metal transformations for a wide range of applications in environmental cleanup, biorefining, production of nanoparticles, and other beneficial applications. successful completion of this research has strong potential to benefit society through improvements in environmental remediation and industrial manufacturing. this project will improve the nation's stem workforce by providing a unique training opportunity for student researchers that bridges diverse fields such as environmental engineering, microbiology, geochemistry, bioinformatics, and art.

remediation of metal contamination is a major environmental challenge because, unlike many organic pollutants, metal species cannot be degraded and can only be extracted or biotransformed to less toxic forms. while past approaches to biotransform metals have focused primarily on single microorganisms, host-microbiome interactions have shown potential to biotransform surrounding environments and improve host resiliency. however, the mechanisms for metal biotransformation by microbial host-microbiome systems are largely unknown. the overall goal of this project is to elucidate the rules of life that govern fungal microbiomes. this goal will be achieved through a specific focus on fungal microbiomes, which include a fungal host, endosymbionts (endobacteria), and symbionts (exobacteria that live extracellularly) as a model host-microbiome system. the specific research objectives of this project designed to achieve the goal are to: understand the effects of metals and metalloids on the **\*\*diversity\*\*** and transmission of fungal microbiomes (facultative and obligatory); and determine the role of fungal microbiomes in metal tolerance by mediating the uptake, transformation, and sorption of metal ions, nanoparticles, or other metal

species. a deeply integrated multidisciplinary approach will be used to investigate physiological, genetic/genomic, and metabolic processes that govern the structure and function of fungal microbiomes in the presence of metals. this will be achieved using novel state-of-the-science isotope probing, advanced microscopy, spectroscopy, and integrated genomics, transcriptomics, and metallomics to elucidate how the microbiome influences the metabolic activity of the host towards metal ions. successful completion of this research has strong potential to identify new genes and/or pathways for metal tolerance and biotransformation, as well as expand our mechanistic understanding of the structure and function of fungal microbiomes in nature. this knowledge has strong potential to benefit society by facilitating applications in remediation, water treatment, electronics manufacturing, antimicrobial production, medicine, and related fields. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Genome editing approaches to unravel microRNA roles in stochastic multistable networks

Awardee: Northeastern University

Amount: \$896,200.00

Abstract: one of the fundamental questions in biology is to understand the roles of the gene regulatory networks driving cellular decisions; cellular decisions drive everything from an organism's development to a cell's fate as healthy or diseased. micrornas (mirnas) are small rna molecules that bind to the mrna of target genes, acting as regulators of gene expression. previous studies have demonstrated the critical roles of mirnas in a variety of biological processes such as cell growth and cell differentiation. however, what is still not well understood concerns possible synergistic effects from multiple mirna molecules targeting different binding sites of the same mrna and concerns how mirna interactions operate within a complex gene regulatory network. to address these issues, an

interdisciplinary platform that combines genome editing, live-cell imaging, and mathematical modeling will be developed in this project. the broader impacts of the project from the university of texas at dallas side will include support for the international genetically engineered machine (igem) team and developing custom educational modules for local schools (plano isd) and summer camps, organizing public educational events at the interface of the biological and physical sciences, and the recruitment of underrepresented minorities. from the northeastern university side, the group will take advantage of the investigators' participation in the nsf center for theoretical biological physics ongoing **\*\*diversity\*\*** efforts to recruit undergraduates from under-represented to work on this project, and spearhead an effort to create a modeling and computational track for undergraduate bioengineering majors. finally, both groups will be directly involved in reaching out to local biomedical groups to create more appreciation for the types of rapid progress that can be made by combining advanced tools such as crispr with state-of-the-art computational methodology including both mechanistic studies and machine learning approaches. lying at the heart of intricate relationships that determine the epithelial-mesenchymal transition (emt) and mesenchymal-epithelial transition (met) phenotypes is a core regulatory unit that consists of transcription factors and micrnas. the project will focus on mirnas targeting the master transcription factor (tf) families of emts, snail and zeb during the cellular decision process of emt in multiple cell lines. the team will first perform crispr-based screens and custom genome and base editing modifications on mirna binding sites that are located at the 3'-utr of the transcription factor families snail and zeb. the effects of binding site modifications in emt and isolated respective clones will be evaluated. second, the team will prepare and optimize an rna imaging platform in live cells and measure time-series data and population distributions for mirna, mrna and protein levels of corresponding genes. using this data, the team will develop stochastic kinetic models of mirna regulation and infer the combinatorial effects of multiple mirna species binding to multiple sites of the same mrna. third, the team will integrate the kinetic models for each mirna interaction into full transcription factor-mirna network models for different cell lines. the models will be refined by calibrating model predictions with

experimental observations on the distributions of gene expression and the distribution of cells in various emt states. this project brings together investigators who have extensive experience in genome editing/systems biology (bleris), epithelial?mesenchymal networks (levine), and systems biology/mathematics (lu). this award reflects nsfs statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Precision Measurement of the 1S-2S Interval in Positronium

Awardee: University of California-Riverside

Amount: \$891,952.00

Abstract: general audience abstract: the positronium atom (ps) is an exotic short-lived atom formed by an electron and its anti-particle, the positron. this project will improve the accuracy of measurements of the structure of ps, revealing detail about the fundamental interactions between the electron and positron. unlike more conventional atoms ps does not contain any protons or neutrons; thus spectroscopy of ps atoms is an excellent test of ?bound-state quantum electrodynamics,? the cornerstone theory for modern atomic physics. this project pushes the state-of-the-art in the ultra-high precision measurement of short lived atoms and molecules and opens the door to better understanding of transient chemical species that are produced as a reaction is taking place. graduate students will build and operate the apparatus designed especially for this experiment. undergraduate students will assist in the experiments, mostly during the summers. local high school teachers will attend a week-long university of california riverside summer academy for high school teachers at which teachers are exposed to research, visit the labs, and are inspired by lectures and demonstrations that explain how to incorporate research within the high school physics curriculum. the pi will visit high school physics teachers and classrooms and work with local county board of education science projects to advance junior and senior high school

curriculum development under the new next generation science standards and state science standards. this project will thus help expand the nation's high technology work force by training students in cutting edge techniques and increase the **\*\*diversity\*\*** of participants in stem fields, starting with the pipeline from junior high school physical science classrooms.

technical audience abstract: the purely leptonic positronium (ps) atom is uniquely well-suited for testing bound-state quantum electrodynamics (qed). high accuracy ps spectroscopy at the few parts per trillion level will provide background information that can be used to extract non-qed physics out of precision atomic measurements with heavier leptons and hadrons. in this way, ps spectroscopy can shed light on the proton charge radius puzzle as well as the recent shifting of the value of the rydberg constant (by about 7 times the previously accepted experimental uncertainty). whenever a measured constant is shifted by such a large amount, then there is an opportunity for closer examination to yield new experiments and new physical understanding in how to measure the constants. higher accuracy can also help constrain higher level recoil effect corrections in muonium. the previous precision measurement of the ps 1s-2s interval,  $1,233,607,216.4 \pm 3.2$  mhz, performed by the co-pi and s. chu has stood for 25 years. the uncertainty in this measurement came from positronium atoms spending too little time in the laser beam (transit time broadening), atoms moving too fast (second-order doppler shift), laser intensity too high (ac stark shift), and metrology limited at the  $\sim 1$  mhz level. this project will implement several new techniques to improve accuracy and precision. a position-sensitive time-of-flight detector will record the trajectory and speed of every detected atom as it passes through a larger laser beam profile, and thereby reduce the uncertainty due to second-order doppler shifts, ac stark shifts, and transit-time broadening. a frequency-comb and a frequency-beat technique will be used to monitor the instantaneous laser frequency as positronium atoms transit the excitation beam. these innovations should reduce the uncertainty in the measurement by a factor of 300, with the goal of reaching a 10 khz uncertainty. this work will train graduate students in a combination of atomic physics, positron science, laser spectroscopy, and metrology. this training will benefit the students as well as the nation by providing highly skilled

ph.d.'s for the scientific workforce. the university of california riverside is a department of education designated hispanic serving institution (hsi) with 50% of physics majors and 10% of domestic graduate students from under-represented ethnic minority groups. several undergraduate researchers and a high school teacher will also be involved in these experiments, and this will help to attract more participants to stem disciplines. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Dimensions US-China: Collaborative Research: Consequences of diversity in Asian and American tree symbionts for functional variation, adaptation and symbiont biodiversity

Awardee: University of Minnesota-Twin Cities

Amount: \$890,075.00

Abstract: the world's approximately 425 oak species maintain species identity even while exchanging genes with their close relatives through hybridization. this history of evolution and genetic exchange has shaped the bio\*\*diversity\*\* of northern hemisphere ecosystems. oaks are ecologically diverse, with related species often growing in close proximity but specializing on areas of the forest landscape that differ in soil texture and moisture level or in the frequency of natural fires. gene exchange can move such ecological specializations between oak species, broadening their ranges and ability to respond to climate change. the impacts of these genetic exchanges may extend beyond the oaks themselves. oaks host an estimated 1000 gall wasp species worldwide and highly diverse communities of fungi associated with their roots (as mycorrhizae) and inside their leaves (as endophytes). using paired field surveys and common garden experiments the p.i.s will evaluate the effects of hybridization and introgression on the genetic, phylogenetic, and functional \*\*diversity\*\* of focal oak species and their symbionts in the us and china. this work will also provide inquiry-based k-12, undergraduate, and graduate education; critical natural history training to the



public through a community-science initiative in oak phenology; and publications that will bring research to public audiences. two interdisciplinary teams of researchers, one based in the us and one in china, will investigate how genomic, functional, and phylogenetic **\*\*diversity\*\*** of oak trees shape the mycorrhizal fungi, endophytic fungi, and gall wasp and other insect communities that associate with them. research will focus on two related groups of interbreeding species: bur oak (*quercus macrocarpa*) and relatives in the us and bao li (*quercus serrata*) and relatives in china. the project has three objectives, each conducted in parallel in china and the u.s. in objective 1 the teams will perform range-wide phylogenomic surveys of natural populations to reconstruct genomic mosaics, characterize geographic patterns of leaf functional traits, and characterize functional and phylogenetic **\*\*diversity\*\*** of associated mycorrhizal fungi, leaf endophytic fungi, and gall wasps. in objective 2 common gardens will be planted across climatic gradients to evaluate the effects of genetic variation and population differentiation on oak functional and spectral traits and relative fitness in different climates, and how these influence the phylogenetic and functional **\*\*diversity\*\*** of oak-associated fungal and insect communities. in objective 3 the teams will use a second set of common garden experiments to evaluate how plant community and phylogenetic **\*\*diversity\*\*** affects focal oak species genetic, phylogenetic, and functional **\*\*diversity\*\***. the project will provide an integrative perspective on how oak **\*\*diversity\*\*** within and among species impacts the broad **\*\*diversity\*\*** of oak-dominated ecosystems across the northern hemisphere. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MRI: Acquisition of a High Temperature and Pressure Solid-state NMR Spectrometer

Awardee: Washington University

Amount: \$886,362.00

Abstract: the award supports the acquisition, installation, and shared research application of a

state-of-the-art solid-state nuclear magnetic resonance (ssnmr) spectrometer system in the nano research facility/jens molecular and nanoscale analysis laboratory (nrf/jens lab) at washington university in st. louis, missouri (wustl). the ssnmr system is capable of high-temperature and high-pressure sample analysis, thus opening the door to the study of a broad range of critical environmental remediation, biological processing, and fuel/chemical/polymer manufacturing technologies under realistic conditions. primary research areas include: (1) homogeneous and heterogeneous catalysis, (2) membrane-based separations, (3) polymeric and biological materials properties, and (4) geochemical and biogeochemical systems (e.g., carbon sequestration). the system will support a broad user base consisting of researchers at multiple universities in the midwest region surrounding st louis (including missouri science and technology, kansas state university, university of kansas, university of notre dame, and the university of oklahoma). the nmr system will play a key, connecting role in advancing fundamental knowledge in critical technology areas while promoting **\*\*diversity\*\*** and stem education at multiple educational levels. the acquired system is a commercial avance neo 400 mhz nmr spectrometer uniquely designed and equipped to acquire in-situ nmr spectra simultaneously from solid, liquid, and/or gas analytes at high-temperatures (up to 250 °c), high-pressures (up to 400 bar at 20 °c), or high-t,p conditions (up to 225 bar at 250 °c). the greater st. louis metropolitan region does not have an ssnmr facility with these capabilities. the spectrometer is designed for magic-angle spinning (mas) solid-state nmr (ssnmr) across a range of nmr-active species for conventional (ex-situ) nmr studies and for in-situ mas ssnmr capable of analyzing simultaneously gases, liquids, and solids under such high-t,p conditions. the spectrometer is equipped with a wide-bore magnet; mas pneumatic and variable temperature (vt) control with heater power booster units; vt-stack for high-t experiments; and high-t mas probe required for in-situ ssnmr experiments at high-t,p. access and administrative support will be provided through the nrf/jens lab with instrument management and oversight coordinated and supported by two advisory committees (a scientific advisory committee and an operations and management committee). the instrument will be available to internal and external academic users as

well as external corporate users through a web-based scheduling system. all users will pay hourly usage fees to support the operation and maintenance of the instrument. this broadly accessible ssnmr instrument, with its modern commercial console and high-t,p capabilities, will provide unprecedented opportunities to (1) familiarize students with this technology?important for their training and professional development, (2) advance the specific science and engineering research projects of user groups, and (3) facilitate shared expertise and catalyze new research partnerships and collaborations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Supporting and Empowering Polar Early Career Scientists through the Polar Science Early Career Community Office

Awardee: University of Colorado at Boulder

Amount: \$884,771.00

Abstract: the university of colorado at boulder will provide support for the association of polar early career scientists (apecs) to accelerate national and international polar workforce development. this effort will bring the apecs leadership office to the usa for the first time and support the us-apecs office functions. the apecs office provides organizational support to the trans-disciplinary international membership of ~3800 early career polar scientists. the goal is to provide leadership development, training, networking and a voice to polar science students and postdocs. the three key activities are to: 1) establish an apecs office in the usa to provide infrastructure and expertise to the network, 2) build us early career polar science capacity through travel grants and support of the usapecs national committee, and 3) directly support impactful initiatives that support belonging, accessibility, justice, equity, **\*\*diversity\*\*** and inclusion (beajedi) in polar science. the cu boulder-based apecs office will leverage existing nsf investments to elevate the visibility of polar

science and connect early career scientists to international polar research efforts, such as large field and modelling campaigns, and efforts aimed at improving the inclusion of local and indigenous voices in arctic research. us polar research will benefit by connecting to this international and diverse pool of early career scientists, creating pathways to new collaborations and opportunities and being exposed to new voices. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MIM: Elucidating the Rules of Cooperation and Resiliency in Microbial Communities through Stochastic Graph Grammars

Awardee: Carnegie Institution of Washington

Amount: \$874,451.00

Abstract: microbial communities in aquatic ecosystems are central to maintaining the resiliency of these important environments. these dense microbial populations are rich in species **\*\*diversity\*\*** and their genomes are dynamic because of processes such as gene duplication and horizontal gene transfer. despite extensive genomic flux due to these evolutionary processes, microbial communities cooperate and maintain stable interactions and are resilient to environmental perturbations. this project aims to develop a suite of computational tools for deciphering the rules that govern cooperation and resiliency in hot spring microbial mats, or biofilms, from yellowstone park. these well-studied environments are ideal for examining how critical environmental parameters such as temperature, light and nutrients influence the **\*\*diversity\*\***, abundance, and evolution of microbial populations. novel computational tools will be developed to identify rules that govern relevant biological processes. understanding how microbiomes evolve and adapt, especially with respect to the environment and to perturbations is crucial to understand many aspects of life. thus, the results obtained from this project will have a significant impact on biology, health, conservation efforts, and

animal and plant management. furthermore, this research will support the interdisciplinary development of a diverse cohort of phd and undergraduate students at rice university and carnegie institution for science located on the stanford university campus. this project will also support the development of a summer reu focused on bioinformatics, ecology, evolution, and microbiology, and will also include summer training opportunities for graduate students with collaborators at the pasteur institute in paris, france. this collaborative, multidisciplinary project presents an innovative plan for combining education and outreach activities to achieve real and lasting impact. all software developed will be made available on open-source code repositories. the overall goal of the project is to understand how microbiomes evolve and adapt, especially with respect to the environment and to perturbations. to meet these goals, the team of researchers will introduce methodological advances at the intersection of graph theory, formal languages, and machine learning to identify rules governing gene duplication and horizontal gene transfer from metagenomic sequencing data. in aim 1, the project will construct and correlate species abundance networks with genome exchange networks through genome assembly graphs. in aim 2, the project will produce a stochastic graph grammar framework for modeling network evolution over time, as well as unveil new rules with deep graph generators. in aim 3, genome-level simulations will be combined with the genomic events identified in aims 1 and 2 to assess the evolutionary benefits of these biological processes and their associated rates. the final project aim will focus on characterizing cooperation and resiliency through the study of graph grammars and network analysis techniques. the open-source computational methods developed across all four project aims will be evaluated on four distinct metagenomic datasets, including both environmental and host-associated microbiomes. finally, a wide variety of metagenomic datasets will be used to show generalizability of the computational approaches to host-associated microbiomes. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: MIM: Gut-inhabiting fungi influence structure and function of herptile microbiomes through horizontal gene transfer and novel metabolic function

Awardee: Middle Tennessee State University

Amount: \$870,000.00

Abstract: reptiles and amphibians are among the most threatened species on the planet, and an increasing number of their species must be managed in captive breeding programs. understanding the bio\*\*diversity\*\* and function of microbes that are present in the digestive tracts of reptiles and amphibians is critical for insight into their role in animal health. early research suggests that the filamentous fungus basidiobolus is an important member of reptile and amphibian gut microbiomes, and that this fungus influences what types of bacteria are present in the digestive tract. genomic sequencing of the basidiobolus fungus shows that genes have been transferred to the fungus from the gut bacteria. this transfer of genes between bacteria and fungi results in novel metabolism in the fungus that may play important roles in regulating the reptile/amphibian host's immune system, iron metabolism, and chemical communication with the gut bacteria. an interdisciplinary scientific approach will be used to understand the functional roles that specialized metabolites play in microbial interactions between fungi and bacteria in gut microbiomes of animals and also other natural microbiomes. outreach activities with zoos and the great smoky mountains national park will share information about reptile and amphibian gut microbiomes with the general public, and educational material will be provided to educators for inclusion in k-12 and university curricula. interdisciplinary training of students and postdoctoral researchers to prepare them for careers in research, education, and outreach is central to the project. this work will advance a new scientific understanding of the fundamental roles that specialized metabolites play in microbial interactions between fungi and bacteria in gut microbiomes. this will be accomplished through an interdisciplinary approach combining ecology and evolutionary biology, genomics and metagenomics, natural product chemistry, synthetic microbiome experiments, and controlled

amphibian feeding trials. preliminary data reveal that fungi in the genus basidiobolus are dominant members of the herptile microbiome, and that microbial community structure is shaped by the genetic **diversity** of basidiobolus, which has acquired specialized metabolism through hgt. integration of biological, molecular, genomic, metagenomic, and chemical resources in the proposed herptile system will allow for tests of the following hypotheses: h1: herptile microbiomes are characterized by unique fungal communities not found in other nonpathogenic, microbiome systems. h2: the bacterial assemblages of herptile microbiomes are structured by interactions with fungi. h3: hgt from co-occurring bacteria to herptile gut fungi allowed basidiobolus to acquire novel metabolic functions necessary to adapt to, and function in, the herptile microbiome. h4: fungal-bacterial interactions in herptile gi systems are regulated by metabolites that influence community structure and function. h5: the phenotype of the host-microbiome association is species/context dependent. this work will further refine the general model that the animal gastrointestinal environment promotes hgt between bacteria and fungi, and that this hgt selects for specialized metabolites that modulate the host immune system (cyclic peptides), and allow fungi to function in a reduced oxygen environment and compete in a bacterial rich microbial community (siderophores and surfactins). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: MIM: Gut-inhabiting fungi influence structure and function of herptile microbiomes through horizontal gene transfer and novel metabolic function

Awardee: Oregon State University

Amount: \$870,000.00

Abstract: reptiles and amphibians are among the most threatened species on the planet, and an increasing number of their species must be managed in captive breeding programs. understanding the bio**diversity** and function of microbes that are present in the digestive tracts of reptiles and

amphibians is critical for insight into their role in animal health. early research suggests that the filamentous fungus *basidiobolus* is an important member of reptile and amphibian gut microbiomes, and that this fungus influences what types of bacteria are present in the digestive tract. genomic sequencing of the *basidiobolus* fungus shows that genes have been transferred to the fungus from the gut bacteria. this transfer of genes between bacteria and fungi results in novel metabolism in the fungus that may play important roles in regulating the reptile/amphibian host's immune system, iron metabolism, and chemical communication with the gut bacteria. an interdisciplinary scientific approach will be used to understand the functional roles that specialized metabolites play in microbial interactions between fungi and bacteria in gut microbiomes of animals and also other natural microbiomes. outreach activities with zoos and the great smoky mountains national park will share information about reptile and amphibian gut microbiomes with the general public, and educational material will be provided to educators for inclusion in k-12 and university curricula. interdisciplinary training of students and postdoctoral researchers to prepare them for careers in research, education, and outreach is central to the project. this work will advance a new scientific understanding of the fundamental roles that specialized metabolites play in microbial interactions between fungi and bacteria in gut microbiomes. this will be accomplished through an interdisciplinary approach combining ecology and evolutionary biology, genomics and metagenomics, natural product chemistry, synthetic microbiome experiments, and controlled amphibian feeding trials. preliminary data reveal that fungi in the genus *basidiobolus* are dominant members of the herptile microbiome, and that microbial community structure is shaped by the genetic **diversity** of *basidiobolus*, which has acquired specialized metabolism through hgt. integration of biological, molecular, genomic, metagenomic, and chemical resources in the proposed herptile system will allow for tests of the following hypotheses: h1: herptile microbiomes are characterized by unique fungal communities not found in other nonpathogenic, microbiome systems. h2: the bacterial assemblages of herptile microbiomes are structured by interactions with fungi. h3: hgt from co-occurring bacteria to herptile gut fungi allowed *basidiobolus* to acquire novel metabolic



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Matched Words: diversity

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Title: Collaborative Research: MIM: Gut-inhabiting fungi influence structure and function of herptile microbiomes through horizontal gene transfer and novel metabolic function

Awardee: Middle Tennessee State University

Amount: \$870,000.00

Abstract: reptiles and amphibians are among the most threatened species on the planet, and an increasing number of their species must be managed in captive breeding programs. understanding the bio\*\*diversity\*\* and function of microbes that are present in the digestive tracts of reptiles and amphibians is critical for insight into their role in animal health. early research suggests that the filamentous fungus basidiobolus is an important member of reptile and amphibian gut microbiomes, and that this fungus influences what types of bacteria are present in the digestive tract. genomic sequencing of the basidiobolus fungus shows that genes have been transferred to the fungus from the gut bacteria. this transfer of genes between bacteria and fungi results in novel metabolism in the fungus that may play important roles in regulating the reptile/amphibian host's immune system, iron metabolism, and chemical communication with the gut bacteria. an interdisciplinary scientific approach will be used to understand the functional roles that specialized metabolites play in

microbial interactions between fungi and bacteria in gut microbiomes of animals and also other natural microbiomes. outreach activities with zoos and the great smoky mountains national park will share information about reptile and amphibian gut microbiomes with the general public, and educational material will be provided to educators for inclusion in k-12 and university curricula. interdisciplinary training of students and postdoctoral researchers to prepare them for careers in research, education, and outreach is central to the project. this work will advance a new scientific understanding of the fundamental roles that specialized metabolites play in microbial interactions between fungi and bacteria in gut microbiomes. this will be accomplished through an interdisciplinary approach combining ecology and evolutionary biology, genomics and metagenomics, natural product chemistry, synthetic microbiome experiments, and controlled amphibian feeding trials. preliminary data reveal that fungi in the genus basidiobolus are dominant members of the herptile microbiome, and that microbial community structure is shaped by the genetic **diversity** of basidiobolus, which has acquired specialized metabolism through hgt. integration of biological, molecular, genomic, metagenomic, and chemical resources in the proposed herptile system will allow for tests of the following hypotheses: h1: herptile microbiomes are characterized by unique fungal communities not found in other nonpathogenic, microbiome systems. h2: the bacterial assemblages of herptile microbiomes are structured by interactions with fungi. h3: hgt from co-occurring bacteria to herptile gut fungi allowed basidiobolus to acquire novel metabolic functions necessary to adapt to, and function in, the herptile microbiome. h4: fungal-bacterial interactions in herptile gi systems are regulated by metabolites that influence community structure and function. h5: the phenotype of the host-microbiome association is species/context dependent. this work will further refine the general model that the animal gastrointestinal environment promotes hgt between bacteria and fungi, and that this hgt selects for specialized metabolites that modulate the host immune system (cyclic peptides), and allow fungi to function in a reduced oxygen environment and compete in a bacterial rich microbial community (siderophores and surfactins). this award reflects nsf's statutory mission and has been deemed worthy of support through

evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Integrating Artificial Intelligence with Smart Engineering and English Language Arts in Upper Elementary Education

Awardee: Tufts University

Amount: \$866,273.00

Abstract: this project will develop upper elementary school students' abilities to work with artificial intelligence (ai) in future careers. ai will be a critical tool for influencing and increasing productivity in the future of work. as such, it is increasingly important to introduce k-12 students to basic ai knowledge and skills, build familiarity with ai technologies, and train students to be competitive in the workforce. through this project, a team of robotics and education researchers at tufts university in massachusetts and maryville university in st. louis, mo will work with over 50 teachers in st. louis county to develop a research-informed educational ecosystem bringing ai concepts to upper elementary school students. this ecosystem will include a novel, low-cost, ai-enabled hardware toolset, including components such as sensors, actuators, and a microcontroller, for students to build smart systems, as well as support for teacher professional development. through after-school and summer programs, the project will engage over 1000 st. louis county students in constructing functional ai-enabled solutions to problems presented in fictional stories that the students read in english language arts and summer reading programs. the goal of the approach is to encourage transdisciplinary learning at the intersection of ai, engineering, and literacy. the education program testing will include 12 teachers and 500 students from the upper elementary target audience, with other participants in pilot testing across the k-12 grade band. the project aims to generate a new model for introducing vital ai concepts to elementary students that reduces barriers to integrating computational thinking into school curricula and provides tangible, trainable representations of ai for students to explore. researchers will investigate three primary research questions: 1) how does the

introduction of tangible artificial intelligence elements lead to changes in upper elementary students' understanding of artificial intelligence concepts and attitudes towards artificial intelligence? 2) how do different levels of complexity and variety of tangible artificial intelligence learning tools impact students' engagement and the **diversity** of their solutions and designs? 3) what are the potential benefits and challenges of introducing tangible artificial intelligence elements in integrated engineering and literacy activities? the project team will apply a design-based research (dbr) approach to jointly generate interdisciplinary education and learning sciences theory alongside iteratively designing and developing the toolset, professional development, and activities. the research will include interviews and surveys with ai professionals to develop and validate grade-appropriate measures of students' understanding of ai concepts and attitudes. the team will evaluate the research questions with a mixed-methods analytic approach, triangulating qualitative data from teacher interviews, lesson and professional development observations, student-made artifact analysis, and artifact-based student interviews with quantitative data from teacher and student surveys. the project's contribution will shift the artificial intelligence education paradigm towards a convergent curriculum and away from the status quo of coding and computing requiring separate instruction. the project findings will help inform the field about challenges specific to ai education in upper elementary grades. the deliverables from this project will include the ai animated inventions (ai2) hardware toolset, a teacher professional development model, a gallery of example activities and student work, and measures of the program's effectiveness, as well as the usability and utility of the tangible artificial intelligence elements for learning ai concepts. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Does responding to stressors prime greater resilience? Testing the long-term effects of challenges on behavior, physiology, epigenetic state, and fitness.

Awardee: Cornell University

Amount: \$863,173.00

Abstract: when faced with a major challenge ? severe weather, the attack of a predator, an injury ? organisms mount a coordinated physiological and behavioral stress response. this response can be vital for surviving and recovering from immediate threats. this project will test whether activating the stress response system has another overlooked benefit that operates over much longer time-scales: priming the system to respond better to future challenges. coordinated experiments will address fundamental questions about when and how environmental challenges prime greater resilience to future challenges, and examine whether those effects persist across generations. this study will also adapt and refine newly developed sensor technology that enables non-invasive monitoring of heart rate in free-living animals ? a tool that could yield considerable advances across fields. a more comprehensive understanding of the lingering impacts of challenges will also be valuable for other fields, including conservation and human health. additionally, the team will lead a career development program that combines a field research internship ? in which students participate in addressing the research objectives outlined in this proposal ? with a laboratory- and classroom-based skills development program for students from underrepresented groups who are interested in careers in stem fields. this opportunity is designed to foster interactions among students from a small liberal arts college and from a large research-intensive university. this project will test the hypothesis that transient challenges experienced in adulthood prime greater resilience or robustness to future challenges, defined as the ability to return to or maintain a stable state. research will use a long-term study population of tree swallows (*tachycineta bicolor*) in which large-scale behavioral and physiological data can be collected from free-living individuals. in the first year of study adult females will be exposed to either an ecologically relevant challenge or a simulated glucocorticoid stress response. in the following year(s) a **\*\*diversity\*\*** of phenotypic traits, and context-dependent performance and fitness, will be measured. this study design will enable comparison of the direct effects of exposure to a challenge with the effects of exposure to a

mediator of the response to that challenge. these experiments will also reveal whether the long-term effects of stressors on behavior, physiology, and fitness are mediated by glucocorticoids and by glucocorticoid-induced changes in dna methylation. this research will also test whether parental exposure history carries over to affect the phenotype and fitness of offspring produced in the year(s) after the challenge. by combining targeted experiments in a free-living population with integrative methods of behavioral, physiological, and epigenetic assessment this project will provide insights important for developing and revising conceptual models of stress and phenotypic plasticity. it will also broaden our understanding of the mechanisms of behavior, how organisms are shaped by their environments, and how sub-organismal responses contribute to organismal resilience and robustness. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Tulane University

Amount: \$856,924.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Investigating chemosensory evolution in longhorned beetles using a comparative phylogenomic framework that integrates genomic, morphological, and biochemical data

Awardee: University of Memphis

Amount: \$856,023.00

Abstract: longhorned beetles are a highly diverse insect group with over 30,000 species. they feed on dead wood and also plants; in addition, they pollinate flowers. thus, they have an important positive ecological impact. however, sometimes they can be serious pests of living trees and timber. in spite of the ecological significance of the group and its rich **\*\*diversity\*\***, the evolutionary relationship of major groups of longhorned beetles remains a mystery. this research will reconstruct the evolution of the group by sequencing genomes of key species and comparing the differences. simultaneously, the project will explore why longhorned beetles have become so diverse and how this is linked to their namesake long ?horns,? or antennae. these horns are highly sensitive chemosensory organs that are used to smell and taste the environment. the latest techniques in microscopy, imaging, and genomics will be used to study longhorned beetle antennae, identify the genes that detect odors and tastes, and reconstruct how changes in these organs have contributed to the success of the group. this information will help assist efforts to control the longhorned beetles that are pests on trees and timber, while avoiding harm to species that have positive ecological impacts. moreover, the knowledge gained will help improve our understanding of chemosensation in other groups of arthropods that also include ecologically beneficial species and pests with major economic impacts. finally, this project will enable science mentoring, education, and outreach, through training undergraduate and graduate students and postdoctoral researchers, teaching k-12 students about insect bio**\*\*diversity\*\***, and widely sharing new data and educational materials. this project will produce the first comprehensive, large-scale phylogeny of longhorned beetles, which comprises a highly diverse radiation of primarily wood-feeding animals, in order to obtain a detailed

understanding of insect chemosensory biology and evolution. data from > 500 nuclear genes obtained from > 600 species via anchored hybrid enrichment sequencing will be considered, and extensive new data on the genetics and morphology of the group will be gathered. scanning electron microscopy will be used to compare the **diversity** and variation of antennal chemosensory organs across several longhorned beetle lineages. the research will yield antennal transcriptomes and annotated chemoreceptor and pheromone receptor gene repertoires, which will be used to conduct a comparative analysis of receptor chemistry. in this manner, the evolution of longhorned beetle chemical communication will be determined. the research will also help reveal how ecological distinctions among longhorned beetles are related to differences in chemosensory organs and chemoreceptor repertoires. this will enhance understanding of the evolution of different modes of longhorned beetle chemical communication and elucidate how the origins of these disparate modes may have influenced diversification. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Investigating the deep origin and evolution of the bird beak by synthesizing the fossil record and comparative embryology of archosaurian reptiles

Awardee: Yale University

Amount: \$856,022.00

Abstract: our planet teems with life in a vast array of shapes and sizes, interconnected in myriad ways by ecology and by descent. one way to understand how and why earth's bio**diversity** came to be is to trace the history of a great evolutionary radiation determine the key events that contributed to its success. among land vertebrates, birds stand out in terms of species number, engineering, and geographic spread. this project will explore both the history and the embryonic development of one of the signal innovations that underpins bird **diversity**: the beak. in doing so,



the project will discover the way in which the beak was built during evolution and the way in which it is assembled anew during the early existence of each individual bird. the avian beak is a ?key innovation,? a sort of technological advance that enabled subsequent success. it is a remarkably effective and versatile biological tool whose complex and efficient architecture has been modified for taking in food as disparate as nectar (hummingbirds) and flesh (birds of prey). the **\*\*diversity\*\*** of birds is, in many ways, a **\*\*diversity\*\*** of beaks. the beak was also integral to the evolution of bird flight: the first beaks, in the dinosaurian ancestors of birds, seem to have acted as ?surrogate hands? to replace the fingers fused and incorporated into the wing. this project will use fossils that document 300 million years of reptile evolution to determine the steps that led to the evolution of the bird beak. they will, in particular, seek to discover how pre-existing anatomical structures, especially the predatory jaws of ancient archosaurs were co-opted and rearranged to make the beak, and will search for signatures of the classic evolutionary (and engineering) phenomena of tradeoffs and co-dependencies (integration and modularity). the project also investigates how the embryonic beak is formed in modern birds and how its development differs from that of the reptilian snout ? in particular, whether comparisons of modern embryos with fossils and fossilized embryos can tell us about which parts of the bird beak form by late ?tweaking? of, or addition to, a fundamentally reptilian embryonic anatomy and which are truly ?new.? the grand narrative of the way in which birds, living dinosaurs, came to be so diverse and abundant in the modern world is naturally compelling, and the data to be generated are often striking and beautiful. the project will incorporate the findings of their work, including digital images and 3d prints of these data, into the courses they teach at yale and into kits and curricula designed for k-12 classrooms, with a focus on low-income urban schools. beyond exchange of materials and knowledge, the project's investigators will visit classrooms and will, moreover, conduct on-campus tours of research and collections facilities for k-12 students, many from underrepresented groups in stem, and their teachers, with the intention of building long-term relationships with schools, teachers and students. the project also will lead to the design of exhibits featuring the discoveries from this work in part of the newly renovated yale

peabody museum. finally, the project team will conduct a series of online and in-person public lectures and question-and-answer sessions throughout the duration of the project. the avian beak is a marvel of biological engineering and a key innovation that enabled the radiation of birds. this project will examine the morphological assembly of the beak from stem reptiles through to crown-clade birds and, simultaneously, the embryonic assembly of the beak as compared to that of the reptilian snout. in particular, the project will test the hypothesis of co-option followed by further novelty and constraint release in the origin of the avian head from the ancestral archosaurian head, then the origin of the neognath jaw apparatus from the ancestral avian kinetic system. this will be accomplished using a combination of 3d ct imaging of fossils and extant taxa, and reconstruction of soft tissue anatomy using phylogenetic bracketing. analyses of shape and transformation will be three-dimensional and quantitative. the project will further test hypotheses of integration and modularity of skeletal elements surrounding major soft tissue structures using a variety of methods, and in particular will elucidate constraint and tradeoffs resulting from spatial packing or competition for space. this will be accomplished by quantitatively analyzing evolutionary trajectories and developmental trajectories (in part reconstructed using high-fidelity confocal imaging of entire immunostained embryos). finally, the project will seek to unravel the relative contributions of the distinct ontogenetic or developmental processes of terminal addition and early transformation in the evolutionary origin of the avian skull, using an integrative approach that incorporates embryos, fossils, and fossil embryos. in particular, the project will include both evolutionary sequences of reconstructed ancestors (from fossil data) and ontogenetic sequences (fossil and extant) in combined analyses and will quantitatively assess the correspondence or non-correspondence of these sequences. ultimately, the project will present a comprehensive picture of the sequence of evolution and development leading to the distinctive avian condition, and will gain insight into the transformational phenomena and evolutionary dynamics in operation during its genesis. this project was jointly funded with the sedimentary geology and paleobiology program in the division of earth sciences. this award reflects nsf's statutory mission and has been deemed worthy of support

through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Tackling Functional Protein States at Atomic Detail by Integrating Weighted Ensemble Simulations with Magnetic Resonance Restraints

Awardee: University of Pittsburgh

Amount: \$855,989.00

Abstract: this project is designed to characterize the alternate structures of proteins?the workhorses of life whose functions in biology are determined by their structures. a major challenge to characterizing these so-called ?functional structures? is that these structures are often too diverse or fleeting to be captured by experimental techniques at the level of individual atoms. an unmet need is therefore a strategy that can determine the structures of functional protein structures at the atomic level and even more crucially, a strategy that can provide insights into how the functional structures interconvert. this project will develop a new software tool that can determine the functional structures of proteins, how the proteins move to convert from one structure to another, and the rates at which the structures interconvert. this tool combines the use of computer simulations with distances within proteins that are measured by experiments and will be made available through a popular, freely available westpa simulation software package. this interdisciplinary, collaborative project is providing a valuable training ground for graduate and undergraduate students participating in the research, and is supporting diverse educational and outreach activities, including biennial westpa software workshops to provide training to the scientific community in using the new tool for determining the functional structures of proteins. a new frontier in biophysics has been the structural characterization of protein functional states. proteins are the workhorses of life and their functions are determined by their structures. a major challenge to characterizing protein structures is that many proteins adopt not just a single structural state, but alternate states that are relevant to the biological functions of the proteins. due to the \*\*diversity\*\* and often transient nature of such

functional states, the determination of their structures at the atomic level has been elusive to experimental techniques. an unmet need is therefore a strategy that can generate atomically detailed structures of functional states, and even more crucially, a strategy that can provide detailed insight into the pathways for interconversion between the states and corresponding kinetics. a key advance of the project is the development of a general strategy that integrates sparse distance restraints from magnetic resonance experiments with rigorous simulations to provide atomic level structures and dynamics of functional protein states. this project will provide a new simulation tool that will be made available to the scientific community through the freely available westpa software. to further enhance the accessibility of the software, the westpa software will be integrated with the orion cloud-computing platform on amazon web services, the world's largest on-demand, cloud-computing facility. this project is funded by the molecular biophysics cluster in the division of molecular and cellular biosciences, with partial co-funding from the chemical measurement and imaging program in the division of chemistry. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: RUI: Will climate change lead to system shifts on tropical mountains?: the interplay of epiphyte losses on host tree function, microclimate, and hydrology

Awardee: Franklin and Marshall College

Amount: \$854,953.00

Abstract: tropical montane cloud forests (tmcfs) are important ecosystems to study and conserve due to their exceedingly high bio\*\*diversity\*\* as well as the critical roles these forests play in local and regional water cycling. deforestation in lowland regions and increases in global sea surface temperatures indirectly threaten these forests due to the lifting of the cloud base and an increase in drought conditions. epiphytes, i.e. plants that live on the surfaces of other plants, cover nearly all

tree surfaces in the tmcf and contribute substantially to ecosystem function due to their high capacity to capture and temporarily store water. unfortunately, these plants are the most vulnerable ecosystem components to projected changes in climate. a loss of epiphytes in the tmcf would lead to substantial bio\*\*diversity\*\* loss as well as a destabilization of water resources for human populations. this work aims to fill an important gap in the understanding of feedbacks among epiphytes and forest functions in the tmcf, and will provide important data for land-use and conservation workers as well as natural resource managers and governments in tropical montane regions concerned with long-term water security. a number of local and us-based workers and students will be trained in field and lab-based techniques and regular training events and exchanges will take place amongst all the participants. epiphyte gardens and accompanying curriculum will be created and placed in local schools to increase understanding and awareness of the connectivity between epiphytes and water cycling in the cloud forest.

tropical montane cloud forests (tmcfs) are under threat due to rapid changes in climate and in fact, recent work suggests that this ecosystem is predicted to contract substantially in the coming decades. this proposal addresses the question: how will a loss of the diverse and abundant epiphyte communities in the tmcf impact tree health, energy balance and hydrologic function? the investigators propose to conduct the first large-scale epiphyte removal experiment, in which trees in forest and pasture will be stripped of their entire epiphyte community. changes in crown-level microclimate (air temperature, relative humidity, leaf wetness, wind speed, solar radiation) as well as growth, water relations (water potential, sap flow, stomatal traits, carbon isotopes) and ecohydrological parameters (soil moisture, throughfall, stemflow) will be measured in and under the trees stripped of their epiphytes and compared with paired trees with intact epiphyte communities. direct field-based measurements will be coupled with remotely sensed parameters (ndvi, air temperature, leaf water content) using a high-precision drone outfitted with an integrated multispectral imaging system. a numerical model of epiphyte-host tree water relations will be developed and coupled to a land-surface hydrology model to scale up the field-based measurements and predict the effect of epiphyte loss on regional energy budgets and

canopy water cycling. field work will take place in five locations in the monteverde region of central costa rica. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: RUI: Will climate change lead to system shifts on tropical mountains?: the interplay of epiphyte losses on host tree function, microclimate, and hydrology

Awardee: Franklin and Marshall College

Amount: \$854,953.00

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Matched Words: diversity

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Title: Inclusively-designing sensory extensions for STEM inquiry learning

Awardee: University of Colorado at Boulder

Amount: \$850,000.00

Abstract: this project investigates innovative sensory extension device technologies to create learning materials that are accessible and enable diverse learners to use multiple modalities in science and mathematics learning. the new technologies will be designed, crafted, customized, and personalized by stem learners with diverse needs. humans think and communicate using multiple

sensory modalities, including sight, sound, gesture, movement, and touch. most science and mathematics learning materials convey information visually, with displays such as diagrams and simulations, resulting in learning experiences with limited sensory engagement. for many learners with visual or print-related disabilities, visual learning materials are inaccessible. even for others, these materials constrain learning opportunities. sensory extension incorporates materials and devices to enable new or enhanced perceptions of real or virtual environments. familiar sensory extension devices include eyeglasses (refractive lenses improve vision), and geiger counters (auditory perception of radioactive decay). in an inclusive co-design process, the project team will partner with diverse members of the learning community, together co-designing flexible, adaptive, and personalizable technologies, which enable new sensory experiences (e.g., sound, gesture, movement, and touch) to augment popular and widely used interactive simulation learning tools. the project team brings together experts in educational technologies at the university of colorado boulder (phet interactive simulations and the craft tech lab) and partner organizations serving youth with learning disabilities and visual impairments. this project will work to create new learning materials, practices and processes for inclusive design with youth, as well as theories and frameworks for the use of sensory extension technologies as learning resources. to accomplish this, the team will investigate (1) pedagogical and design practices within inclusive inquiry learning in stem learning settings; (2) the co-design and evolution of sensory extension devices; (3) learners' experiences of the impact of the inclusive design process on their own perceptions of self-efficacy and stem; and (4) the learning experience of youth with diverse needs using sensory extension devices for stem inquiry. the sensory extension devices are expected to enable new forms of collaboration among learners with differing sensory needs, and couple with existing educational technologies to expand their inclusive and accessible use and enrich the learning experience for all users. a rich corpus of data will be collected, tracking the trajectory of each design, including video and audio recordings of co-design sessions and the sensory extension devices in use, photographs of design artifacts and group activities, co-designer reflections and interviews, and self-efficacy



survey responses. through the inclusive co-design process, the project will work to advance foundational understanding of egalitarian processes of educational technology development, embrace sensory **\*\*diversity\*\***, and empower educationally marginalized learners through the creation, customization, and personalization of their own innovative learning tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Understanding microbial control of dissolved organic nitrogen (DON) in the ocean: New amino acid tracers for bacterial source and cycling of refractory DON

Awardee: University of California-Santa Cruz

Amount: \$849,702.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). one of the most mysterious components of the global nitrogen cycle is the vast amount of dissolved nitrogen-containing organic molecules (dissolved organic nitrogen, or ?don?) which exist in the ocean. the identities of these molecules are mostly unknown, but they are important in the ocean?s biological and geochemical cycles, because they persist for many thousands of years and in many cases these molecules are too complex for simple organisms at the base of the food web to use. this project will develop new chemical tools to understand this material, including stable isotopes, radioisotopes, and the chirality of amino acids. together, this new set of tracers will focus on the roles of marine bacteria as sources and creators of persistent dissolved organic nitrogen. the project will begin in the laboratory, where the team will first grow large cultures of ocean algae. natural ocean bacteria will then be added, and investigators will measure the proposed new tracers in dissolved nitrogen materials created. these data will reveal how the proposed tracers work: how and when they are produced, if they map to bacterial sources, and how bacterial degradation may affect them. the investigators will then conduct a series of field expeditions at contrasting sites on the california coast and in the central pacific ocean, isolating large amounts of natural dissolved organic nitrogen. the team will apply what has been learned in the lab together with the first ever radiocarbon measurements on individual tracer molecules. together these activities will open a new window into sources and cycling of the critical marine dissolved organic nitrogen material. the project will support the education, training, and career development of a graduate student, a postdoctoral researcher, and undergraduate students from underrepresented groups, who will be recruited to receive real hands-on laboratory and field experience. this project will develop three new amino acid?-based proxies for bacterial source and alteration of dissolved organic nitrogen: 1) compound-specific stable carbon isotope fingerprinting of essential amino acids, 2) a recently discovered suite of new d-amino acids found to be concentrated in radiocarbon-old, low molecular weight don material, and 3) individual amino acid radiocarbon values for key hypothesized tracer

amino acids. the investigators hypothesize that refractory ocean don is essentially completely microbial, however that it is also far more diverse than has previously been understood in terms of its sources, molecular composition, and especially cycling rates. in particular, the project will test the idea of completely different don origin, molecular composition, and cycling rates in high vs. low molecular weight don fractions throughout the water column. autotrophic and heterotrophic bacterial growth / degradation experiments will test assumptions about the sources and degradation- related changes to d/l and stable carbon isotope signatures. synoptically making these measurements together with individual amino acid radiocarbon values in high productivity coastal vs. oligotrophic pacific gyre don in both surface and deep ocean will allow understanding the **\*\*diversity\*\*** of don bacterial sources, degradation impacts, and n-specific cycling rates for the first time. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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bacterial sources, degradation impacts, and n-specific cycling rates for the first time. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: CAREER: Physiological and Behavioral Determinants of Energy Use in Tropical Mammals

Awardee: University of Maine

Amount: \$829,716.00

Abstract: the ability to use energetically costly physiological processes to maintain body temperature at levels elevated above ambient temperature or endothermy, is a defining characteristic of mammals. the evolution of endothermy allowed mammals from warm, aseasonal climates to diversify and radiate into previously inhospitable environments as temperatures cooled. much of what is known about temperature regulation and energetics in mammals, however, has been derived from high latitude, northern hemisphere species whose evolutionary history has been shaped by large changes in temperature and extreme seasonality. to address this gap, the pi will leverage an existing collaboration, to examine the costs of living for nocturnal and diurnal small mammals in the tropical forests of malaysian borneo. the pi and her team will collect long term data on the body temperatures, metabolic rates, and life history characteristics of free-living small mammals. a novel, comprehensive database of mammalian physiological and life history traits, will be generated providing access to new, real data as a valuable learning experiences for the impact of climate on mammalian energetics. education activities will target university of maine undergraduate and graduate students, and k-12 students throughout maine. through first-hand experience with novel datasets from a unique environment, students will learn the importance of thermoregulatory physiology in understanding how animals respond to their environment. by increasing our knowledge of the functional energetics of tropical mammals not only can we understand the mechanisms underpinning current species distributions, but also help to improve our

predictions of organismal responses to changing global climates. the ultimate goal of this early career project is to build a framework to better understand the macrophysiology of mammals and better predict their potential responses to a warming world, by integrating physiology, ecology, and evolutionary biology. a high degree of bio\*\*diversity\*\*, endemism, and an almost complete lack of basic data physiological data available for small mammals from the indo-malayan zoogeographic region, creates an ideal arena in which to stage a long-term project of integrated research and education. the pi and her team seek to answer the following questions: 1) do nocturnal small mammals have more flexible body temperatures than their diurnal counterparts; 2) does it cost more (in terms of energy and water) to be nocturnal or diurnal in a consistently hot and humid environment and, 3) how will these differences affect their ability to respond to climate change. through answering these questions, the research will generate novel datasets on the physiology and energetics of six or more species of tropical small mammals. when combined with existing data from temperate mammals, these data will be used test hypotheses on the evolution of homeothermy, and the role of energetics in the life history of mammals. ultimately, the research will generate a comprehensive framework for using mammalian thermoregulatory phenotypes in modeling mammalian responses to climate. the research aims of this proposal will be integrated with education activities that will target undergraduate and graduate students at the university of maine and k-12 students throughout the state. through first-hand experience with novel datasets from a unique environments, will learn demonstrate the importance of thermoregulatory physiology in understanding how animals respond to their environment, while providing research and outreach opportunities for junior scientists and the general public. together the knowledge of the functional energetics of tropical mammals will advance the understanding of mechanisms controlling current species distributions, but also help to improve our predictions of organismal responses to changing global climates. this career proposal was supported by the integrative ecological physiology program within the division of integrative organismal systems within the directorate for biological sciences and the established program to stimulate competitive research (epscor) program within the

office of integrative activities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: HCC: Medium: Designing Human-Centered Environments for Enhancing Diversity in Open Source

Awardee: Carnegie-Mellon University

Amount: \$820,000.00

Abstract: to increase inclusion and enhance **\*\*diversity\*\*** at all levels of participation, this research will investigate gender-based barriers to involvement in open source software. surveys show that the representation of women in open source software is only about 5%, even worse than the technical workforce overall. previous research on gender in the computing profession has identified lack of self-efficacy and mentorship support as key barriers to participation and retention for women and underrepresented individuals. this project will investigate how these barriers influence participation in open source software development communities. it will identify and disseminate actions project owners and contributors can take to enhance participation from underrepresented groups. this research will create tools and conduct workshops to enhance participation from underrepresented members. since participation in open source is increasingly important for obtaining employment in technical fields, this research has the potential to significantly enhance workforce development. finding ways to make open source more welcoming to all genders could nearly double the available technical workforce, with major benefits both to industry, where talent is in short supply, and to society, by enhancing the nation's ability to create software-intensive products and services. this research will enhance **\*\*diversity\*\*** in open source by first performing a series of mixed-methods studies of practice, consisting of interviews, a large-scale survey, and archival analyses to understand: (a) how participation experiences vary based on subjects' genders; and (b) why they



leave or do not join open source software projects. based on these studies, the research team will design, deploy, and evaluate interventions that enhance self-efficacy and facilitate new forms of mentoring in open source environments. the following specific research contributions are expected: (1) deeper knowledge about the causes of low participation by women in open source software development and open collaborative environments; (2) an understanding of how automation and visualization can support self-efficacy and mentorship for underrepresented contributors in open collaboration environments; and (3) guidelines for the design of inclusive collaboration environments. more generally, this research is expected to yield new knowledge about how to enhance human performance through the design of inclusive, open environments in software engineering and even more broadly, for computer-supported collaboration. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: CAREER: Development of Unmanned Ground Vehicles for Assessing the Health of Secluded Ecosystems (ECHO)

Awardee: Woods Hole Oceanographic Institution

Amount: \$813,964.00

Abstract: part i: non-technical description: understanding human-induced changes on bio\*\*diversity\*\* is one of the most important scientific challenges we face today. this is especially true for marine environments that are home to much of the world's biomass and bio\*\*diversity\*\*. a particularly effective approach to investigate the effects of climate change on marine ecosystems is to monitor top-predator populations such as seabirds or marine mammals. the food web in the southern ocean is relatively small and involves few species, therefore climate-induced variations at the prey species level directly affect the predator species level. for example, seabirds, like penguins, are ideal to detect and study these ecosystem changes. this study combines traditional methods to study emperor penguin population dynamics with the use of an autonomous vehicle to conduct the population dynamic measurements with less impact and higher accuracy. this project leverages an existing long-term emperor penguin observatory at the atka bay colony which hosts penguins living in the weddell sea and the atlantic sector of the southern ocean. the study will kickstart the collection of a multi-decadal data set in an area of the southern ocean that has been understudied. it will fill important gaps in ecological knowledge on the state of the emperor penguin and its adaptive capabilities within a changing world. finally, the project supports nsf goals of training new generations of scientists through collaborative training of undergraduate students and the creation of a new class on robotics for ecosystem study. emperor penguins are an iconic species that few people will ever see in the wild. through the technology developed in this proposal, the public can be immersed in real-time into the life of an emperor penguin colony. public outreach will be achieved by showcasing real-time video and audio footage of emperor penguins from the field as social media science and engineering-themed educational materials. part ii: technical description:

polar ecosystems currently experience significant impacts due to global changes. measurable negative effects on polar wildlife have already occurred, such as population decreases of numerous seabird species, including the complete loss of colonies of one of the most emblematic species of the antarctic, the emperor

penguin. these existing impacts on polar species are alarming, especially because many polar species still remain poorly studied due to technical and logistical challenges imposed by the harsh environment and extreme remoteness. developing technologies and tools for monitoring such wildlife populations is, therefore, a matter of urgency. this project aims to help close major knowledge gaps about the emperor penguin, in particular about their adaptive capability to a changing environment, by the development of next-generation tools to remotely study entire colonies. specifically, the main goal of this project is to implement and test an autonomous unmanned ground vehicle equipped with radio-frequency identification (rfid) antennas and wireless mesh communication data-loggers to: 1) identify rfid-tagged emperor penguins during breeding to studying population dynamics without human presence; and 2) receive global positioning system-time domain reflectometry (gps-tdr) datasets from very high frequency vhf-gps-tdr data-loggers without human presence to study animal behavior and distribution at sea. the autonomous vehicles navigation through the colony will be aided by an existing remote penguin observatory (spot). properly implemented, this technology can be used to study of the life history of individual penguins, and therefore gather data for behavioral and population dynamic studies. the new data will contribute to intelligent establishment of marine protected areas in antarctica. the education objectives of this career project are designed to increase the interest in a stem education for the next generation of scientists by combining the charisma of the emperor penguin with robotics research. within this project, a new class on ecosystem robotics will be developed and taught, robotics boot-camps will allow undergraduate students to remotely participate in antarctic field trips, and an annual curriculum will be developed that allows k-12 students to follow the life of the emperor penguin during the breeding cycle, powered by real-time data obtained using the unmanned ground vehicle as well as the existing emperor penguin observatory. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: West Virginia University Research Corporation

Amount: \$811,417.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **diversity** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Dimensions US-China: Collaborative Research: Consequences of diversity in Asian and American tree syngameons for functional variation, adaptation and symbiont biodiversity

Awardee: Morton Arboretum

Amount: \$808,747.00

Abstract: the world's approximately 425 oak species maintain species identity even while exchanging genes with their close relatives through hybridization. this history of evolution and genetic exchange has shaped the bio**diversity** of northern hemisphere ecosystems. oaks are ecologically diverse, with related species often growing in close proximity but specializing on areas of the forest landscape that differ in soil texture and moisture level or in the frequency of natural fires. gene exchange can move such ecological specializations between oak species, broadening

their ranges and ability to respond to climate change. the impacts of these genetic exchanges may extend beyond the oaks themselves. oaks host an estimated 1000 gall wasp species worldwide and highly diverse communities of fungi associated with their roots (as mycorrhizae) and inside their leaves (as endophytes). using paired field surveys and common garden experiments the pis will evaluate the effects of hybridization and introgression on the genetic, phylogenetic, and functional **diversity** of focal oak species and their symbionts in the us and china. this work will also provide inquiry-based k-12, undergraduate, and graduate education; critical natural history training to the public through a community-science initiative in oak phenology; and publications that will bring research to public audiences. two interdisciplinary teams of researchers, one based in the us and one in china, will investigate how genomic, functional, and phylogenetic **diversity** of oak trees shape the mycorrhizal fungi, endophytic fungi, and gall wasp and other insect communities that associate with them. research will focus on two related groups of interbreeding species: bur oak (*quercus macrocarpa*) and relatives in the us and bao li (*quercus serrata*) and relatives in china. the project has three objectives, each conducted in parallel in china and the u.s. in objective 1 the teams will perform range-wide phylogenomic surveys of natural populations to reconstruct genomic mosaics, characterize geographic patterns of leaf functional traits, and characterize functional and phylogenetic **diversity** of associated mycorrhizal fungi, leaf endophytic fungi, and gall wasps. in objective 2 common gardens will be planted across climatic gradients to evaluate the effects of genetic variation and population differentiation on oak functional and spectral traits and relative fitness in different climates, and how these influence the phylogenetic and functional **diversity** of oak-associated fungal and insect communities. in objective 3 the teams will use a second set of common garden experiments to evaluate how plant community and phylogenetic **diversity** affects focal oak species genetic, phylogenetic, and functional **diversity**. the project will provide an integrative perspective on how oak **diversity** within and among species impacts the broad **diversity** of oak-dominated ecosystems across the northern hemisphere. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the

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Awardee: Morton Arboretum

Amount: \$808,747.00

Abstract: the world's approximately 425 oak species maintain species identity even while exchanging genes with their close relatives through hybridization. this history of evolution and genetic exchange has shaped the bio\*\*diversity\*\* of northern hemisphere ecosystems. oaks are ecologically diverse, with related species often growing in close proximity but specializing on areas of the forest landscape that differ in soil texture and moisture level or in the frequency of natural fires. gene exchange can move such ecological specializations between oak species, broadening their ranges and ability to respond to climate change. the impacts of these genetic exchanges may extend beyond the oaks themselves. oaks host an estimated 1000 gall wasp species worldwide and highly diverse communities of fungi associated with their roots (as mycorrhizae) and inside their leaves (as endophytes). using paired field surveys and common garden experiments the project will evaluate the effects of hybridization and introgression on the genetic, phylogenetic, and functional \*\*diversity\*\* of focal oak species and their symbionts in the us and china. this work will also provide inquiry-based k-12, undergraduate, and graduate education; critical natural history training to the public through a community-science initiative in oak phenology; and publications that will bring research to public audiences. two interdisciplinary teams of researchers, one based in the us and one in china, will investigate how genomic, functional, and phylogenetic \*\*diversity\*\* of oak trees shape the mycorrhizal fungi, endophytic fungi, and gall wasp and other insect communities that associate with them. research will focus on two related groups of interbreeding species: bur oak (*quercus macrocarpa*) and relatives in the us and bao li (*quercus serrata*) and relatives in china. the

project has three objectives, each conducted in parallel in china and the u.s. in objective 1 the teams will perform range-wide phylogenomic surveys of natural populations to reconstruct genomic mosaics, characterize geographic patterns of leaf functional traits, and characterize functional and phylogenetic **diversity** of associated mycorrhizal fungi, leaf endophytic fungi, and gall wasps. in objective 2 common gardens will be planted across climatic gradients to evaluate the effects of genetic variation and population differentiation on oak functional and spectral traits and relative fitness in different climates, and how these influence the phylogenetic and functional **diversity** of oak-associated fungal and insect communities. in objective 3 the teams will use a second set of common garden experiments to evaluate how plant community and phylogenetic **diversity** affects focal oak species genetic, phylogenetic, and functional **diversity**. the project will provide an integrative perspective on how oak **diversity** within and among species impacts the broad **diversity** of oak-dominated ecosystems across the northern hemisphere. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Core Support for Future Earth International Global Change Research

Awardee: University of Colorado at Boulder

Amount: \$804,895.00

Abstract: this project supports the us secretariat of future earth. future earth harnesses the insights and capacity of the global scientific community to address global problems, like a warming and increasingly unstable climate, and a rapid loss of bio**diversity** and ecosystem services. the future earth effort is based on the recognition that modern global change challenges require coordinated research efforts bringing together the world's best researchers in the natural, social, behavioral, and engineering sciences, and connecting these researchers with the needs and capacities embedded within a wide range of stakeholder institutions and communities. the secretariat leads and co-leads



core functions that include research enabling, networks and capacity, information technology, and communications. In addition, the US Global Hub leads the evolution and growth of Future Earth's global efforts and directs many of Future Earth's core global initiatives, including a flagship capacity building program, communications products, and collaborative data-platforms. Future Earth provides a critical service to the science community by advancing global change science in the US and around the world, and by supporting the full range of research modalities from fundamental disciplinary research to transdisciplinary research. By connecting research across geography and discipline, the project supports the emergence of novel, integrative scientific ideas. By elevating the spread and impact of scientific results and connecting these results with constituencies in business, government, and civil society, Future Earth's work supports decision making around the world. It also connects US researchers with a vast and rapidly growing network of leading international scholars in global change research and provides direct access to new knowledge and initiatives. This work includes a broad range of communication capacities in the US and around the world, like the establishment of the Sustainability Research and Innovation Congress, the first global convening that brings the global change research and innovation communities together, on an annual basis. The Future Earth US Global Hub has also established partnerships to build and diversify the next generation of global change researchers through an internship program. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity  
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Title: IntBIO Collaborative Research: An integrative approach for projecting insect responses to a rapidly changing climate

Awardee: Georgetown University

Amount: \$803,034.00

Abstract: Projecting species' responses to climate change at continental scales is a current "grand

challenge? of ecological research. insects are sensitive indicators of both climate and land-use change and recent studies indicate widespread declines in many geographic regions. to predict changes across entire ranges, a variety of species distribution models have been developed, but rarely account for regional variability, ecological interactions or a species? potential to adapt to changing conditions. this project spans multiple institutions situated in the united states? southwest, polar north, and temperate eastern regions. a series of physiological experiments will be implemented for five widespread butterfly species with populations sourced from different biomes within each of their ranges. caterpillars will be subjected to a range of conditions mimicking past, current and future climates. their development rate, survivorship, immune response, and genetic structure and gene expression (which genes are actively coding for proteins) will be measured and used to build models that predict distributional shifts. data collected by community (?citizen?) scientists will be used to validate the models. this project requires substantial cross-disciplinary collaboration, and a central goal is to recruit diverse trainees at the graduate and undergraduate levels and train them in the ?science of team science?. project trainees will develop independent research ideas that align with and expand the project?s scope and travel between and work at collaborating institutions as an inter-lab exchange to learn new techniques and be exposed to different research philosophies. finally, the project has significant management implications for insect bio\*\*diversity\*\* conservation.

projecting responses to climate change at continent scales is a current ?grand challenge? of ecological research. insects are the most diverse and ecologically important terrestrial animal taxon and are strongly affected by climate change. to predict changes, species distribution models (sdms) have been widely implemented across many taxa. sdms, however, rarely account for ecological interactions, plasticity or evolutionary adaptive potential owing to the extensive physiological and ecological data required to parameterize such models. the biology of lepidoptera, particularly butterflies, is extremely well observed, thus it is logistically feasible to build upon past knowledge and collect additional data that enables mechanisms to be more seamlessly integrated into sdms. multiple populations for each species will be sourced from

different biomes across its range. caterpillars will be reared in common gardens under a range of temperature conditions mimicking past, current and future climates. their development rate, survivorship, immune response, genetic structure and gene expression will be measured and used to build models that predict future distributions. distribution data collected by community (?citizen?) scientists will be used to validate and improve models and allow robust estimates of uncertainty. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Noyce Scholar Retention in Racially and Culturally Non-dominant Communities: Studying the Relationship between Partnerships and Persistence in the Teaching Profession

Awardee: American University

Amount: \$800,000.00

Abstract: this project aims to serve the national need to increase the **\*\*diversity\*\*** of the stem teacher workforce by understanding the factors that contribute to stem teacher retention. this project investigates how the quality of research-practice partnerships that support noyce scholars influences persistence and retention of both teachers of color and white teachers in high-need schools serving racially and culturally non-dominant communities. the research team aims to investigate how the three noyce program components - teacher preparation, induction/mentoring, professional development - and the collaborative nature of those teacher development components (i.e., partnerships) affect noyce scholars? persistence in high-need schools serving racially and culturally non-dominant communities. this project includes the study of six noyce projects at bowie state university, george washington university, mercy college, montgomery college, the university of maryland, and american university. the principal investigator (pi) team seeks to identify differences, and the extent to which the three components contribute to such differences, in persistence and retention in teaching between scholars of color and white scholars. the study is

framed through the lens of determining how the scholars have experienced race, racism, and power within the three noyce program components described above and how these experiences influenced their retention in the six noyce projects and in teaching. in particular, the pi team seeks to develop deeper understanding of how the experiences of serving in racially and culturally non-dominant communities interact with the scholars? individual teacher preparation, induction, and professional development experiences at each institution. the research design also examines in what ways, if at all, the partnerships created to support the three noyce program components have influenced the persistence and retention of noyce scholars of color. such partnerships include those between stem departments and schools/colleges of education, and between noyce teacher preparation programs and high-need school districts, and other partners. finally, the research team also asks: what is the quality of the partnerships, how are the quality of the partnerships related to the three noyce program components, and how the partnership itself influences teacher persistence and retention in schools serving racially and culturally nondominant communities? the research team will use a mixed methods approach that includes surveys of scholars, and noyce program and partner program faculty and staff. structured, semi-structured, and empathy interviews with selected members of those groups will be conducted. in addition, a multi-case comparison of at least two teacher preparation programs with robust partnership components will occur. the results of this study are intended to provide evidence-based insights into the influence partnerships have on stem teacher persistence and retention and how to improve partnerships for the benefit of all stakeholders. results will be disseminated to practitioner and research audiences including stem education programs. this track 4: noyce research project is supported through the robert noyce teacher scholarship program (noyce). the noyce program supports talented stem undergraduate majors and professionals to become effective k-12 stem teachers and experienced, exemplary k-12 teachers to become stem master teachers in high-need school districts. it also supports research on the persistence, retention, and effectiveness of k-12 stem teachers in high-need school districts. this award reflects nsf's statutory mission and has been deemed worthy of support through

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Matched Words: diversity

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Title: FW-HTF-R: Collaborative Research: Worker-AI Teaming to Enable ADHD Workforce Participation in the Construction Industry of Future

Awardee: Purdue University

Amount: \$800,000.00

Abstract: while people with neuro\*\*diversity\*\* have been marginalized in the construction workplace due to potentially higher risks of injuries, their unique talents could be leveraged using an ecosystem of co-bots driven by artificial intelligence (ai). for humans and machines to become true teammates?and correlatively, for technology to extend occupational opportunities to people with such neuro\*\*diversity\*\*?intelligent machines must assess, adapt, and respond to both workers and their environment. such agility requires a reciprocal teaming capability wherein workers can engage their ai counterparts as more than tools, and ai systems can collaborate with workers seamlessly by predicting their behaviors. to extend future occupational opportunities for people with neuro\*\*diversity\*\*, this project builds an ai-driven learning platform to enable distribution of ai teammates in construction workplaces to support employment opportunities and safety outcomes for construction workers with varying abilities. this study also investigates the intended work scenarios of worker-ai teaming, the unintended consequences of ai-teaming for workers, and the well-being of society. considering that 4.2% of workers are diagnosed with attention-deficit/hyperactivity disorder (adhd)?a disorder that is associated with more than 120 million lost workdays in the usa each year, equating to a human capital value of \$19.5 billion?this project?s efforts to enable diverse workforce participation in the construction industry will have positive social and economic impacts. additionally, this project will educate a new generation of leaders in worker-ai teaming and will create partnerships between academia and industry. to lay the necessary foundations for building this human-ai teaming workspace for construction workers with neuro\*\*diversity\*\*, this proof-of-concept project will translate non?invasive biomechanical and neuro-psychophysiological responses into information a personalized ai-based training systems can assess, model, and leverage to predict workers? behaviors for improved worker?machine teaming without cultivating technological over-reliance or threats to privacy. in this project, a multidisciplinary team of researchers integrates expertise in civil engineering, computer science, cognitive and behavioral psychology, industrial engineering, and public policy and economics to address fundamental questions regarding the risk

taking behavior and cognitive processes of workers with adhd, barriers to adopting ai and wearable technologies, and the socioeconomic impacts of improved access to construction jobs for adhd-diagnosed workers, especially in the context of interdependent human-ai partnerships. as this project?s global paradigm moves toward deeper human-machine teaming, the knowledge gained through this project advances the science and technology that influences diverse workforce development, education, and positive work outcomes for workers and society at large. by demonstrating the effectiveness of this ai-driven platform, this project illustrates how human-machine teams can progress on job sites and within communities across all sectors to augment human cognitive capabilities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: CNS Core: Medium: Systems Support for Federated Learning

Awardee: Regents of the University of Michigan - Ann Arbor

Amount: \$800,000.00

Abstract: traditional approaches toward applying machine learning techniques to end-user data often require copying all data to the cloud. this is not only expensive but faces data privacy risks as well. by analyzing data on the device where it is generated, federated learning aims to mitigate both cost and privacy concerns of centralized machine learning without sacrificing its benefits. this collaborative project brings together investigators from two institutions to develop building blocks for practical federated learning by addressing challenges arising from the **\*\*diversity\*\*** of user devices and the heterogeneity of data distributions in those devices. the project takes a three-pronged approach: (1) enable performance improvements for machine learning developers (e.g., judicious participant selection instead of randomly selecting participants); (2) provide efficiency improvements for service providers (e.g., redundancy elimination for data transfers); (3) enable end-users to



control their data privacy (e.g., akin to app permissions in android) without sacrificing device usability. two core principles underpin these solutions: multi-tenancy both in the cloud and on individual devices; and maintaining theoretical correctness, convergence characteristics, and privacy/security guarantees of federated learning algorithms. widespread adoption of practical federated learning can fundamentally change how we gather insights from end-user data and how users value data privacy, because users may not have to sacrifice privacy for convenience in many cases. this, in turn, can force large corporations to rethink their data collection and usage practices, and influence policy makers to consider stricter privacy regulations. all software from this project will be open source. through outreach and new educational materials, this project will pioneer the training of privacy-aware systems builders. this collaborative project will produce software artifacts, experimental harnesses, benchmarks, and results of running those benchmarks and artifacts. these materials will be available for public use under permissive open-source licenses at multiple locations, including <https://github.com/symbioticlab>. they will be retained for at least three years after the completion of the project. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Howard-Columbia Partnership for Research and Education in Superatomic and 2D Materials (PRES2M)

Awardee: Howard University

Amount: \$800,000.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). howard university is a private, federally chartered historically black university in washington, dc with more than 10,000 students pursuing 120 areas of study; and currently classified as a high research activity institution. materials science and engineering (mse) related research at

howard focuses primarily on quantum materials, optics and photonics and quantum technologies (computing, communications, and sensing). the research focus of this partnership for research and education in materials (prem) with columbia university materials research science and engineering center (mrsec) is on interaction of light with matter for new optical and electrical devices for the quantum information age. this collaboration, namely partnership for research and education in superatomic and 2d materials (pres2m), is to establish the framework needed to pursue new prem-pathway for faculty and students at howard university in mse. in particular, the following is envisioned: an integrated research and education program that increases participation of undergraduate students in mse-related research mentored by graduate student trainees and teacher-scholar postdoctoral associates in mse to strengthen existing **\*\*diversity\*\*** efforts at columbia and provide a foundation for the mse degree-granting program at howard. the prem pathway focuses on matriculation of undergraduate students in mse-related disciplines to allow for significant growth in the total number of black students that attain degrees. furthermore, the collaboration between howard and columbia university mrsec is aimed at impacting current **\*\*diversity\*\*** efforts at columbia with respect to k-12 outreach, undergraduate student research opportunities, and graduate student admissions. the primary research goal of pres2m is a better understanding of the quantum phenomena within functional materials, such as, 2d materials and superatomic molecules through a cyclic interplay between materials synthesis, processing, analysis, and theory. the research is aimed at altering material properties to manipulate light-matter interaction including new experimental techniques for thermal tunability of ultra-strong coupling in 2d nanopatterned films and plasmon-enhanced conductance. this research builds on the materials science of 2d and superatomic materials and applications of quantum phenomena, currently pursued at the columbia university mrsec. the goal of this partnership is to fundamentally impact condensed matter physics and materials science and engineering. through the mrsec, howard faculty and students have access to infrastructure, new materials, and expertise in quantum materials research. with the pres2m, there is an expanded collaboration between both institutions

and additional opportunities for co-mentorship of students and postdoctoral associates, joint projects and publications as well as student/faculty exchanges. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Unraveling post-invasion dynamics of the amphibian-killing fungus via rapid genetic diversity assessments of both hosts and pathogens

Awardee: Texas State University - San Marcos

Amount: \$797,737.00

Abstract: in wildlife, prominent examples of mycoses (diseases caused by fungi) include white-nose syndrome and the recent spread and emergence of snake fungal disease, but no other fungal pathogens have been more destructive to wildlife than the amphibian chytrids (genus *batrachochytrium*). chytrids are essentially ubiquitous in the environment, yet they are relatively understudied. amphibian chytrids continue to cause population declines and species extinctions globally. unfortunately, the most severe amphibian declines have occurred in neotropical forests, which are also threatened by deforestation. for tropical amphibians, the threat of disease, coupled with habitat loss, requires rapid measurements of host **\*\*diversity\*\*** at the population scale to unravel complex disease dynamics. studies of disease dynamics can benefit from the development and use of genetic methods that can be applied in real-time and in the field. by leveraging emerging portable technology to measure genetic **\*\*diversity\*\***, this project will gather data for both hosts and pathogens to test hypotheses regarding the specificity of their interactions, determine which hosts drive spread or act as reservoirs, and contribute to amphibian conservation. the research and educational goals of the project will be implemented at a hispanic-serving institution and led by a first-generation, mexican-american principal investigator (pi), and thus, will increase the participation of underrepresented groups in stem at all levels. additionally, the project will serve to train the next

generation of students and international biologists in the application of emerging genetic methodologies to address common challenges in disease ecology, which can be extrapolated to other systems where diverse hosts drive pathogen spread. the overarching goal of this project is to elucidate fungal pathogen **diversity** and post-invasion pathogen dynamics in equatorial forests and their understudied canopies by identifying which hosts have driven the transition from an epizootic to an enzootic pathogen. the aims of this research are to: 1) perform real-time strain detection using portable quantitative pcr instruments and dna sequencing using portable nanopore sequencers to reveal pathogen **diversity** and geographic distribution along an equatorial transect, 2) parse amphibian genetic identity in a hyper-diverse assemblage to allow host-specific estimates of pathogen/strain prevalence, and 3) use cophylogenetic analyses to test for the influence of host **diversity** on pathogen invasions. the pi is uniquely positioned to achieve these research goals while providing experiential learning opportunities to underrepresented students in stem at the undergraduate and graduate level. this project is being jointly funded by the systematics and bio**diversity** cluster and the evolutionary processes cluster in the division of environmental biology at the national science foundation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: RUI: Role of the Endoplasmic Reticulum in mediating cell fate

Awardee: San Francisco State University

Amount: \$796,064.00

Abstract: a major step during development in multicellular life is the generation of cell \*\*diversity\*\*. specifically, the task of cells adopting a specific shape and function is essential towards development of the adult body plan and formation of tissues in multicellular organisms. this is a highly conserved process among multicellular creatures and involves an unequal or asymmetric partitioning of factors during cell division to allow cells to adopt different fates (e.g. to become neurons or become skin). there has been significant progress in understanding the distribution of these factors; however, the regulation of movement and the selection of these determinants and how they are passed to daughter cells is still poorly understood. the principal investigator (pi) has formed a model in which cell fate-determining factors are organized and distributed during cell division by the endoplasmic reticulum (er), the largest compartment in the cell involved in protein folding and distribution. the objectives of this project are to define a pathway for the transport and correct establishment of cell-fate determinants during cell division, and to characterize the role of the er in the generation of cell \*\*diversity\*\*. in addition, the pi will provide opportunities to engage a diverse student population and promote peer mentorship, thereby broadening participating in science. the outcomes of the project will help close a gap of knowledge regarding how cell fate is determined, and to provide a broader understanding for the generation of cell \*\*diversity\*\* during development. the generation of cell \*\*diversity\*\* is a highly conserved mechanism and involves the

asymmetric partitioning of factors during cell division. over the past 30 years, several cell fate determinants have been identified, including cell fate determinants that are partitioned apically or basally during mitosis leading to the daughter cells adopting different cell fates. despite the considerable knowledge regarding the factors involved in cell fate selection, there is little known regarding the transport, localization, and organization of these cell fate determinants along the division plane during mitosis. preliminary data from the pi's laboratory identified the highly conserved endoplasmic reticulum (er) integral membrane protein, jagunal (jagn) as being partitioned asymmetrically in pro-neural cells during drosophila melanogaster embryogenesis. the pi's central hypothesis is that the jagn-mediated asymmetric division of the er acts as a scaffold for organization and transport of transcriptional machinery involving the basal cell fate determinants towards the diversification of cell types in the central nervous system. the pi will test this hypothesis in vivo by examining neuroblast division in the drosophila melanogaster larval brain by means of super-resolution confocal microscopy, and determine which cell fate outcomes are dependent on jagn. the pi's work will deepen our understanding of cell fate selection and outline the role of the er in the generation of cell \*\*diversity\*\*. this research is funded by the cellular dynamics and function cluster in the division of molecular and cellular biosciences in the directorate of biological sciences.

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: IUCRC Phase II: North Dakota State University: Center for Bioplastics and Biocomposites [CB2]

Awardee: North Dakota State University Fargo

Amount: \$793,875.00

Abstract: the center for bioplastics and biocomposites (cb2) at iowa state university (isu), university of georgia (uga), washington state university (wsu), and north dakota state university (ndsu) seeks

to develop and build on an industry/university cooperative research center (i/ucrc) that focuses on bioplastics and biocomposites. the mission of cb2 is to develop fundamental knowledge related to bioplastics and biocomposites, to disseminate research-based findings to industry to promote sustainability, and to educate future scientists and engineers. as such, there is an expressed industrial interest in leveraging research efforts to accelerate systematic development of standardized material and processing data for these novel plastics and composites. the center focusses on the development of jobs in the area of sustainable manufacturing and the conversion of agricultural and woody crops to bio-based materials that contribute to job creation in the united states. the center also strives to support education and **\*\*diversity\*\*** through engagement of undergraduate and graduate students in research on sustainable materials. the goal of cb2 is to improve the basic knowledge of synthesis, processing, properties, and compounding of bioplastic and biocomposite materials, to develop reliable materials characteristics data for industrial partners, and to support large-scale industrial implementation of renewable materials. the vision of the center is to develop knowledge that will facilitate the production of an array of high-value products, including plastics, coatings, adhesives, and composites, from renewable feedstocks. the materials are compatible with current industrial manufacturing systems and promote rural development as well as national growth. the goals of the phase ii are fourfold: 1) expand the knowledge and develop the science for recycling and end of life treatment of sustainable materials, in particular as they are mixed with petrochemical plastics; 2) expand membership by engaging new companies that have expressed a need for recycling and end of life treatment; 3) develop fundamental knowledge on sustainable materials; 4) prepare students to join the workforce equipped with the knowledge and skills required by industry. the team of researchers includes experts in the fields of polymer processing, polymer chemistry, materials science, and crop utilization. wsu's research focuses on utilizing industry-relevant technology platforms to develop bio-based composites, coatings and adhesives, and polymers for various industry applications, as well as to recycle bio-based composite materials. ndsu's research focuses on use of biobased fibers, novel monomers derived from



biomass, biobased polymers with applications in coatings, adhesives and composites, and materials for packaging applications. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Amount: \$793,875.00

Abstract: the center for bioplastics and biocomposites (cb2) at iowa state university (isu), university of georgia (uga), washington state university (wsu), and north dakota state university (ndsu) seeks to develop and build on an industry/university cooperative research center (i/ucrc) that focuses on bioplastics and biocomposites. the mission of cb2 is to develop fundamental knowledge related to bioplastics and biocomposites, to disseminate research-based findings to industry to promote sustainability, and to educate future scientists and engineers. as such, there is an expressed industrial interest in leveraging research efforts to accelerate systematic development of standardized material and processing data for these novel plastics and composites. the center focusses on the development of jobs in the area of sustainable manufacturing and the conversion of agricultural and woody crops to bio-based materials that contribute to job creation in the united states. the center also strives to support education and **\*\*diversity\*\*** through engagement of undergraduate and graduate students in research on sustainable materials. the goal of cb2 is to improve the basic knowledge of synthesis, processing, properties, and compounding of bioplastic and biocomposite materials, to develop reliable materials characteristics data for industrial partners, and to support large-scale industrial implementation of renewable materials. the vision of the center is to develop knowledge that will facilitate the production of an array of high-value products,

including plastics, coatings, adhesives, and composites, from renewable feedstocks. the materials are compatible with current industrial manufacturing systems and promote rural development as well as national growth. the goals of the phase ii are fourfold: 1) expand the knowledge and develop the science for recycling and end of life treatment of sustainable materials, in particular as they are mixed with petrochemical plastics; 2) expand membership by engaging new companies that have expressed a need for recycling and end of life treatment; 3) develop fundamental knowledge on sustainable materials; 4) prepare students to join the workforce equipped with the knowledge and skills required by industry. the team of researchers includes experts in the fields of polymer processing, polymer chemistry, materials science, and crop utilization. wsu?s research focuses on utilizing industry-relevant technology platforms to develop bio-based composites, coatings and adhesives, and polymers for various industry applications, as well as to recycle bio-based composite materials. ndsu?s research focuses on use of biobased fibers, novel monomers derived from biomass, biobased polymers with applications in coatings, adhesives and composites, and materials for packaging applications. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Excellence in Research: Statistical Network Modeling and Inference for Complex Data

Awardee: North Carolina Agricultural & Technical State University

Amount: \$783,432.00

Abstract: estimation and inference of network structure have wide applications in many scientific fields such as genomics and finance. however, the abundance of complex data presents a great demand for new statistical learning methods in network analysis. a main goal of this project is to develop a set of novel methodological and theoretical tools to identify change points and infer structural changes for high-dimensional networks. success of this project can have significant

impacts on biomedical sciences and finance. data applications to the alzheimer's disease and portfolio risk monitoring will help to offer new insights. the team will develop computational packages to facilitate the application and dissemination of the proposed methods to academia and industry. furthermore, the research will be closely integrated with education, through joint supervision of students and joint development of courses from two institutions. underrepresented minority students will be recruited and involved in the project. the collaborative project will provide an opportunity for students and faculty in an hbcu institution to gain access to cutting-edge research and educational resources, and help increase the **\*\*diversity\*\*** of the next generation of data scientists. the research of this project has two main directions. the first one focuses on change point analysis for heterogenous data. to detect possible change points of a high-dimensional graph, a threshold variable and a threshold parameter are introduced while considering all nodes simultaneously to construct a highly effective algorithm. to simultaneously identify change points in a high-dimensional linear model, an innovative method to test homogeneity of the corresponding regression coefficients across different segments is considered. for the second direction, a nonparametric testing method is developed to compare correlation/covariance matrices. the team plans to investigate theoretical properties of the proposed methods and apply the methods to genomics and finance. this project can provide unique contributions to the statistical learning and big data literature. in addition, the knowledge gained from the proposed research can be valuable for handling other complex high dimensional problems in statistics and machine learning. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: CCRI: New: Medium: A Development and Experimental Environment for Privacy-preserving and Secure (DEEPSECURE) Machine Learning

Awardee: Old Dominion University Research Foundation

Amount: \$780,000.00

Abstract: while machine learning (ml) is embraced as an important tool for various science, engineering, medical, finance, and homeland security applications, it is becoming an increasingly attractive target for cybercriminals. deepsecure is a first-of-its-kind development and experimental platform to support secure and privacy-preserving ml research. with its novel modular design integrated with fully customizable function blocks and sample modules, deepsecure is a game-changing tool to effectively support research in this emerging field by enabling fast design, prototyping, evaluation, and re-innovation of trust-worthy ml applications. it enables a variety of compelling new research projects that focus on ml security and privacy, leading to breakthroughs to protect ml systems and accelerating their development and widening their adoption. it will contribute significantly to the protection of the future cyber and physical world and safeguard human society. deepsecure receives strong community support from over 20 key stakeholders across the country. the project includes significant efforts for fostering and sustaining an ml security and privacy research community, including monthly virtual open forums to provide a regular update to and seek feedback from the community, quarterly advisory board meetings, annual symposiums, and a training workshop series. the project includes specific measures and plans for inspiring the participation of underrepresented groups and infusing **\*\*diversity\*\*** and inclusion in all deepsecure events and activities. the project output includes an open-source and easy-to-use learning platform for curriculum development and workforce training. to support building a sustainable workforce development pipeline, the project team participates in the existing annual gencyber summer camps for k-12 students and a cyber saturday series to introduce cybersecurity and ai career paths and educational resources to k-12 school counselors, teachers, students, and parents. recent development in privacy-preserving and secure ml draws expertise from both ml and security/privacy to tackle the multi-faceted problem. however, the research community is facing fundamental challenges in this emerging area due to its interdisciplinary nature. on the one hand, although deep learning frameworks such as pytorch and tensorflow have been made widely available, a critical

hurdle faced by ml researchers is the steep learning curve to effectively use security techniques and libraries to tackle ml security and privacy problems. on the other hand, while the security community has developed highly efficient cryptographic libraries, it remains nontrivial to integrate them into deep learning models to achieve a computation efficiency suited for practical applications. the overarching goal of the project is to close the gap by developing deepsecure, which integrates a spectrum of essential functions and building blocks that are ready-to-use to flatten the learning curve for researchers coming from both ml and security/privacy communities. at the same time, deepsecure is fully customizable and scalable, enabling deep and fundamental research toward privacy-preserving and secure ml. to meet the overarching goal, specific project objectives include: (1) acquiring a scalable and re-configurable compute environment based on the latest dell, amd, and nvidia technologies to establish the deepsecure hardware infrastructure across the campuses of old dominion university and university of buffalo; (2) developing a new software platform to support deepsecure sde (software development environment) and mec (multi-user experimental chamber). the platform is integrated with pytorch to enable great usability for both beginners and advanced researchers and feature a scalable and customizable modular framework with seamlessly integrated libraries, function blocks, and sample modules; (3) promoting deepsecure across the nation to ensure broad participation, collaboration, and sharing; (4) leveraging deepsecure to foster a long-lasting, self-sustainable ml security and privacy research community that engages all stakeholders in a sustained and ongoing way; and last but not least, (5) educating and training diverse cybersecurity workforce to safeguard the future intelligent cyber systems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative research: From Community to Practice: Evaluating How Open Educational Resources Facilitate Implementation of Vision and Change Principles Across Diverse Institutions

Awardee: University of Nebraska-Lincoln

Amount: \$778,131.00

Abstract: this project aims to serve the national interest by examining how open educational resources (oers), which are educational materials available in the public domain, have enabled implementation of vision and change (v&c) principles. the v&c report called for biology departments to transform their programs by using student-centered teaching approaches and integrating core concepts and competencies throughout their curriculum. this report also recognized that course transformation represents a major undertaking for individual instructors and that achieving widespread change would require a distributed effort across biology educators. the biology community has responded to this call in a variety of ways, including supporting peer-reviewed oer journal articles that describe structured lessons with demonstrated potential to improve undergraduate student success. however, there has been little work to understand the composition, implementation, and impacts of the v&c principles in oers. by characterizing the existing resources, describing community oer engagement, and measuring oer implementation and student learning, this project has a unique vantage from which to understand at a national level how the v&c call has been realized by the community for the benefit of students. the unifying goal of this project is to advance undergraduate biology education by examining how oer articles have enabled implementation of v&c principles across a variety of undergraduate institution types. despite the potential usefulness of oers, the field lacks a comprehensive understanding of the scope of existing lessons described in articles, how instructors implement them, and whether these resources consistently lead to positive student outcomes. this project will address this gap using an array of data sources, from published oer articles to present day student learning. the project aims to conduct a scoping review of oer article content from a variety of journals. the scoping review will address questions about the coverage of v&c core concepts and competencies; the use of active learning practices; and the advancement of **\*\*diversity\*\***, equity, and inclusion. this project will also survey authors and users to determine their engagement with oers. for authors, the focus will be on

how they construct their lessons with v&c principles and how their institutions reward oer contributions. for users, the focus will be on how they modify lessons for their courses. to further determine how implementation affects student learning, instructors who teach pre-selected oer lessons aligned with v&c core concepts and competencies will share course artifacts (e.g., lecture slides), video recordings of their instruction, and student assessment results. taken together, these data will provide insights into the range of ways that instructors adapt v&c-aligned oers for their own contexts and determine the extent to which lesson components influence student learning across institution types. drawing from emergent research, instructors from a variety of institutions will meet regularly in faculty mentoring networks (fmns) to identify and enact strategies to improve the oer sharing process. these strategies will promote v&c principles through mechanisms such as issuing community calls for specific resource development; reflecting on how oer articles can promote **\*\*diversity\*\***, equity, and inclusion; hosting workshops at home institutions to help colleagues adopt and implement oers; and identifying suggestions for departmental incentives and community supports that encourage increased oer growth. this project will benefit society by understanding how v&c aligned oers can be used to promote student learning in undergraduate biology courses. this project is funded by the program description 21-7412, vision and change that supports projects that study the impact of the vision and change movement in undergraduate biology education. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: GeoGaze: Gaze-Driven Adaptive Multimedia to Augment Geoscience Learning for Neurodiverse Learners

Awardee: University of Florida

Amount: \$774,654.00

Abstract: much of learning occurs today in multimedia environments. this project will design and test

geogaze, a novel technology that uses eye tracking to augment learning with multimedia in real time. geogaze analyzes and predicts effective strategies for students based on differences in working memory capacity and changes the presentation of learning materials to help everyone view and learn information. investigators will first study what visual attention strategies work best for learners with different levels of working memory capacity. this information will be used to build a gaze-driven technology to help each learner use the most effective strategies by adapting the learning materials in real time and for each learner. examples of this include predicting where learners will look on the screen, what order they will explore the content, and then highlighting the most important elements in the sequence to be viewed or blurring the less relevant content before revealing when appropriate. the results of this project will help us understand how individual differences in visual attention and working memory capacity influence multimedia learning and how to adapt learning materials to improve learning in real time. this project seeks to engage more students in learning geoscience, a field not well represented by a **\*\*diversity\*\*** of students and researchers. studies of multimedia learning traditionally focus on final learning outcomes but what happens during the learning process (e.g., visual attention strategies to integrate multimedia) is often unexplored. this project addresses these shortcomings to gain a robust perspective of how students with different working memory capacities learn authentic stem content (geoscience) in multimedia environments, and how their cognition can be enhanced using gaze-driven adaptive learning technology, geogaze. this approach is based on a novel integration of behavioral and psychophysiological data as well as multi-layer backpropagation neural network analysis to predict media integration strategies. geogaze represents a novel gaze-driven technology for adapting multimedia learning in real time based on effective media integration strategies for each learner. this research will generate new empirical evidence for using real-time gaze-driven adaptation of learning materials to augment cognition and improve learning. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.



Matched Words: diversity

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Title: Collaborative Research: DMREF: Microstructure by Design: Integrating Grain Growth Experiments, Data Analytics, Simulation, and Theory

Awardee: Columbia University

Amount: \$774,628.00

Abstract: most technologically useful materials are polycrystalline microstructures composed of a myriad of small monocrystalline grains delimited by grain boundaries. an understanding of the evolution of grain boundaries and associated grain growth (coarsening) is essential in determining the properties of materials across multiple scales. despite tremendous progress in formulating microstructural models, however, current descriptions do not fully account for various grain growth mechanisms, detailed grain topologies and the effects of different time scales on microstructural evolution. as a result, conventional theories have limited predictive capability. the goal of the project is to develop a predictive theory of grain growth in polycrystalline materials through the construction of novel, closely integrated data-driven numerical simulation and mathematical modeling combined with data analytics, analysis, and a set of critical experiments. this interdisciplinary project, requiring the complementary expertise of applied mathematicians and materials scientists, is firmly aligned with the materials genome initiative. the new knowledge and tools that will emerge from the project will have a profound impact on the performance and reliability of polycrystalline materials used in many technologically useful systems and structures, thereby expediting advanced materials development and deployment. predictive computational algorithms and data will be made available and accessible to other researchers. for the training of the next-generation materials workforce, in addition to mentoring of graduate and undergraduate students, the pi's (from columbia university, illinois institute of technology, lehigh university and university of utah) will participate in outreach activities and will continue to work towards increasing **\*\*diversity\*\*** and broadening participation within stem. grain growth is a very complex process and may be viewed as the anisotropic

evolution of a large metastable network. one of the main thrusts of the project will be to uncover possible stochastic processes that define the evolution of various statistical measures of grain growth, discover relations among them, and establish links to materials properties. results from structure-preserving numerical simulations alongside critical sets of experiments and new experimental data will be invaluable in navigating the modeling and analysis. the project will also create and employ specific data analysis techniques for the study of dynamic evolution of grains in experimental and computational systems with the goal of validating and further refining the microstructural models. this component of the project, will lead to a) the development of new materials informatics methods, b) innovative stochastic differential equations/differential equations models of grain growth, c) new mathematical and numerical analysis techniques for coarsening systems, as well as d) improved computational tools. in turn, the results of combined data analytics, modeling and analysis will be used to guide the design of subsequent experiments. experimentally, grain growth will be examined in prototypical metallic thin films (pd, ni, cr, fe). as most elemental metals and many metallic alloys have cubic structures, the proposed studies will have broad applicability. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Collaborative Research: DMREF: Microstructure by Design: Integrating Grain Growth Experiments, Data Analytics, Simulation, and Theory

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systems, as well as d) improved computational tools. In turn, the results of combined data analytics, modeling and analysis will be used to guide the design of subsequent experiments. Experimentally, grain growth will be examined in prototypical metallic thin films (Pd, Ni, Cr, Fe). As most elemental metals and many metallic alloys have cubic structures, the proposed studies will have broad applicability. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative research: From Community to Practice: Evaluating How Open Educational Resources Facilitate Implementation of Vision and Change Principles Across Diverse Institutions

Awardee: Cornell University

Amount: \$773,789.00

Abstract: This project aims to serve the national interest by examining how open educational resources (OERs), which are educational materials available in the public domain, have enabled implementation of Vision and Change (V&C) principles. The V&C report called for biology departments to transform their programs by using student-centered teaching approaches and integrating core concepts and competencies throughout their curriculum. This report also recognized that course transformation represents a major undertaking for individual instructors and that achieving widespread change would require a distributed effort across biology educators. The biology community has responded to this call in a variety of ways, including supporting peer-reviewed OER journal articles that describe structured lessons with demonstrated potential to improve undergraduate student success. However, there has been little work to understand the composition, implementation, and impacts of the V&C principles in OERs. By characterizing the existing resources, describing community OER engagement, and measuring OER implementation and student learning, this project has a unique vantage from which to understand at a national level how the V&C call has been realized by the community for the benefit of students. The unifying goal of this project is to

advance undergraduate biology education by examining how oer articles have enabled implementation of v&c principles across a variety of undergraduate institution types. despite the potential usefulness of oers, the field lacks a comprehensive understanding of the scope of existing lessons described in articles, how instructors implement them, and whether these resources consistently lead to positive student outcomes. this project will address this gap using an array of data sources, from published oer articles to present day student learning. the project aims to conduct a scoping review of oer article content from a variety of journals. the scoping review will address questions about the coverage of v&c core concepts and competencies; the use of active learning practices; and the advancement of **\*\*diversity\*\***, equity, and inclusion. this project will also survey authors and users to determine their engagement with oers. for authors, the focus will be on how they construct their lessons with v&c principles and how their institutions reward oer contributions. for users, the focus will be on how they modify lessons for their courses. to further determine how implementation affects student learning, instructors who teach pre-selected oer lessons aligned with v&c core concepts and competencies will share course artifacts (e.g., lecture slides), video recordings of their instruction, and student assessment results. taken together, these data will provide insights into the range of ways that instructors adapt v&c-aligned oers for their own contexts and determine the extent to which lesson components influence student learning across institution types. drawing from emergent research, instructors from a variety of institutions will meet regularly in faculty mentoring networks (fmns) to identify and enact strategies to improve the oer sharing process. these strategies will promote v&c principles through mechanisms such as issuing community calls for specific resource development; reflecting on how oer articles can promote **\*\*diversity\*\***, equity, and inclusion; hosting workshops at home institutions to help colleagues adopt and implement oers; and identifying suggestions for departmental incentives and community supports that encourage increased oer growth. this project will benefit society by understanding how v&c aligned oers can be used to promote student learning in undergraduate biology courses. this project is funded by the program description 21-7412, vision and change that supports projects that

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Matched Words: diversity

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Title: SBP: The Emergence of Social Biases in Infancy

Awardee: University of Chicago

Amount: \$765,000.00

Abstract: this project investigates the developmental origins of social bias. before their first birthdays, infants prefer people from familiar racial groups and people who speak their native language. these biases are related to social experience: infants who have more contact with social **\*\*diversity\*\*** are less biased against people from unfamiliar groups. the proposed studies will shed new light on the mechanisms that give rise to infants' social biases by innovating methods to: (1) assess the emotional and cognitive aspects of infants' biases, (2) investigate the neural systems involved, and (3) identify the aspects of social experience that may be important for establishing social bias. the findings will provide insights into how to mitigate the negative consequences of social biases, as well as developing new research tools for studying relations between behavior, brain and social experience during early development. a major goal of this project is to address the dearth of research with minority populations in cognitive development research. studies will involve equal numbers of infants from minority and majority backgrounds in order to better understand how social biases emerge across the **\*\*diversity\*\*** of human experience. prior research indicates that infants' visual preferences express social bias, but the cognitive and affective processes involved, and the associated social and neural mechanisms are poorly understood. this project addresses these open issues by bringing together an innovative set of behavioral, neural and social measures in research with 9-month-old infants. across six studies, infants will be presented with people from different linguistic and racial groups and infants' brain activity (eeg: frontal-temporal theta; mu

rhythm; frontal alpha asymmetry) and behavioral responses (attention, learning, imitation, and approach-withdrawal tendencies) to members of familiar vs. unfamiliar social groups will be compared. the **\*\*diversity\*\*** in infants? social environments will be assessed via neighborhood census data and a parent survey to assess infants? close social networks. this research will provide fundamental new insights into the nature of infants? social biases and the conditions that contribute to them. the multidisciplinary approach will inform scientific understanding of brain-behavior-environment relations during early development. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Tackling microbial biodiversity to create ecological strategies relevant to soil carbon cycling

Awardee: West Virginia University Research Corporation

Amount: \$756,318.00

Abstract: soil contains the second largest reservoir of carbon on earth. as climate change continues, altered temperature and precipitation can affect soil microorganisms and alter the cycling of carbon in soil, potentially mitigating or exacerbating climate change. the ability of scientists to predict this feedback remains poor, at least in part because the ecology and function of microorganisms in soil is not well understood. further, soil carbon is a mixture of everything from simple sugars to complex plant and microbial debris. this research will determine which microorganisms consume key types of soil carbon. the experimental work will consider a range of soils from distinct regions, climates, and soil types to provide broadly applicable knowledge. the project will test the hypothesis that describing the populations of microorganisms that break down and consume different constituents of soil carbon will improve soil carbon models. accurate predictions of ecosystem feedbacks to global change benefit society by allowing decision makers to prepare for the future. additional broader impacts of this work include experiential learning opportunities for over one hundred high school

students in a rural and economically depressed region of west virginia. the project will contribute hands-on science learning activities to an early college program and stem academy to improve scientific literacy with at-risk, economically disadvantaged, under-served youth in a county where fewer than 10% of adults have bachelor?s degrees. a single gram of soil contains thousands of microbial ?species?, making soils among the most biodiverse habitats on earth. perhaps due to this bio\*\*diversity\*\*, the struggle to connect composition with function in microbial communities persists. this research will connect microbial identity and phylogeny to phenotypic traits by quantifying taxon-specific rates of carbon assimilation and growth. the traits of soil microbes will be leveraged to build ecological strategies that connect them to soil carbon pools and facilitate ecosystem modeling. specifically, the project will test the hypothesis that soil heterotrophs can be grouped as primary decomposers that assimilate complex plant debris, secondary decomposers that assimilate microbial necromass, passive consumers that assimilate labile dissolved substrates and predatory microbes that consume live microorganism. using phylogenetic tools, the researchers will determine whether these ecological strategies are evolutionarily conserved, facilitating connections between taxonomy and function. the empirical data will be used to refine and parameterize a microbial-explicit decomposition model. this effort uses state-of-the-art empirical tools, phylogenetics, and ecological theory to distill microbial communities into a currency that models can directly use to enhance our predictive understanding of soil carbon cycling. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF RUI: Characterizing Adaptation to Heterogenous and Stressful Environments

Awardee: California State University-Dominguez Hills Foundation

Amount: \$753,010.00

Abstract: this project takes advantage of experimental evolution in which organisms are evolved in



the laboratory under defined conditions. experimental evolution has been especially successful with microorganisms because they can grow quickly to large population sizes, making the pace of evolution fast enough to study in short periods of time. in this case, the bacteria are propagated under defined but variable environmental conditions to mimic the stressors bacteria encounter in nature. this project aims to characterize the role of gene expression in adaptation and evolution by focusing on the role of genes that can affect cellular behavior by regulating other genes. mutations in regulatory genes may be particularly advantageous for bacteria in changing environments. this work will be performed in collaboration with undergraduate students at a hispanic and minority serving institution where almost 90% of students are from groups underrepresented in stem. further, the pi will integrate this project into an upper-division microbiology course as an authentic research experience for 48 undergraduate students per year, and perform outreach activities related to this project with k-12 educators. in these ways, the research will help to increase the **\*\*diversity\*\*** of students entering the stem pipeline and leave them better prepared for roles in stem fields.

changes in gene regulation are a driving force for evolution. cis regulatory elements are often the cause of evolutionary change when comparing different species, whereas trans regulatory elements are often altered when organisms need to adapt to changing environments. experimental evolution studies with microbes have begun to probe the role of these factors, but often in unchanging environments where either functional or cis regulatory changes would be favored. the pi will explore the role trans regulatory elements play in adaptation to a heterogeneous environment by first identifying each trans regulatory factor that affects survival of escherichia coli in long-term cultures in complex media. then, the pi will characterize the role of these trans regulatory factors in adaptation, by first correlating the genotype with the transcriptome of the population to identify gene expression changes, and determine which of those changes confer the growth phenotype. the pi will then perform experimental evolution on mutant cells to determine how these mutations may change the evolutionary pathways cells can use to adapt to a heterogeneous environment. understanding how these types of regulatory changes affect adaptation will contribute to the fundamental understanding

of evolutionary principles. this research is funded by the genetic mechanisms program in the division of molecular and cellular biosciences in the directorate of biological sciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: NSF Convergence Accelerator Track E: Convergence Towards Nationwide Smart Precision Aquaculture Networks for Sustainable Shellfish Farming

Awardee: University of Maryland, College Park

Amount: \$750,000.00

Abstract: this convergence accelerator project is intended to address the sustainability of shellfish aquaculture. as an important driver of the coastal economy, shellfish aquaculture is the most ecologically sustainable form of aquaculture. shellfish aquaculture offers numerous environmental benefits, and shellfish can serve as a healthy source of protein to enhance human health. however, current domestic shellfish production is bottlenecked by outdated technology and tools. many shellfish farming practices are inefficient, labor intensive, and environmentally destructive. this is

particularly true for on-bottom oyster farming, which has changed little in the past 200 years. this convergence accelerator project will develop a novel framework on nationwide smart precision aquaculture networks (span) to achieve sustainable shellfish production, while preserving healthy marine ecosystems. in the long term, this project will address the global issues of food, planetary resilience, and health as identified by the united nations. the planned education effort will bring philanthropy and social change as a core value for science and engineering education as well as promote **\*\*diversity\*\*** and inclusion. this will help prepare the next-generation workforce to advance the networked blue economy and to improve the health of the planet and quality of life for all. the span framework will be established by using revolutionary concepts empowered by advanced technologies (e.g., internet of things (iot), robotics, and artificial intelligence (ai)), scientific discoveries in biology, environmental science, and ocean sciences, and stakeholder-driven economic development. the project will fundamentally push research boundaries in the following specific directions: i) iot sensor networks will be established to advance the monitoring capabilities for future shellfish aquaculture; ii) novel smart precision harvesting tools based on robotics and automation solutions will be developed to improve farming efficiency and productivity, reduce labor and energy usage, and minimize environmental impact; iii) empirical dynamic models will be created to gain new understanding on feedback between production and environment, as well as to make production predictions; and iv) an optimization framework based on economic models will be established to support production decision-making to gain environmental and economic benefits. collectively, these research activities will ultimately lead to better farm management, economic optimization, and better coping with planetary resilience, and thus enhance production and sustainability. this convergence accelerator project brings together an interdisciplinary team with extensive expertise in sensing and imaging, ai and computer vision, underwater robotics and controls, shellfish biology, climate and ocean dynamics and oceanography, environmental economics, and aquaculture extension, along with readily-engaged stakeholders, in pursuit of research with high impact. the planned education effort will bring change as a core value for science

and engineering education as well as promote collaboration. this will help prepare the next-generation workforce to advance the networked blue economy and to improve the health of the planet and quality of life for all. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Advancing Innovative Convergence Between Fisheries and Offshore Energy to Drive Adaptive Stewardship of Fisheries Habitat in a Dynamic Blue Economy

Awardee: BLUE LATITUDES, LLC

Amount: \$750,000.00

Abstract: for decades, fisheries and offshore energy in the gulf of mexico have developed concurrently, with offshore oil and gas platforms providing fisheries habitats and fishing opportunities for many commercial and recreational fishers. this project will quantify how fisheries use the highly productive artificial reef ecosystems found on offshore oil and gas platforms and produce tools to better understand the impacts of future offshore development (e.g., wind installations) on fisheries. this project will establish the framework for an ecological-economic fisheries model that integrates spatial data from commercial and recreational fisheries and data from ecological parameters, including **\*\*diversity\*\***, abundance, and connectivity, to realize the direct and indirect value that offshore platforms provide for fisheries in the gulf of mexico. the goal is to facilitate decision-making for decommissioning and future offshore energy development that considers the ecological, economic, and social implications of the removal or addition of artificial structures on fisheries. the broader impacts of this project will improve sustainable use of fisheries resources for economic growth, create streamlined pathways to capitalize on existing ocean resources, and improve interactions between disconnected ocean-related sectors in the blue economy, while also providing educational opportunities in the gulf of mexico region.

Matched Words: diversity

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Title: Collaborative Research: FET: Medium: Robust Quantum Networks via Efficient Entanglement Distribution

Awardee: SUNY at Stony Brook

Amount: \$749,771.00

Abstract: quantum computing has the potential, if realized, to significantly alter the computing landscape. however, building large-scale quantum computers is a key challenge. quantum networks (qns) enable the construction of large, robust, and more capable quantum-computing platforms by connecting smaller quantum computers. networked quantum systems have the potential to significantly alter various activities in society by leading to faster development in medicine and engineering; more secure and privacy-preserving communication; and hitherto infeasible optimizations that leverage the immense computational power to identify efficiencies in manufacturing, logistics, finance, etc. this project is also using the potential and attractiveness of qns to design and offer a variety of educational programs, including a flexible post-baccalaureate program in quantum computing and networking to cater to non-traditional students, improve the **\*\*diversity\*\*** of undergraduate and graduate student body, and develop a quantum capable workforce. building qns that support robust communication across nodes requires several fundamental scientific and technological advances, especially since classical techniques cannot be directly used in the quantum regime. qns can be used to build quantum computing systems that are more capable and more resilient than stand-alone quantum computers. this project is examining the design and implementation of qns from the ground up by developing an infrastructure for efficient communication and management of quantum entanglements in the network. in addition, the project is addressing specific challenges in two key applications of qns: (i) distributed quantum algorithms, and (ii) quantum sensor networks. the project is evaluating the developed techniques using large-scale simulations and over a 6-node qn testbed spread across long island, ny. the testbed is

providing a high-fidelity platform to evaluate the effectiveness of our developed techniques. overall, the project has three research thrusts. in the first thrust, the project is developing an infrastructure to facilitate efficient communication and entanglement management. in particular, it is developing optimization techniques for (i) efficient generation of long-distance entanglement using multiple paths, and (ii) efficient distribution of pre-distributed entanglements. in addition, the project is developing efficient entanglement-distillation strategies in practical settings, and protocols for multicast primitives. in the second thrust, the project is addressing challenges in the context of two key qn applications to corroborate and validate the developed techniques. in particular, the project is developing optimization techniques for efficient distributed implementation of centralized quantum circuits; efficient distributed implementations are important for qn's computational success. in the context of quantum sensor networks, it is designing efficient protocols for the estimation of binary parameter functions and investigating the benefit of entanglements in these settings. in the third thrust, the project is evaluating the above techniques using large-scale simulations and a small qn testbed. to evaluate qn performance effectively, the project is formulating novel performance metrics for qns; this requires non-trivial generalization of the classical network metrics. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Convergence Accelerator Track E: Reconfiguring Urban Shorelines for Resilience:  
Convergence Research Meshing Ecology, Engineering and Architecture

Awardee: SUNY at Stony Brook

Amount: \$749,688.00

Abstract: abstract - reconfiguring urban shorelines for resilience: convergence research meshing ecology, engineering and architecture. this project addresses a significant national infrastructure need, the replacement of failing shoreline protection in urban areas. it will produce designs that

increase protection, benefit social communities, and maximize the development of shoreline biological communities and the services they provide, including enhancing fisheries. the blue economy includes traditional marine industries, such as fisheries, mining, and trade, as well as emerging industries like offshore renewable energy, and the ecosystem services provided by natural communities, such as carbon sequestration and coastal protection. urbanized coastal zones drive much of the blue economy, but are increasingly vulnerable to damage from waves, flooding, storms, and sea level rise associated with continued climate change. hardened or armored shorelines, such as bulkheads and sea walls, have been the major tool for protecting shorelines from erosion and storms, particularly in urban settings. but, current infrastructure is failing and must be replaced. it is failing physically and functionally as it cannot adapt to changing sea conditions and is deteriorating due to age in many locations. these structures neither support diverse ecological communities nor provides a place for humans to experience and understand the valuable nature of the urban coastal ecosystem. this failure is not only a cause of the impoverishment of urban life, but a contributing factor to the lack of resilience in cities. therefore, there is a need for innovating a new generation of replacements for existing hardened shorelines that will protect the urban edge, while supporting bio\*\*diversity\*\* and expanding human experience at the coastal interface. this project will design a digital prototype that is not only a solution to an urgent problem, but is also scalable and transportable to other urbanized shores within the us and elsewhere. solving problems that are complex and socially relevant requires expertise in a wide range of fields, including fields that do not normally collaborate. this project involves a team from fields that rarely work together including ecologists, engineers, architects, and social scientists. this project will also engage local stakeholders, including underserved communities, to provide education about shoreline issues, science and design evaluation tools, and include their feedback in development of the model. this project will include engagement with industry, agencies, and regulatory bodies, as well as citizen groups and students. to integrate disciplinary knowledge of natural sciences, social sciences, engineering and architecture, with local knowledge, the team will conduct workshop sessions with



stakeholders, including students. interested students will be encouraged to engage as ?citizen-scientist/citizen-designers? for the duration of the project. the research team aims to advance knowledge in 3 ways: 1) within and among disciplines, 2) among citizens, and 3) between experts and citizens. coastal zones are an essential element of the blue economy. they represent the most urbanized and economically productive areas, provide habitat and nursery areas for marine bio\*\*diversity\*\*, and support important fisheries and aquaculture. however, sea level rise and increased risk of storm surge are threatening the people and economic value of urban coastal areas. shoreline hardening has been the major tool for protecting urban areas, but existing structures are failing and need replacement. they have depauperate ecological communities, reduced nursery areas for fish, are ineffective during storm surges, and limit human interaction with the waterfront. therefore, there is urgent need for innovative replacements to protect the urban edge, support bio\*\*diversity\*\*, and elevate human experience. the goal of this project is to design a new type of infrastructure to better protect urban shorelines while simultaneously enhancing local biological communities and human engagement with the coastline. this project will use a convergence, transdisciplinary approach with use of new materials, complex architectural morphologies, and advanced hydrological computer analyses to design new multi-scalar structures and spaces for the urban edge. it will: develop a transdisciplinary framework of structural, material, biotic, economic and social parameters for building new infrastructure to enhance biological and social communities, while advancing protection from sea-level rise and storm surge; use architectural design and engineering modeling to propose new approaches to constructed coastal reinforcements that provide protection for cities and harbors from storm surges and climate change while maximizing development of biotic communities and the services to people. it will be developed as a digital prototype and will engage local stakeholders, including underserved communities, in design activities that will integrate education about shoreline issues, science and design evaluation tools, and will include their feedback. these outcomes will be used to develop guidelines and design principles to improve coastal infrastructure. this project will create pragmatic scenarios on which to

base decision-making for climate-resilient shoreline structures that have greater ecological and social value while upgrading urgently needed mechanical function. the prototype design will deliver a novel model capable of increasing well-being for people, ocean edges, and shoreline species, boost disaster risk reduction, and increase ecosystem and urban services. it will represent a benchmark approach for future research on the development and application of shoreline infrastructure. the team will link fields that rarely interact (natural and social sciences, engineering, and architectural design), with local users, stakeholders, regulatory agencies, and industry through a convergence framework. this project will help advance knowledge, collaboration, and education in 3 ways: within and among previously isolated disciplines, among citizen groups, and between experts and citizens. local users, stakeholders, regulatory agencies and industry will be important components of this interactive team. this project will serve as a platform for developing and implementing this approach through collaboration with the team's convergence network, curriculum integration, strategic network expansion, and pursuit of new allies. network partners will be brought directly into the processes of public space and infrastructure design. this project will have an important outreach to high schools and will engage citizens and students from underserved communities and members of underrepresented groups. project progress, process, and results will be shared to the wider public through a project website, active engagement through various social media and traditional scientific conference presentations and publications. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Experimental tests of competition and facilitation among migratory large herbivores from Yellowstone National Park

Awardee: Brown University

Amount: \$748,079.00

Abstract: a big question in ecology is: "who eats what?" biologists need answers to this question in order to know how food webs are structured. this knowledge is what enables us to understand where species live, how they behave, and whether any disturbances to the system are liable to have adverse effects on the valuable services that nature provides to people. yet despite working to answer this question for more than a century, researchers still struggle to identify all of the feeding links that together create the food webs of ecosystems around the world. this project focuses on the food web of yellowstone national park in order to understand how the diets of bison and other large mammalian herbivores are able to sustain their epic annual migrations across the ecosystem. in a collaboration with the national park service, undergraduates and early career researchers will track the migrations of five iconic species, monitor their foraging behaviors, and develop new types of molecular biomarkers that will enable biologists to measure animal nutrition in the wild. this career project integrates real-world and classroom-based learning objectives that will advance the training of a diverse workforce capable of implementing the types of rapid diagnostic tests that are essential in modern environmental science, healthcare, and epidemiology. the research team will evaluate competing hypotheses about how seasonal changes in plant **diversity** and availability alter the diets of five co-occurring herbivore species: bison, elk, mule deer, bighorn sheep, and pronghorn antelope. a combination of field observations and experiments, fecal dna metabarcoding, and an innovative adaptation of crispr technology for the analysis of animal nutrition will reveal: (i) how variation in animal diets feeds back to influence the structure and composition of vegetation and (ii) how different herbivore species stimulate the production of their own preferred food plants compared to the food plants preferred by other herbivores. results will be used to parameterize a generalizable nutritional model in order to identify competition and facilitation operating in the food web. by developing, testing, and employing novel laboratory methods in combination with a series of time-tested experimental strategies in field ecology, the team aims to overcome the long-standing challenge of precisely characterizing trophic interactions in many research and training programs. this award reflects nsf's statutory mission and has been deemed worthy of support through

evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Convergence Accelerator Track E: A Globally Coordinated, Universally-Accessible Digital Twin Network for the Coral Reef Blue Economy

Awardee: Woods Hole Oceanographic Institution

Amount: \$747,606.00

Abstract: oia - 2137882 nsf convergence accelerator track e: a globally coordinated, universally-accessible digital twin network for the coral reef blue economythis project proposes to develop a "digital twin" technology to improve stewardship of coral reef ecosystems. digital twins are virtual replicas and the use of this technology is growing in many sectors, providing opportunities to collaborate virtually, visualize entire systems, intake sensor data and update system status in real time, design what-if scenarios, predict results of proposed interventions, and create strategies to improve the real-world features that the twin represents virtually. this technology has not yet been applied to analysis and stewardship of coral reefs but has the potential to facilitate the collaboration among diverse interest groups that is needed to preserve these crucial ecosystems. the team has identified three critical gaps that limit the utility of scientific knowledge in the management, conservation, and restoration of coral reef ecosystems which they are confident can be addressed by the digital twin approach: i) lack of a whole systems approach, ii) absence of a global platform for data integration, analysis and visualization, and iii) lack of universal access to data and knowledge, which in turn prohibits sharing and collaboration. the end goal of the effort is a global-scale, interconnected network of digital reefs with the potential to transform the management, conservation, restoration, and sustainable harvest of coral ecosystems for the 21st century blue economy. coral reef ecosystems play a central role in the global blue economy. in the us, coral reefs contribute billions of dollars to the blue economy each year, create jobs, and protect coastal infrastructure. however, coral reefs everywhere are declining at a pace and scale unprecedented in

human history. this project incorporates valuable **\*\*diversity\*\*** and expertise, including includes the university of guam, an accredited asian american, native american, pacific islander-serving institution; the marshall islands conservation society (mics), with strong stakeholder interests in coral reef sustainability; and the nature conservancy, whose coral reef program is established in over thirty countries around the world. all products generated as part of this research will be made publicly available via a project-specific website and existing portals as well as other media such as film, gamification, and collaborations with large public aquariums in the us. this strong network will help ensure co-development with a broad range of stakeholders and global utilization of the tools developed.      the team will develop the prototype coral reef digital twin on palmyra atoll, a us territory in the pacific, and then during phase 2 will expand the digital twin model to priority sites identified by collaborators from federal agencies and conservation organizations. the 3-dimensional virtual replica of a living reef will facilitate the integration, analysis and accessibility of a **\*\*diversity\*\*** of geological, physical, chemical, biological and socio-economic data and models from anywhere in the world. the data will be incorporated into a holistic representation of the living reef that can be visualized in 3-d, analyzed at any point in space and time, and simulated under different, future scenarios. connection between the physical reef and its digital replica, via sensors, robotics and satellites, will allow the digital twin to receive and integrate updates on coral reef status in near-real time, providing critical information to managers, restoration practitioners, and stakeholders, including tourism operators, fishermen and coastal communities.      this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: RoL: The intersection between cell fate decisions and phenotypic diversification in a rapidly radiating butterfly lineage

Awardee: Smithsonian Institution

Amount: \$747,521.00

Abstract: animal structures are made of combinations and arrangements of distinct cell types, the product of complex cell decision-making during development. but how do cells, which contain identical genetic information, decide their fate? this research addresses this fundamental biological question in a simple, yet spectacularly diverse animal structure?the color patterns on the wings of heliconius butterflies. although heliconius wing patterns are highly diverse, they are created by altering the distribution of just three cell types (red, black and yellow wing scales) across the wing surface. unlike in a complex organ, the cell decisions that create these patterns unfold on a flat canvas of non-migrating cells. this attribute greatly simplifies the process of understanding the interactions among genes and how these interactions change throughout development to create a specific pattern. this research capitalizes on this fact and emerging genomic tools to characterize the molecular decisions that determine how a developing wing cell becomes specified into one of the three different scale cell types. the project is strengthened by a 6-month internship program that targets traditionally underrepresented groups and offers an in-depth research experience and hands-on professional development. moreover, through partnerships with science museums, this project will create bilingual (english and spanish) experiential learning resources that harness the potential of butterflies to educate a variety of audiences (school children, teachers, and life-long learners) about genes, development, natural selection, and the role that interactions among them play in generating earth?s bio\*\*diversity\*\*. evolutionary processes constantly generate and rearrange specialized cell types, forging the morphological dimension of bio\*\*diversity\*\*. research is starting to connect changes in gene expression and open chromatin to cell fate decisions. however, this research has mostly focused on early embryonic development or on the developmental trajectories of complex organs in a few species. although powerful, these studies do not have an explicit goal of linking changes in cell fate decisions to phenotypic change. this research fills this important knowledge gap by characterizing the rules governing cell specification? from signals, to reception, transduction, transcriptional activation, and fate determination during the critical

developmental period when the wing patterns of heliconius butterflies are established. here, extensive knowledge of the ecological and evolutionary significance of wing color patterns, experimental tractability, and fantastic \*\*diversity\*\* make heliconius a powerful experimental system for understanding how the processes of cell specification are modified by natural selection to produce \*\*diversity\*\*. by casting single-cell transcriptomics, open chromatin profiling and crispr loss-of-function experiments within an evolutionary framework that includes replicated cases of the independent evolution of identical wing patterns, this project will determine the rules that govern how cells communicate and acquire a specialized fate during development, and how those rules are applied to generate \*\*diversity\*\*. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: What Black Doctoral Students in STEM Want and What Their Faculty are Giving: How the Differences Impact Students? Mental Health and Career Trajectory

Awardee: Arizona State University

Amount: \$744,966.00

Abstract: to increase the \*\*diversity\*\* of the phd-prepared workforce, understanding underlying issues affecting retention and completion of doctoral degrees is essential. researchers at arizona state university and university of massachusetts boston, propose to study the expressed needs of black doctoral students in relation to faculty perceptions of what they are providing during advising relationships. understanding the mental health impacts of cumulative experiences that marginalize black graduate students, will advance knowledge by providing recommendations for developing inclusive environments and mentoring strategies that are effective at supporting black students. through a two-phase design, the project aims to use detailed interviews regarding the experiences of marginalization, mental health, and career trajectory decisions of graduate students, and faculty

perceptions of supports and contributors or deterrents to providing supports. the project is aligned with the ehr core research program's goal of addressing challenges in stem interest, learning, and participation. the research design is framed by extending role strain theory to include the tension that black students may feel in relationships during graduate programs. the central hypothesis is that intersectional experiences of marginalization and the stem environment among black doctoral students impact mental health and career trajectory decisions. the project aims to understand the contributors and deterrents for faculty to address systemic barriers. a nationwide sampling strategy will include representation from historically black colleges and universities (hbcus), predominately white institutions (pwis), and minority-serving institutions (msis). the project aims to match critical identity aspects in the interviewer-interviewee pairing within each phase of the project. phenomenological principles grounded in a social constructivist paradigm will guide the interpretation of individual interviews. the research responds to the need for understanding barriers to success in graduate programs for black students by novel coordination and expansion of traditional educational research strategies with strategies typically utilized by counseling psychologists. the creation of a tip sheet on promising practices for supporting black students and an online repository aims to inform faculty advisors who seek to improve communication and mentoring for their students. the project is funded by the ehr core research program that supports fundamental research focused on stem learning and learning environments, broadening participation in stem, and stem professional workforce development. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: SBP: Understanding how diversity exposure impacts social categorization

Awardee: University of California-Santa Barbara

Amount: \$741,659.00



Abstract: people divide the social world into groups, based on attributes such as race, gender, and nationality. beginning early in life, people use information about another person's groups to form expectations about that person's likely traits and behaviors. even infants expect people in the same group to be similar. expecting people within a group to be similar may lay the foundation for negative stereotypes and bias. one potential way to reduce bias is through positive interactions. past research has shown that positive interactions with someone from an unfamiliar group improves attitudes towards other members of that group. but most communities do not include representation of people from every background. as a result, it is not feasible to have positive interactions with people from all groups. this project develops a new idea: that exposure to **diversity** more broadly (rather than to a specific group) may itself reduce stereotyping. this idea is tested by developing measures of the racial and linguistic **diversity** of infants' and children's neighborhoods and networks along with traditional measures of stereotyping. the project develops novel measures of exposure to **diversity**, based on the principle of entropy: networks that contain a greater number of groups and with more equal representation of groups are scored as more diverse. by pairing this novel measure with other validated measures of children's stereotyping, the research will test whether differences in exposure to **diversity** are related to differences in stereotyping. this approach helps to address a number of fundamental questions. one is whether exposure to racial **diversity** reduces race-based stereotyping. another is whether the effects of **diversity** exposure are even broader, such that exposure to linguistic **diversity** can reduce race-based stereotyping. a third is how children's stereotyping based on racial groups compares to linguistic groups. the broad aim is to better understand how early exposure to **diversity** is related to stereotyping in infants and children. the laboratory-based research is a critical first step that can be leveraged for future interventions aimed at mitigating the negative impacts of stereotyping. the project also provides training in social psychology and developmental science for a diverse group of early-career researchers, and supports partnerships between the university and local museums aimed at increasing scientific literacy. this award reflects nsf's statutory mission and has been

deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: PurSUIT: Species diversity and evolution of parasitic microfungi

Awardee: Purdue University

Amount: \$739,694.00

Abstract: fungi are essential to ecosystem functioning, occur virtually everywhere, and form complex relationships with diverse organisms including prokaryotes, algae, plants, invertebrates, vertebrates, and other fungi. nonetheless, fungi are the most undersampled and poorly documented major lineage of eukaryotes, even though total species estimates range conservatively from 1.5-6.1 million species. this uncertainty reflects numerous gaps in knowledge about fungal distributions, especially regarding range and extent of unculturable fungi, microscopic fungi (microfungi), parasitic fungi, and tropical fungi. this project will document **diversity** of fungi in two groups that represent major gaps in our knowledge: the first are unculturable microfungi that associate with insects, called labouls, and the other are unculturable microfungi that associate with plants, called rust fungi. members of labouls and rust fungi are expected to have profound effects on ecosystem health and functioning through both beneficial and harmful interactions with their animal and plant hosts. the research team will explore several global habitats in tropical and temperate regions that have not previously been surveyed for these fungi. it is expected that hundreds of new species will be discovered and described during this project. in addition to enhancing the documented bio**diversity** on the planet, this project will resolve the "tree of life" for both groups and use this information to resolve long-standing questions regarding the evolution of the fungi. broader impacts include graduate and undergraduate training, international workshops to enhance collaboration between us and local researchers, and outreach to the public through "bat night" and "roach hunt" field trips. these fungal lineages are being studied for several reasons: 1) both represent groups poorly documented

from tropical world regions; 2) both represent groups that are not detected by commonly applied culture-based and high throughput sequencing efforts; 3) neither group has been resolved, phylogenetically, by application of multi-locus analyses of known species; 4) both represent obligately parasitic lineages that are rarely studied but expected to have profound effects on ecosystems; and 5) both are or are related to heteroecious fungi (requiring two different hosts), a phenomenon that is extremely rare in fungi. a complementary team of us and other global experts on these fungi, ranging from junior to senior scientists, have designed an experimental approach that includes standardized sampling strategies from tropical and extra-tropical regions with multi-locus phylogenetic, phylogenomic, comparative genomic, and statistical analyses to: 1) determine whether accurate estimates from obligate microparasitic fungi, not included in any other estimates, will affect overall fungi species estimates; 2) whether parasitic microfungi follow the reverse latitudinal gradient posited for other fungal groups; and 3) resolve long-standing unresolved phylogenetic nodes by the incorporation of ?missing? lineages. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: GCR: Collaborative Research: Designing a Sustainable Agricultural Production System through Convergence Research Using a Multi-Scale Ecosystems Approach

Awardee: Tulane University

Amount: \$739,184.00

Abstract: this project addresses the grand challenge of sustainability of food systems, a complex issue that requires deep integration of scientific and engineering disciplines as well as participation by all stakeholders. this project brings together conservation biologists, ecologists, agronomists, farmers, indigenous peoples, economists, social scientists, land managers, and engineers to co-design and implement a framework for testing approaches to sustainable agricultural production.

the research team will use this to study the impact in a model system, coffee production, of integrating technological innovations, such as us-built, industrial renewable-energy dryers and clean wet mills that recycle coffee pulp and reduce water pollution, with environmentally-friendly economic development where farmers are compensated for preserving forest on their lands through carbon offset credits, and community-led training and outreach and microcredit programs intended to increase both the participation of women and production. such a system has the potential to conserve forest critical to reducing carbon emissions, support bio\*\*diversity\*\*, including migratory birds, and enhance the stability of economic and social conditions. the goal of the project is to develop a framework for convergence research targeting the development of sustainable food systems using the tools of socio-ecological systems, extended to a multiscale ecosystem framework. the research team will construct a multi-scale empirical socio-ecological model of the food production system, identifying the structural elements at all relevant scales, the inter- and intra-scale interactions among those elements, and ecosystem and social services at multiple scales. this model will allow quantification of sustainability metrics under different scenarios. it will be used to identify tradeoffs, synergies and critical points among sustainability indicators and to perform scenario analyses of the impacts of critical exogeneous drivers, including market fluctuations and climate change, on the elements of the system. this project is jointly funded by the growing convergence research program and the established program to stimulate competitive research (epscor). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: NRT-QL: A Program for Training a Quantum Workforce

Awardee: San Jose State University Foundation

Amount: \$739,029.00

Abstract: recent progress in quantum information science and technology (qist) promises advances that will fundamentally reshape today's leading technologies, including computing, communications, and sensing. a well-prepared workforce is essential to fulfilling this promise. in response to this critical workforce need, this national science foundation research traineeship (nrt) award to the colorado school of mines (mines) and san jose state university (sjsu) supports the development of rigorous, integrated, interdisciplinary training programs preparing both master's and doctoral students for careers in qist. the program has three components that address key challenges in training a quantum workforce. first, new training materials will be developed to introduce qist basics to students from different disciplines. trainees will come from physics, electrical engineering, metallurgical and materials engineering, applied mathematics and statistics, computer science, and quantum engineering. second, industrial and national lab partners will be engaged to provide trainees access to cutting-edge technologies and research experiences. finally, student recruitment and mentoring programs, unconscious bias training, ally workshops, and regular climate surveys will be developed to ensure **\*\*diversity\*\*** in the qist workforce. the project will train one-hundred and twenty-five (125) ms and ph.d. students, including thirty-five (35) fully-funded trainees. these efforts will result in an institutionalized program that produces leaders in qist for careers in academia, industry, government, and national labs. the research program addresses three grand challenges in quantum technology: (1) how can demonstrable quantum speed-up using existing or near-term quantum computing architectures be achieved? (2) how can materials and electrical engineering interface with quantum technology to provide meaningful advances in device development and fabrication? (3) how can new directions in quantum algorithms advance and challenge the notion that quantum technology can solve problems that are impossible to tackle with conventional technology? these interdisciplinary research challenges require close synergy between fundamental physics, materials science, electrical engineering, and algorithm development. new courses and degree pathways in qist are being developed at both mines and sjsu, which include integration of professional skills development into the graduate curriculum. through classroom training and

research, trainees will be exposed to the full range of quantum technology architectures, providing a holistic view of this rapidly developing field. an innovative educational agreement between mines and sjsu will provide opportunities for students to complete an ms/ph.d. bridge program from sjsu to mines. the program will result in a template for qist graduate education, which will be accessible to stem students from all backgrounds and types of institutions, increasing **\*\*diversity\*\*** in qist. the nsf research traineeship (nrt) program is designed to encourage the development and implementation of bold, new potentially transformative models for stem graduate education training. the program is dedicated to effective training of stem graduate students in high priority interdisciplinary or convergent research areas through comprehensive traineeship models that are innovative, evidence-based, and aligned with changing workforce and research needs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Incorporating host phenology into the framework of biodiversity-disease relationships

Awardee: Purdue University

Amount: \$738,584.00

Abstract: major changes to bio**\*\*diversity\*\*** are occurring around the world - this can alter the risk of disease. understanding and predicting how these changes impact infectious disease requires knowledge of the relationship between bio**\*\*diversity\*\*** and disease. however, because bio**\*\*diversity\*\*** may vary throughout the year, it can be difficult to measure host **\*\*diversity\*\*** and the contribution of each species to disease transmission. therefore, scientists must understand how the seasonality of organisms in a community affects the risk of disease. in this project, researchers will study seasonal changes to amphibian bio**\*\*diversity\*\*** and how these changes impact infection with a fungus. a greater understanding of bio**\*\*diversity\*\***-disease relationships is essential for effective

control of emerging infectious diseases and management of susceptible species. this career project also incorporates educational activities that focus on increasing the **\*\*diversity\*\*** of students who receive training in the scientific process by providing research opportunities for undergraduate and high school students. this study will combine field sampling, experimental manipulations, and modeling to incorporate host phenology into the study of bio**\*\*diversity\*\***-disease relationships. the project focuses on the following complementary objectives: (1) enhance estimates of host competence for individual species by incorporating data on temporal habitat use, (2) quantify the temporal niche of a pathogen in communities with varying species composition, and (3) predict the effects of climate change on disease risk via altered host phenology. this work will address these objectives by utilizing an amphibian-fungal pathogen system, where the presence of amphibian host species in the aquatic environment varies seasonally and across space. the educational objectives of this career project focus on increasing the **\*\*diversity\*\*** of students receiving quality training in the scientific process. educational activities include (1) improving the availability of course-based undergraduate research experiences, (2) increasing the **\*\*diversity\*\*** of undergraduate research interns, and (3) engaging high school students in research through participation in science fairs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Incorporating host phenology into the framework of biodiversity-disease relationships

Awardee: Purdue University

Amount: \$738,584.00

Abstract: major changes to bio**\*\*diversity\*\*** are occurring around the world - this can alter the risk of disease. understanding and predicting how these changes impact infectious disease requires knowledge of the relationship between bio**\*\*diversity\*\*** and disease. however, because

bio\*\*diversity\*\* may vary throughout the year, it can be difficult to measure host \*\*diversity\*\* and the contribution of each species to disease transmission. therefore, scientists must understand how the seasonality of organisms in a community affects the risk of disease. in this project, researchers will study seasonal changes to amphibian bio\*\*diversity\*\* and how these changes impact infection with a fungus. a greater understanding of bio\*\*diversity\*\*-disease relationships is essential for effective control of emerging infectious diseases and management of susceptible species. this career project also incorporates educational activities that focus on increasing the \*\*diversity\*\* of students who receive training in the scientific process by providing research opportunities for undergraduate and high school students. this study will combine field sampling, experimental manipulations, and modeling to incorporate host phenology into the study of bio\*\*diversity\*\*-disease relationships. the project focuses on the following complementary objectives: (1) enhance estimates of host competence for individual species by incorporating data on temporal habitat use, (2) quantify the temporal niche of a pathogen in communities with varying species composition, and (3) predict the effects of climate change on disease risk via altered host phenology. this work will address these objectives by utilizing an amphibian-fungal pathogen system, where the presence of amphibian host species in the aquatic environment varies seasonally and across space. the educational objectives of this career project focus on increasing the \*\*diversity\*\* of students receiving quality training in the scientific process. educational activities include (1) improving the availability of course-based undergraduate research experiences, (2) increasing the \*\*diversity\*\* of undergraduate research interns, and (3) engaging high school students in research through participation in science fairs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Increasing the Number and Diversity of Highly Effective STEM Teachers in High-need Urban School Districts



Awardee: Davenport University

Amount: \$737,538.00

Abstract: this project aims to serve the national need for highly effective, diverse stem teachers in high-need urban schools. over the next decade, teacher preparation efforts will be challenged by school administration turnover, social and policy changes, and demographic shifts. thus, preparing excellent teachers will become even more important. this project is designed to increase interest in teaching careers among high school students, community college students, undergraduate stem majors, and stem career changers. the project features an innovative pipeline development approach that includes recruiting potential teachers from urban high-need high schools and by developing dual enrollment programs that accelerate college degree attainment. by offering early teaching experiences to high school and undergraduate students, the project has the potential to increase student interest in teaching. since many of these teaching experiences will be conducted as service-learning projects, these efforts will benefit the community as well. the project will leverage stem teaching methods courses and undergraduate urban education courses to help prospective teachers understand the context of urban education, including challenges and data-driven educational strategies that increase student achievement. this project at davenport university (du) includes partnerships with grand rapids community college and four high-need local educational agencies (detroit public schools community district, muskegon heights public school academy system, hope academy of west michigan, and grand rapids public schools). the project aims to strengthen the recruitment pipeline and increase the size and **\*\*diversity\*\*** of the pool of eligible stem candidates in du's urban education teacher preparation program. the project aims to recruit, provide scholarships or stipends, educate, and graduate 23 prospective stem teachers. these students will include 15 eligible juniors and seniors pursuing a bachelor of science in computer science or biological laboratory science and 8 stem professional career changers. these prospective teachers will be prepared to gain michigan k-12 teacher licensure with a focus on biology, chemistry, physics, integrated science, and/or mathematics. they will also gain experience in implementing

culturally relevant pedagogical models of instruction. upon certification, the new teachers will receive mentoring, academic resources, and induction support to successfully transition into a teaching career in high-need, urban school districts. the project will collect data and analyze how service-learning experiences, mentoring, coaching, and an enhanced curriculum emphasizing culturally responsive teaching practices prepares prospective stem teachers to be successful stem teachers in urban stem classrooms. this track 1: scholarships and stipends project is supported through the robert noyce teacher scholarship program (noyce). the noyce program supports talented stem undergraduate majors and professionals to become effective k-12 stem teachers and experienced, exemplary k-12 teachers to become stem master teachers in high-need school districts. it also supports research on the persistence, retention, and effectiveness of k-12 stem teachers in high-need school districts. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: The Simpson Neutron Monitor Network

Awardee: University of New Hampshire

Amount: \$730,638.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). this three-year collaborative project is focused on building of a network of ground-based cosmic-ray monitors, called neutron monitors (nms), operated by a consortium of three u.s. academic institutions, namely universities of new hampshire, delaware and wisconsin-river falls. invented by prof. john simpson in 1948, following his experience on the manhattan project, nms have been used to detect and measure radiation in space, starting almost ten years before the space age. they are stationed on the ground all over the globe, providing continuous measurements of cosmic radiation for over a half century. nms measure the trends and changes in the radiation

levels in space, which is critical information for travel by astronauts to the moon and mars. they can also detect intense, short-term bursts of radiation from the sun that reach the ground. all this activity is driven entirely by what the sun is doing. nms are robust and reliable and have assumed a new importance in recent years when used in conjunction with the international fleet of spacecraft and with neutron monitors in other countries. now, all the nms sponsored by the u.s. are being linked into what will be the simpson neutron monitor network, which will make it more efficient to coordinate operations and science. during this three-year collaborative project, the consortium will carry out this research, teasing new information out of these heritage instruments and providing researchers around the world with up-to-date radiation climate data. cosmic rays entering the earth's atmosphere are messengers informing us about large-scale heliosphere structure, local space environment and solar activity. they have already passed through and interacted with the interplanetary magnetic field, and they carry information of its detailed structure. some of these cosmic rays possess enough energy to reach the ground. a nm is a ground-based particle detector that records the nucleonic component in particle showers. this directly correlates with the number of high energy cosmic rays striking the earth's atmosphere. the analysis of these data is used to build an understanding of the sun's influence on the solar system. because of the large detector volume exploited by ground-based stations, neutron monitors remain the state-of-the-art instrumentation for measuring rigidity  $>1\text{gv}$  cosmic rays. the programmatic linking of these instruments run by the universities of new hampshire, delaware and wisconsin-river falls will secure a continuity of quality data for the global community, as called out in the national space weather plan and congressional legislation. the data from these instruments are used by many, including, space weather predictors, industry, space scientists, homeland security and hydrologists. the nm stations span a wide range of latitudes, from the south pole to the arctic regions. the contributors to the nm signal include cosmic rays from the galaxy that are heavily modulated by solar activity and from the sun itself in the form of high energy bursts of protons. the variability of these agents reveals conditions in interplanetary space, general solar activity and the fundamental processes that produce cosmic rays throughout

the universe. with today's computing resources, we better understand how these instruments detect radiation, and the consortium will thus be able to extract new information from these workhorse devices. this will shed new light on how the distribution of cosmic rays varies with time, geography and particle energy. the consortium will study how to permanently secure the operations of the monitor network and intelligent ways of expanding the network to complement those at existing sites. the education and outreach goals of the project include a research position for a postdoc, a wide variety of opportunities and experiences for undergraduates, as well as opportunities for high school and elementary school students. the research and education agenda of this collaborative project supports the strategic goals of the agency division in discovery, learning, **diversity**, and interdisciplinary research. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Wood-eating protists: An evolutionary transition enabled by gene transfer?

Awardee: Arizona State University

Amount: \$725,355.00

Abstract: wood-feeding termites can be highly destructive pests. their ability to survive on such a nutritionally poor diet as wood comes from symbiotic gut microbes. in certain termites, these microbes include protists (protozoa) that can engulf wood particles and extract sugars using specialized enzymes. this project will determine how the protists evolved their wood-digesting ability. did they acquire new genes for wood-degrading enzymes from bacteria or fungi, or did they adapt enzymes that are also present in non-termite protists? a better understanding of wood digestion in protists could be useful for developing termite control strategies or learning how to convert woody biomass into biofuels or other biochemicals. because most termite protists have not been studied, this project will also illuminate a dark area of the tree of life by describing many new protist species

and determining how they are related to one another and to non-termite protists. as part of the bio\*\*diversity\*\* discovery and documentation effort, a course-based undergraduate research experience at arizona state university will train approximately 200 students in systematics and bio\*\*diversity\*\* research. the research activities will include transcriptome sequencing of 43 protist species, 31 from termite-associated lineages and 12 from related, non-termite lineages. these transcriptomes will be studied to determine the \*\*diversity\*\*, distribution, and phylogeny of cellulases and hemicellulases in the protist superphylum metamonada. transcriptomic data will also be used for phylogenomic analyses to resolve the protist phylogeny and provide a framework against which to interpret the evolution of wood digestion. because termite gut protists are so understudied, an additional ~200 protist species symbiotic in 21 phylogenetically diverse termite species will be characterized by morphology and 18s rRNA sequence by single cell PCR. this number includes an estimated 50-70 currently undiscovered species that will be formally described. the characterization of arizona termite protist species will be carried out by teams of undergraduate students receiving training in taxonomy and systematics as part of a course-based research experience (CURE). involvement in authentic research has been shown to increase undergraduates' appreciation of and retention in science. the proposed CURE will specifically target first-generation college students, including transfer students from a local community college. research results will be disseminated broadly to protistology, microbial ecology, and termite specialist communities through conferences and the biennial international termite course at the university of florida. this award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MRI: Acquisition of a Massive Database to Accelerate Data Science Discovery

Awardee: University of Vermont & State Agricultural College

Amount: \$725,016.00

Abstract: this project is jointly funded by the major research instrumentation and the established program to stimulate competitive research (epscor) programs. the project funds construction of datamountain, a massive database cluster for high performance computing at the university of vermont (uvm). the large-memory machine will enhance the vermont advanced computing core, a virtual laboratory supporting the research of over 500 scientists in the state of vermont. with so many fields transitioning from data-scarce to data-rich environments, many important research areas will benefit from this new machine including research into addiction, mental illness, climate change, drug discovery, food systems, and the spread of online misinformation. datamountain will allow for fast access to enormous datasets, supporting several projects that require computational power and speed to effectively analyze, describe, and explain rapidly growing datasets. datamountain will increase by nearly two orders of magnitude the largest random access memory machine available for computational research at uvm, accelerating large-scale data-driven research requiring rapid reading and writing, and facilitating a broad and diverse set of important scientific investigations not currently possible given the existing hardware. it will also enhance the functionality of the high performance computing clusters bluemoon and deepgreen, which are dedicated to parallel processing and machine learning respectively. for example, the machine will allow for interactive access to over 50 terabytes of social media data through <http://storywrangling.org> and <http://hedonometer.org> for timely analysis of changes related to the covid-19 pandemic in population-scale physical and mental health data. in addition, datamountain will allow for massive increases in the spatial and temporal resolution of computational chemistry simulations being performed for data-driven design of next-generation antimicrobial peptides to combat antibiotic resistance. datamountain will also enable exploration of petabytes of fmri, genetic, task performance, and survey data associated with 10,000 adolescents across the united states over the next decade. in addition, the machine will accelerate research using unmanned aerial surveillance imaging for tree canopy assessments, facilitate network science modeling of agricultural **\*\*diversity\*\*** of crops and nutritional outcomes globally, and help quantify the impacts of the covid-19 pandemic

on food insecurity. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Emergence of Functional Organization in the Adaptive Immune System

Awardee: University of Washington

Amount: \$720,000.00

Abstract: it takes decades for humans to reproduce, but our pathogens can reproduce in less than a day. how can we coexist with pathogens that can evolve more than 10,000 times faster than us? the answer lies in our adaptive immune system, which is a self-organized system of highly diverse immune cells that develop during the lifetime of an organism. the adaptive immune system incorporates all aspects of life, from molecular signaling to cellular evolution. the result is an information processing molecular organization with many interacting components, which can reliably sense and adaptively respond to diverse and evolving pathogens. the vast differences in immune repertoires between individuals suggest the existence of many molecular solutions to statistically similar pathogenic environments. the goal of this project is to use machine learning to derive a map from the diverse and high-dimensional space of receptor repertoire sequences to a lower dimensional space of immune functions that relates to biophysics of immune recognition. this effective functional representation of immune repertoires would allow construction of predictive models for immune responses to pathogens, and will shed light on functional organization of immune repertoires. to bridge the gap between physics and biology, the pi will introduce pre-college and undergraduate students to biophysics research, with particular emphasis on women and underrepresented minorities. the pi will create new teaching modules to introduce both the physics and the life-science undergraduate and graduate students to current progress in physics of living systems. in addition the pi will commit significant resources to mentor undergraduate and high

school students during summers and the academic year to pursue biophysics research. the pi will invite biophysics researchers to the department's "frontiers of physics public lecture series", to foster an appreciation and support among the community for the exciting developments in this field.

the adaptive immune system develops during the lifetime of an organism and consists of highly diverse b-and t-cells, whose unique surface receptors are generated through genomic rearrangement, mutation, and selection. this diverse repertoire of receptors can mount specific responses against a multitude of evolving pathogens and keep a memory of past infections for future encounters. pathogens in return, evolve to escape the immune challenge, forming a rapid co-evolutionary arms race during the life-time of an organism. over the past decade, high throughput immune repertoire sequencing has been instrumental in characterizing the **diversity** of immune receptor sequences. however, we still lack an understating of how receptor sequence **diversity** translates to immune function. in this project, the pi will combine theoretical modeling with inference from molecular data to uncover the biophysical and evolutionary basis of the functional organization and encoding of pathogenic information in the adaptive immune system. the life-cycle of immune cells is defined by a continuum of selection stages leading to their functional specialization. the pi will develop biophysical inference techniques to leverage receptor repertoire data of distinct immune cell-types and use machine learning to derive sequence-determinants of immune function. in addition the pi will develop predictive fitness models to characterize how the short-and long-term dynamics of immune repertoires relate to functional responses to pathogens. by building upon recent advances in machine learning, the pi will infer a latent representation (i.e., a shape space) for immune receptors that reflects the relevant biophysics of immune recognition and function. the inferred immune shape space will allow to ask fundamental questions regarding the biophysical determinants of antigenic interactions, and self/non-self discrimination. lastly, a theoretical framework to study how the co-evolutionary history of hosts and pathogens has shaped immune strategies, both at the individual-and the population-level will be developed. this award reflects nsf's statutory mission and has been deemed worthy of support



through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Nonclassical mechanisms to modify and control organic crystal nucleation and growth

Awardee: University of Houston

Amount: \$714,558.00

Abstract: non-technical summary    solution-grown single crystals serve as semiconductor, optoelectronic, and photovoltaic devices and detectors for high-energy radiation. these studies, supported by the solid state and materials chemistry program in the division of materials research, fill a gap in understanding crystallization of organic materials that carry promising optical and electronic properties for use as semiconductors, solar cells, and field-effect transistors. additionally, the research can provide valuable information about crystallization processes, which are essential for a myriad of industrial, natural, and physiological processes. researchers at the university of houston take on the grand fundamental science challenge to control crystallization by designing robust control strategies that rest on understanding the fundamental thermodynamic and kinetic mechanisms, and in particular the role of foreign compounds. in industry, soluble foreign compounds that interact with the solution or the crystal-solution interface are deployed to promote or inhibit crystallization. nature achieves remarkable **\*\*diversity\*\*** of shapes, patterns, compositions, and functions of the arising crystalline structures by applying ingredients that control the number of formed crystals and their rates of growth. insights gained from this project advance the science of organic crystallization in general, and the influence of foreign compounds on the synthesis of solid state organic materials in particular. the researchers also involve a diverse cohort of high school, undergraduate, and graduate students in carrying out this research, which provides them with training in advanced science and engineering concepts and methods. this in turn contributes to narrowing the gap between the demand and availability of educated workforce in houston, which is among the widest in large u.s. cities.    technical summary    as part of this project, which is supported

by the solid state and materials chemistry program in the division of materials research, the pi and this team design novel strategies to control the nucleation and growth of crystals from organic solvents that employ foreign compounds to regulate nonclassical crystallization behaviors and the nucleation and growth precursors. the accepted models of modifier activity presume that crystal nucleation and growth advance along classical pathways. recent experiments have accumulated significant discrepancies with the classical theories. the highlighted nonclassical features involve mesoscopic crystallization precursors, ordered or disordered, which assemble in the solution independently of crystallization and may both facilitate nucleation and feed a fast mode of crystal growth. how additives impact the properties of the crystallization precursors to enhance or suppress crystal nucleation and growth has not been examined. the researchers bring complementary expertise in molecular thermodynamics and kinetics of crystallization, crystal design and advanced characterization, and molecular simulations to pursue three specific aims: 1. design strategies to control crystal nucleation by manipulating precursors involved in nonclassical nucleation modes. 2. elucidate molecular and mesoscopic crystallization mechanisms that persist after removal of the modifier from the growth medium by exploiting the interactions of modifiers with crystal growth precursors and with step bunches on the crystal surface. 3. characterize interactions between pairs of modifiers mediated by the step structures and dynamics that lead to antagonistic, additive, or synergistic cooperativities between modifiers; these interactions have been disregarded by classical inhibition models. to cover a diverse array of nucleation and crystallization behaviors, the researchers employ organic crystals that carry promising optical and electronic properties for use as semiconductors, solar cells, and field-effect transistors. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: RoL: The intersection between cell fate decisions and phenotypic

diversification in a rapidly radiating butterfly lineage

Awardee: Duke University

Amount: \$710,178.00

Abstract: animal structures are made of combinations and arrangements of distinct cell types, the product of complex cell decision-making during development. but how do cells, which contain identical genetic information, decide their fate? this research addresses this fundamental biological question in a simple, yet spectacularly diverse animal structure?the color patterns on the wings of heliconius butterflies. although heliconius wing patterns are highly diverse, they are created by altering the distribution of just three cell types (red, black and yellow wing scales) across the wing surface. unlike in a complex organ, the cell decisions that create these patterns unfold on a flat canvas of non-migrating cells. this attribute greatly simplifies the process of understanding the interactions among genes and how these interactions change throughout development to create a specific pattern. this research capitalizes on this fact and emerging genomic tools to characterize the molecular decisions that determine how a developing wing cell becomes specified into one of the three different scale cell types. the project is strengthened by a 6-month internship program that targets traditionally underrepresented groups and offers an in-depth research experience and hands-on professional development. moreover, through partnerships with science museums, this project will create bilingual (english and spanish) experiential learning resources that harness the potential of butterflies to educate a variety of audiences (school children, teachers, and life-long learners) about genes, development, natural selection, and the role that interactions among them play in generating earth's bio\*\*diversity\*\*. evolutionary processes constantly generate and rearrange specialized cell types, forging the morphological dimension of bio\*\*diversity\*\*. research is starting to connect changes in gene expression and open chromatin to cell fate decisions. however, this research has mostly focused on early embryonic development or on the developmental trajectories of complex organs in a few species. although powerful, these studies do not have an explicit goal of linking changes in cell fate decisions to phenotypic change. this research fills this

important knowledge gap by characterizing the rules governing cell specification? from signals, to reception, transduction, transcriptional activation, and fate determination during the critical developmental period when the wing patterns of heliconius butterflies are established. here, extensive knowledge of the ecological and evolutionary significance of wing color patterns, experimental tractability, and fantastic **\*\*diversity\*\*** make heliconius a powerful experimental system for understanding how the processes of cell specification are modified by natural selection to produce **\*\*diversity\*\***. by casting single-cell transcriptomics, open chromatin profiling and crispr loss-of-function experiments within an evolutionary framework that includes replicated cases of the independent evolution of identical wing patterns, this project will determine the rules that govern how cells communicate and acquire a specialized fate during development, and how those rules are applied to generate **\*\*diversity\*\***. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Disentangling biological and environmental drivers of diversification in the Andean flora

Awardee: Louisiana State University

Amount: \$709,712.00

Abstract: the tropical andes of south america is one of the world's richest bio**\*\*diversity\*\*** hotspots. this **\*\*diversity\*\*** likely evolved due to the complex environmental and geological history of this region. however, exactly how plant **\*\*diversity\*\*** arose from the combination of mountain uplift, the development of new habitats, and species interactions is unclear. this research aims to understand how these factors led to plant **\*\*diversity\*\*** in cloud forests and high-elevation grasslands. the researchers will develop new software to compare plant genomes to understand the ancestry of four groups of flowering plants in the andes. the project will also result in new mathematical models to

test the importance of different factors in shaping **diversity** in these plant groups. these new methods will have broad application to studies of bio**diversity** in the andes and beyond. additionally, this project aims to train the next generation of scientists in the study of bio**diversity** through a variety of interrelated activities, including: (1) a course for undergraduates to do guided genomic research; (2) collaborative training for students; and (3) computational training for diverse students. the project will first establish well-supported phylogenetic hypotheses for each of the four focal clades of andean plants using low-coverage and targeted genome sequence data. samples will be collected from colombia as well as museums. this work highlights the importance of natural history collections in cutting-edge biological research, and new fieldwork will add to those collections. a component of the research will be to develop new approaches to address complexities common in plant genomes, including polyploidy and paralogy, that can affect estimates of evolutionary relationships. these methods will be made available through open-source software such that other researchers can easily estimate phylogenies and examine support for phylogenetic hypotheses using sequence data. second, the project will develop new models that jointly infer the roles of dispersal and trait evolution in species diversification. these methods will be applied to phylogenomic, morphological, and distribution data collected for this project. these methods will also be made publicly available for widespread use. finally, by comparing the roles of biogeographic and ecological processes in generating **diversity** in these clades, the research will address the generality or idiosyncrasy of the processes facilitating rapid radiation in tropical andean plants. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Houston

Amount: \$709,334.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and \*\*diversity\*\* of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: IUCRC Phase 1: The City College of New York: Center for Building Energy Smart Technologies (BEST)

Awardee: CUNY City College

Amount: \$706,349.00

Abstract: the building energy smart technologies (best) iucrc brings together universities and industries to transform the building industry through the development and adoption of sustainable and intelligent technologies. best will apply innovative, energy-smart technologies through a wide spectrum of us buildings. best will be located in two sites: the lead site at university of colorado boulder (cub) and the partner site at city college of new york (ccny), taking advantage of the diverse academic, natural and industrial environments these locations provide. the best center will foster smart, sustainable, and efficient development and utilization of energy in the built environment through an integrated systems approach to design, retrofit, construct, and operate sustainable buildings and cities. ultimately, the best center will support the u.s. building industry's efforts to meet increasingly stringent building energy-efficiency regulations, and society's expectations for

improved sustainability, resiliency, and security in communities and cities. the best center will support the goal of achieving net-zero greenhouse gas emissions by 2050. moreover, the center will educate and train a skilled and diverse workforce to address current and future employment needs for the u.s. building industry. the best center will enable the development of new and sustainable building energy technologies through a holistic understanding of the interactions between built and-natural systems. in particular, the center will address design and operation solutions for the built environment associated with extreme weather events, which are becoming more frequent and intense due to a rapidly changing climate. additionally, the center will focus on the emerging challenges in the building sector due to pandemics and health crises such as those caused by covid-19, and increase cybersecurity of the buildings systems and of occupants? privacy. the center?s research scope spans various disciplines specific to building energy systems, including indoor-outdoor energy flows, advanced building envelope systems, demand-response informatics, application of advanced in-situ and remote sensing for monitoring the environment and occupants, and distributed energy efficient and renewable technologies. to cover the rich and wide \*\*diversity\*\* of the building industry needs, five thrust areas are proposed for the center?s research activities: (i) smart buildings materials, (ii) intelligent building mechanical and electrical energy systems, (iii) distributed and renewable energy systems, (iv) city-scale building energy systems and informatics, and (v) smart grid systems integrated with distributed energy and data systems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Measurements of stable carbon isotopes on board GO-SHIP cruises in the South Atlantic Ocean to enhance our ability to quantify anthropogenic CO<sub>2</sub> uptake rates by the ocean

Awardee: University of Delaware

Amount: \$702,050.00

Abstract: rising carbon dioxide concentrations in the atmosphere, global climate change, and the sustainability of the earth's biosphere are of great scientific and societal concern. approximately one-quarter of fossil fuel emissions of carbon dioxide emitted each year are absorbed by the oceans, and it is important to understand where and how fast this process occurs. stable isotopes of carbon can be used as a "signature" to identify fossil fuel-derived carbon dioxide in the atmosphere and ocean. the investigators have developed a new method for measuring the stable carbon isotope composition of dissolved carbon dioxide rapidly and precisely while at sea. they will measure several thousand samples on two research expeditions to the south atlantic ocean. they will compare their measurements to ones made in the same locations approximately ten years earlier, and determine the amount of carbon dioxide absorbed over that time period. the proposed research will enhance ocean carbon research infrastructure, general science education, and public awareness of climate change and environmental issues. the investigators plan to enhance \*\*diversity\*\* in earth sciences by recruiting underrepresented minority students in the research and have a graduate and an undergraduate student involved in all phases of this project. the team, including the students, will actively disseminate the research results in international, national, regional, local education and outreach activities, and in peer-review journals.

in the south atlantic ocean, anthropogenic  $\text{CO}_2$  uptake rates are high and variable as mode and intermediate waters are formed and are sensitive to climate changes. the carbon-13 suess effect makes  $\delta^{13}\text{C}-\text{CO}_2$  in the atmosphere a clearly defined endmember and  $\delta^{13}\text{C}-\text{DIC}$  in the ocean a powerful tracer to independently estimate anthropogenic  $\text{CO}_2$  uptake and storage in the ocean. the team has developed a precise, rapid, and sea-going method to simultaneously measure dissolved inorganic carbon (DIC) concentration (to plus or minus 2 micromol per kilogram) and stable carbon isotope composition ( $\delta^{13}\text{C}-\text{DIC}$ ) (to plus or minus 0.03 permil) by combining a  $\text{CO}_2$  extraction device with a cavity ring-down spectroscopy (CRDS) isotope analyzer. they will use this method aboard go-ship cruises a13.5 and a16s to analyze about 1000 samples onboard the ship and 2000 samples on land for each cruise. extensive evaluation and comparison of this method with the traditional isotope ratio mass spectrometry (IRMS)-based method



will be done. the pis hypothesize that the formation and the strength of mode and intermediate waters have a strong influence on the lateral transport of anthropogenic carbon and thus the decadal variability of the water column anthropogenic carbon inventory change. as a result, the change in inventory has both meridional and zonal trends, and therefore a combination of a13.5 and a16s will better represent the basin-wide changes. two objectives will be achieved in testing this hypothesis: (1) demonstrate that precise and accurate  $\delta^{13}\text{C}$ -dic data, comparable in quality to irms-based data, can be collected via the crds-based method, and that large numbers of samples can be analyzed onboard ships and back home with high spatial resolution comparable to other go-ship level 1 parameters such as dic; (2) assess the spatial variations and temporal changes of the anthropogenic carbon uptake and storage rates in the south atlantic ocean. in particular, the pis will compare estimated anthropogenic carbon inventories independently from  $\delta^{13}\text{C}$ -dic and dic observations from transect a13.5 (2022 vs. 2010 and earlier data) in the eastern basin with those of transect a16s (2024 vs. 2013 and earlier data) in the western basin. they will also compare the basin-wide water column anthropogenic  $^{13}\text{C}$ -dic inventory with the surface ocean anthropogenic  $^{13}\text{CO}_2$  uptake flux estimated from air-sea carbon isotope disequilibrium, the difference being anthropogenic carbon carried by lateral transport. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Probing and Manipulating Electronic and Spin Degrees of Freedom in Paramagnetic Single Molecule Circuits

Awardee: Trustees of Boston University

Amount: \$701,995.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). with the support of the chemical structure, dynamics, and mechanisms a program in

the division of chemistry, dr. maria kamenetska of boston university is investigating the electronic and magnetic properties of single paramagnetic molecules wired into an electric circuit. the use of molecules as switches, transistors, or qubits could enable the development of smaller and more powerful electronic devices than what is currently available. of particular interest for this application are paramagnetic molecules, which have intrinsic magnetic properties, making them candidates for applications in non-volatile memory and in quantum information science. maria kamenetska and her group use an approach based on scanning tunneling microscopy to measure current through a single molecule bound to metal electrodes. these experimental measurements are complemented with computational investigations to elucidate how the chemical environment influences the electronic and magnetic properties of the resulting molecular circuits. understanding chemical interactions between the electrodes and paramagnetic molecule can improve circuit reliability, control, and functionality, with potential for magnetic sensing and gating in single molecule circuits. broader impacts focus on training a diverse and quantum-literate workforce at the interface of molecular science, electronics and quantum technology as well as building and improving the curriculum of and mentoring students in the newly-implemented chemistry and physics undergraduate major at boston university. this research aims to identify chemical design principles and nano-manipulation techniques for forming robust single paramagnetic molecule circuits and to investigate their emergent electronic and spin degrees of freedom. experimental approaches, such as inorganic synthesis and scanning tunneling microscope break junction (stmbj) single molecule conductance measurements are coupled with density functional theory (dft) and non-equilibrium green function (negf) computational techniques to achieve a comprehensive and iterative study of magnetically-functional single molecule circuits. three terminal electrical measurements are performed using an electrochemical stm configuration to reveal the effect of metal-molecule chemistry on electronic degrees of freedom of the junction, while stmbj measurements on ferromagnetic electrodes allow spin-resolved electron transport measurements. dft calculations support the experimental work and provide further insight into structure-property relationships in

metal-molecule junctions. the broader impacts focus on student training at the interface of molecular science, electronics and quantum technology. a newly developed chemistry and physics undergraduate major, that aims to promote **\*\*diversity\*\*** and inclusion, serves to create of an environment that encourages interdisciplinary science at an early career stage. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RCN: LEAPS: Leveraging, Enhancing and Developing Biology (LED-BIO) Scientific Societies  
Shedding Light on Persistent Cultural Challenges

Awardee: American Society For Cell Biology

Amount: \$701,434.00

Abstract: each field in the sciences has historically been represented by its own scientific society, bringing together individual researchers for regular meetings where they can network, share discoveries, and collaborate. while it is rare for multiple distinct scientific societies to interact, they often perform similar functions, such as promoting the professional development of their members and promoting **\*\*diversity\*\*** among the next generation of researchers in their respective fields. this project will establish a collaborative network of experts to identify evidence-based inclusion strategies to accomplish the following: (1) collect consistent demographic data of society memberships, (2) better integrate scientists in transitional career stages into scientific society activities, and (3) diversify the ranks of scientific society leaders. by fulfilling these goals, this project aims to overcome persistent challenges that frequently undermine **\*\*diversity\*\*** efforts within independent communities of scientists and to broadly share this information for the benefit of all scientific communities. scientific societies predominantly approach **\*\*diversity\*\*** and inclusion efforts by supporting the professional development of individual members who are from historically underrepresented groups in stem. unfortunately, data is lacking to evaluate the efficacy of these

efforts, and additional approaches are likely to be required to address the systemic inequities underpinning skewed demographics among stem practitioners. fortunately, scientific societies that function as communities of practice (cops) are uniquely positioned to lead cultural change and promote inclusive environments to foster a diverse stem workforce. this research coordination network (rcn) project will use virtual town halls and in-person think tanks to expand and strengthen a cross-disciplinary network of cops. this network will collaborate to identify evidence-based strategies to address three persistent challenges that scientific societies face as identified by members of the alliance to catalyze change for equity in stem success (access): (1) lack of data to track scientific society membership demographic composition, (2) lack of integration of scientists in transitional stages of their careers into disciplinary cops, and (3) lack of **\*\*diversity\*\*** among highly visible thought leaders, including speakers in scientific programs. this rcn is coordinated by access and its member societies in the life sciences (the american society for biochemistry and molecular biology, the american society for cell biology, the american society for pharmaceutical and experimental therapeutics, the endocrine society, and the biophysical society), the quality education for minorities network, the marine biological laboratories at woods hole, and the nsf includes aspire alliance. the resulting strategies and standards will be reported and disseminated through open access training materials and publications. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: AF: Medium: Markov Chain Algorithms for Problems from Computer Science, Statistical Physics and Self-Organizing Particle Systems

Awardee: Georgia Tech Research Corporation

Amount: \$700,000.00

Abstract: self-organization can be viewed as a phenomenon whereby unanticipated global

configurations and patterns of a collective emerge from fully distributed and simplistic rules performed by each individual, without any global coordination or external intervention. self-organization and emergent behavior arise naturally across many fields: distributed systems and swarm robotics in computer science, interacting particle systems in physics, population dynamics and flock coordination in biology, autonomous systems in robotics and control theory, and smart materials, to name a few. recently, the synergy between discrete probability, algorithms and statistical physics has provided a new approach for designing self-organizing particle systems by harnessing collective, emergent behavior of physical systems. the laws of physics play an increasingly important role in collective behavior at the nano- and micro-scales, especially since individual agents are far less capable than their macroscopic counterparts. yet, while the principles of statistical physics have motivated many experimental systems, little has been done to make the corresponding underlying distributed algorithms rigorous. this project investigates how to program collections of agents to perform tasks by modeling the dynamics as self-organizing particle systems performing steps of markov chains through local interactions that can be rigorously analyzed. the limiting distributions of these chains have distinct equilibrium characteristics that can be used to program collective behavior. the principal investigators take a three-pronged approach: first, they introduce and study generalizations of common statistical physics models, such as the potts, ising and hard-core models, to better capture the constraints imposed by micro-scale systems of interacting agents. next, they explore methods to better understand the nonequilibrium dynamics of these systems long before convergence and possibly subject to forces that make the markov chains nonreversible. finally, they explore how collective systems might be programmed through deliberate placement of obstacles and features in the environment, rather than programming the agents themselves, as many of these tiny agents are incapable of any sophisticated (traditional) computation. as an example of programming the environment, a new version of the schelling segregation model is being studied where people move with higher probabilities if they are unhappy with the local demographics of their neighborhoods, but these preferences can be somewhat

mitigated by the placement of desirable urban infrastructures that modify individuals' incentive structures and biases. the project is having impact in promoting and advancing interdisciplinary research across many fields; education, through advanced graduate courses and broad, interdisciplinary talks; **\*\*diversity\*\*** at the graduate, undergraduate, and faculty levels; outreach to the general public and for k-12 education; and municipal planning, through coordination with regional planning faculty and the city of atlanta. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Catalyzing Transformative Change in STEM Education through an Institute for Inclusive Pedagogy

Awardee: Massachusetts Bay Community College

Amount: \$699,994.00

Abstract: this project aims to serve the national interest by implementing an institutional change to broaden participation in stem fields. a series of three annual five-week stem summer institutes at massbay community college will aim to make significant, lasting, and positive changes in the way faculty teach students who identify as black, indigenous and/or people of color (bipoc). the project will train a total of thirty stem faculty and staff and include fifteen high school faculty from two regional high schools in the institution's catchment area as well. participants will learn how to better serve bipoc stem students. massbay faculty will be mentored through implementation of revised classroom practices during the academic year. this project will help to address the problem that massbay is retaining and graduating bipoc stem students at lower levels compared to their counterparts. the project will seek to impact faculty through professional development at massbay and at regional high schools, thereby contributing, over time, to an increase in the **\*\*diversity\*\*** of students in the stem pipeline and workforce. the goals of the project will be to (1) educate stem

faculty regarding bipoc needs; (2) connect stem faculty to resources to incorporate culturally inclusive pedagogy into their courses; (3) mentor those faculty; and (4) monitor faculty progress via professional, external evaluation. the method to be employed will be professional development that will emphasize culturally responsive pedagogy?pedagogy that requires faculty to understand how to incorporate multiple methods of instruction that are based on students? life experiences and backgrounds. the project will focus on systemic institutional change in attitudes toward teaching bipoc students that will be measured at the departmental and institutional levels, and across communities of stem educators and/or educational researchers. as a result, over time, massbay will recruit, support, and graduate more bipoc students. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the institutional and community transformation track, the program supports efforts to transform and improve stem education across institutions of higher education and disciplinary communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Toward an integrated modeling framework for physics-based estimates of megathrust rupture potential

Awardee: University of California-San Diego Scripps Inst of Oceanography

Amount: \$698,099.00

Abstract: subduction zones, where tectonic plates are recycled back into the mantle as in the cascadia margin of the pacific northwest of the united states, host the largest earthquakes and give rise to significant hazard through ground shaking, landslides, and tsunamis. this project seeks to better utilize existing geophysical and geological observations from important ?natural laboratories? (cascadia, japan and new zealand) by merging them more fully into new, comparative computer models of system behavior. developing new modeling software and integrating constraints is

expected to lead to new insights into the physics of subduction zone earthquakes, what observations imply for future earthquakes, and, importantly, which observations are needed to improve our understanding of subduction zone hazards and how to reduce uncertainties about system behavior. the project will involve international collaborations, leverage past investments, and will contribute to defining future, optimal observational strategies. an interdisciplinary workforce of students and post-docs will be trained through research and educational efforts, and all project software, tutorials and ?cookbooks? for subduction earthquake modeling will be shared with the community, contributing to advancing computational geoscience approaches in general. a program for precollege, undergrad, and early grad students will be developed to emphasize computational geoscience as an avenue to enhance **\*\*diversity\*\*** in the geosciences. this collaborative effort seeks to integrate seismological, geodetic, experimental, and geological constraints for the japan, new zealand and japan natural subduction zone laboratories into numerical models to advance our understanding of megathrust earthquakes. forward models and a new numerical modeling framework for data assimilation will be deployed to get closer to versatile tools for data-driven, physics-based hazard assessment. the focus is on the evolution of fault stress and strength over a range of spatio-temporal scales, quantifying uncertainties and sensitivity to parameters. this will allow formulating best strategies for inferring relevant parameters from data in the presence of ambiguous physics, including optimal observational design within the ongoing sz4d community effort. all code will be made publicly available along with cookbooks and tutorials, and a networked effort will establish new, quantitative links and leverage individual efforts greatly. fres funding will support a growing community of solid earth geodynamicists who want to deploy their models in a hazard and monitoring context. a focus will be on training and sharing material for interdisciplinary computational geoscience efforts, from undergraduate to post-doc and practitioner level. project participants will develop sustainable pathways for participation and work to enhance representation and inclusion in the geosciences by providing new pathways of entry based on modeling and remote sensing to complement field-based approaches. this award reflects nsf's statutory mission and has



been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Preparing Secondary STEM Teachers to Improve STEM Learning in High-need Schools by Applying Restorative Justice in Education

Awardee: Eastern Mennonite University

Amount: \$690,061.00

Abstract: this project aims to serve the national need to increase the number and **\*\*diversity\*\*** of highly effective stem teachers in high-need school districts. to address this need, the project will recruit, prepare, graduate, place, and support 24 stem majors to become secondary mathematics and science teachers. these stem majors will earn bachelor's degrees in biology, chemistry, computer science, or mathematics and be eligible to earn secondary teaching certification in one of these disciplines. an innovative aspect of the project is its focus on restorative justice in education, which can transform school climate by building relationships that support student learning, success, and identity in stem. the project will build upon strengths at the institution, including expanded recruitment activities to increase the number of diverse stem teaching candidates, teaching opportunities/field experiences in high-need schools, mentoring and peer relationships, and new in-service teacher supports. this project at eastern mennonite university includes a partnership with harrisonburg city public schools. project goals include implementing restorative justice in education across diverse school settings, improving learning outcomes and teacher retention in local school communities, and providing an innovative, replicable model for teacher preparation. increased collaboration with the partnering school district will prepare qualified stem teachers, add meaningful supports for new teacher retention, and strengthen restorative justice in education professional development. project objectives include to: 1) recruit, support, and graduate 24 biology, chemistry, computer science, and mathematics majors with secondary education certification; 2)

engage the project's pre-service stem teachers in training about restorative justice in education, as well as in mentoring relationships and field experiences; 3) place and retain the project's graduating pre-service stem teachers in high-need school districts; 4) institutionalize and sustain successful elements of the project; and 5) study the impact of integrating restorative justice in education into the curriculum for pre-service and professional development of in-service stem teachers in high-need school districts. new knowledge will be generated through investigating two research questions: 1) to what extent and in what ways does a restorative justice-infused curriculum help pre-service and early-career stem teachers feel prepared to meet the challenges associated with teaching in culturally and linguistically diverse school settings? and 2) which project elements are associated with the development of one or more aspects of equitable practice? external evaluation will provide formative feedback for continuous improvement during implementation, and project results and lessons learned will be shared with the community so that effective methods and practices can be replicated at similar institutions and teacher training programs. this track 1: scholarships and stipends project is supported through the robert noyce teacher scholarship program (noyce). the noyce program supports talented stem undergraduate majors and professionals to become effective k-12 stem teachers and experienced, exemplary k-12 teachers to become stem master teachers in high-need school districts. it also supports research on the persistence, retention, and effectiveness of k-12 stem teachers in high-need school districts. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Trade-offs, limits to adaptation, and multiple solutions: rules elucidated by selective breeding for high activity levels

Awardee: University of California-Riverside

Amount: \$687,489.00

Abstract: this project focuses on understanding how organisms make trade-offs in energy allocation to different activities and how multiple solutions to enhance locomotor activity may evolve. biological **diversity** encompasses not only numbers of species but the functional **diversity** that they exhibit. organisms work in a variety of ways, and often exhibit trade-offs and multiple solutions. one example of a trade-off is the negative relationship between the number of offspring produced and the size of individual offspring, as documented in many groups of plants and animals. this trade-off is often attributed to a constraint on the total amount of energy available for reproduction. multiple solutions are apparent in the various ways that flight has evolved (e.g., birds versus bats). this research project addresses both of these phenomena in the context of a novel experiment that involves selective breeding for high voluntary levels of exercise in house mice. two hypotheses will be tested: (1) selection for high activity is associated with reductions in lifetime reproductive success, representing a trade-off between locomotor activity and fitness, and (2) the trade-off between average running speed and duration that has evolved among the high-activity mouse lines is reflected in corresponding differences in characteristics of their muscle tissues. the project will help to elucidate the fundamental nature of bio**diversity**. the results will be disseminated in scientific publications and wikipedia pages will be created and updated. an online open educational resource version of ecological and evolutionary physiology, an undergraduate course, will be developed. this project will involve training for both graduate students and undergraduates in a collaborative, integrative, and cross-disciplinary research setting. to increase participation and **diversity**, students from underrepresented groups and educationally or economically disadvantaged backgrounds will be recruited. trade-offs and multiple solutions are inherent to life and appear to underlie a substantial amount of the variation in bio**diversity** over time. however, few studies have used experimental evolution to address these topics. the proposed research will use selection for high locomotor activity, in a model organism (laboratory house mice), to elucidate trade-offs and multiple solutions during locomotor evolution. because locomotor activity is a key component of the life history of animals, results of these studies should provide insight into general

principles. the research will take advantage of a unique resource comprising four replicate lines of high runner mice that have been selectively bred for more than 90 generations for voluntary locomotor activity, and an additional four lines that serve as non-selected controls. aim 1 will test for reduced lifetime reproductive success in the selected lines and whether this trade-off manifests in different ways in the replicate lines (e.g., reduced litter size vs. reduced length of reproductive lifespan). aim 2 will test whether trade-offs in muscle function underlie the trade-off between average running speed and duration that has evolved among the four selected lines, and if multiple solutions at the level of muscle performance are involved. the mouse lines will be made available to other researchers, and the online course materials and wikipedia content to be developed will be broadly disseminated. several undergraduate and graduate students, recruited from groups traditionally under-represented in science, will participate in the research. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Discovery and Design with the FAST Principle: Following Local Models of Stability to Emergent Phenomena in Intermetallic Structures

Awardee: University of Wisconsin-Madison

Amount: \$685,579.00

Abstract: non-technical summary: the role played by metallic materials in the advancement of prosperity and national security is evolving. research in these materials has increasingly shifted from mechanical properties, conductivity, and corrosion resistance to more exotic effects related to the quantum nature of electrons, such as the resistance-free conduction of electric currents, advanced magnetic phenomena, and the conversion of thermal energy into electric energy. underlying these properties is a startling **\*\*diversity\*\*** in the geometrical arrangements that the atoms of materials can form at the microscopic level. understanding and learning how to control these

arrangements is a limiting factor in the design of new metallic materials. this project is promoting the progress of science by building a predictive model for how different types of interactions between neighboring atoms in a metal propagate to form the observed complex atomic arrangements, opening avenues to the discovery of new materials. theoretical calculations are being used to analyze these interactions and explore their implications, while databases of structural information are scanned to identify metallic materials in which intriguing behavior at the atomic level are expected. the predictions of theory are guiding experimental investigations of new metallic compounds, which provide feedback on the models being developed. this project also impacts the training and education in the stem fields, with an emphasis on solid state chemistry. new content is being created for the science through comics website, which uses relatable analogies and humor to inspire interest in science. in addition, the free on-line textbook interactive solid state chemistry is being developed for dissemination to a broad range of students and educators in collaboration with libretexts. here, comics introducing the materials are integrated with interactive tools for active student engagement, such as structure models that can be manipulated in three dimensions. the research team is also increasing the participation of members of underrepresented groups in the sciences through outreach activities and mentoring.

technical summary: intermetallic phases are a rich source of potential functional materials, as they combine an unparalleled structural **\*\*diversity\*\*** with valuable physical properties. to fully realize this promise, however, design principles are still needed for guiding the crystal structures of these phases, such that their structure-properties relationships can be systematically investigated, and materials with structures tailored to specific applications can be prepared. in this project, the need for such design principles is being addressed through the development of the predictive capabilities of the frustrated and allowed structural transitions (fast) approach. of the many transformations or modifications a structure could potentially undergo, those that involve cooperation between the various factors influencing stability can be expected to out-compete energetically those in which the factors conflict with each other. in one component of this work, the scope of the fast approach is being expanded

through the computer-aided screening of crystal structure databases for geometrical features associated with easy transitions, yielding candidate structures for theoretical analysis and experimental investigation. simultaneously, the completeness of the fast picture is tested and improved through its application to the structural preferences involving 18-n+m isomerism in transition metal-main group intermetallics, in which a variety of bonding configurations are used by different compounds to adhere to the 18-n electron counting rule for any given electron count. finally, the predictive implications of the fast schemes are explored by translating these pictures into force field models for large-scale molecular dynamics simulations. predictions of emergent structural properties, such as incommensurate modulations or phase transitions, are pursued experimentally. in all of these endeavors, the experimental results are being used to refine the theoretical and conceptual approach. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: CSBR: Rehousing of the Mammal Collection at the University of Kansas Biodiversity Institute

Awardee: University of Kansas Center for Research Inc

Amount: \$682,711.00

Abstract: this project ensures the long-term preservation and security of the mammalian research collections housed at the university of kansas (ku) bio\*\*diversity\*\* institute. the ku bio\*\*diversity\*\* institute?s mammal collection is of international importance, ranked as the sixth largest in north america, and the third largest university holding in the world. this project replaces antiquated wooden specimen cabinets with updated stainless steel casing to rescue irreplaceable specimens from environmentally deficient conditions and preserve them in ideal, climate-controlled, pest-free housing in perpetuity. safeguarding the ku bio\*\*diversity\*\* institute?s mammal collection ensures the continued contribution of these resources to bio\*\*diversity\*\* science, formal undergraduate and



graduate education, and public programming for K-12 students, teachers, and public audiences of the KU Biodiversity Institute's Natural History Museum. This project engages several undergraduate and graduate students in collections-based research projects and active curation. The physical specimens preserved at the Biodiversity Institute provide a critical foundation for research and education on DNA, climate change, evolution, conservation, and emerging pathogens, and are available for loan by researchers across the globe. The KU Biodiversity Institute's mammal collection houses 279,936 dry specimens in 332 cabinets, 185 of which are antiquated and compromised wooden cabinets that date to the 1950s and 1960s, and whose joints, doors, and seals are inadequate for protecting dry specimens from pest infestations. Specimens will be vacuumed and frozen at -40°C for 2 weeks to eliminate pests, then transferred to stainless steel cases for long-term preservation. During the transfer, data from specimen tags will be verified and digitally recorded in the Specify Museum database, and served to the community through GBIF, iDigBio, BiSON, and VertNet. As specimens are processed, phenotypic characters will be recorded, including the reproductive status or molting progress of each specimen, and these data will be used to test for shifts in mammalian life history events over time. Students will collaborate with Exhibits staff at the KU Biodiversity Institute to conceive and build a new public exhibit focused on the importance of scientific collections. The exhibit will highlight research stories that illustrate how critical collections are for solving problems of societal interest, including recognizing emerging pathogens and tracing the origins of invasive species. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: How do multiple coastal stressors structure the genomic diversity of marine populations?

Awardee: University of Rhode Island

Amount: \$680,897.00

Abstract: marine species face a complex suite of stressors that span multiple temporal and spatial scales from long-term global ocean change to localized episodes of coastal acidification. the cumulative and concurrent impacts of multiple stressors remain relatively unknown and requires investigating their synergistic impacts across all life stages. two common stressors in coastal environments are hypoxia, or low dissolved oxygen, and coastal acidification. hypoxia and coastal acidification are linked to daily cycles of respiration and photosynthesis, even in pristine bays and estuaries. coastal waters are also affected by pulses of natural and artificial freshwater runoff driven by rainfall and storm events. pulses of freshwater can cause short-term, low salinity conditions, another stressor, that are expected to worsen with climate change. for many marine species, larval stages are the only means of migration and genetic exchange, and larvae are likely encountering hypoxia, coastal acidification, and low salinity stressors while they are in shallow coastal waters. additionally, early juveniles may encounter extended periods of all three stressors. the interaction of early life-history stages with repeated and combinations of coastal stressors has the potential to result in an increase of larval/juvenile mortality or the removal of less tolerant larvae. the consequences of this differential mortality are being investigated in the eastern oyster using laboratory multi-stressor exposure experiments and in the field through genomic surveys of natural populations. patterns of genetic selection are being analyzed by combining genomic and environmental data to elucidate how multiple stressors are shaping marine populations. broader impacts include training opportunities for a post-doctoral fellow, graduate and undergraduate students and societal impacts. results from the study are key to predicting how oyster reefs will adapt to long-term climate change and human population growth. a symposium is planned to bring scientists and members of the broader community together to discuss conservation and restoration of oyster reefs and sustainable aquaculture. a better understanding the physiological limits of larvae and juveniles to stressors is contributing to new strategies for oyster hatcheries to optimize selection and screening of brood stock for robust larvae and juveniles. the broad goal is to characterize how hypoxia (do), coastal acidification (ca), and low salinity events (ls) shape population connectivity and

microevolutionary processes of marine invertebrates. as larvae grow and develop, they may be able to tolerate short-term exposures to environmental stressors, but prolonged exposure to diurnal do/ca cycling and ls events may reduce subsequent survival, especially in juveniles. larval and juvenile interactions with multiple stressors have the potential to either disrupt gene flow by simply not allowing migrant exchange or to act as a selective force, structuring populations through genotype-environment interactions. this project uses a coupled experimental and seascape genomics approach to investigate how multiple stressors are shaping observed genomic **diversity**. phase 1 is determining how larval and juvenile genotypes and phenotypes respond to multiple stressors across different developmental time points. experiments include two larval short-term exposures to factorial combinations of do/ca and ls, and a long-term juvenile exposure to factorial combinations of do/ca diurnal cycling and ls. the coding regions of genes expressed during experimental exposures are being sequenced using a cost-effective exome capture method. phase 2 is determining the role of natural and anthropogenic forces shaping the evolution of oyster populations by testing if selective regimes differ and interact across life-history stages and if the frequencies of both neutral and resistant genotypes correlate with environmental conditions. surveys of the genomes of adult populations across multiple localities from several urbanized estuaries are generating a seascape genomic framework based on a panel of genomic markers, including potential loci under selection during early-life history. these data are being integrated with environmental data to elucidate the mix of factors that contribute to population structure and local genetic **diversity**. results are linking adult genotype frequencies at both neutral and putatively selective loci to changes in allele frequencies in response to early larval, late larval, and early juvenile exposure to stressors. the research is unraveling the complex interaction of selection, migration, and drift on marine genetic **diversity** for a mechanistic understanding of the genomic consequences of coastal stressor and their interaction on larvae. this project is jointly funded by biological oceanography and integrative organismal systems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's

intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Redefining the high field strength element systematics of subduction systems using non-traditional stable isotopes

Awardee: University of Arizona

Amount: \$679,590.00

Abstract: reconstructing the nature of the geologic processes responsible for the evolution of our planet, including when and how continents formed and plate-tectonic cycles were established, has been a long-standing goal of earth scientists. clues for answering these questions are "coded" into the geochemistry of the ancient rock and mineral record, but interpreting these geochemical signatures is not always straightforward. over billion-year timescales, the rocks that constitute earth's continents have been deformed and overprinted by younger geologic processes, significantly obscuring their original structural and chemical characteristics. in order to "see through" this complex evolution, geoscientists use chemical signatures retained by elements that are not easily altered and/or remobilized, and thus that can provide clues into primary rock-forming processes despite subsequent overprinting. a group of elements particularly suited for these investigations are the so-called high-field strength elements (hfse), a group of transition metals with unique geochemical characteristics which make them not only important to understand crust formation but also very resilient to alteration. in particular, the isotopic compositions of these elements, which can now be measured with great accuracy and precision, can provide unique glimpses into the geochemical processes taking place in convergent tectonic margins and during formation of continental crust. nevertheless, making geologically meaningful interpretations from these data requires a robust understanding of the processes that control the observed isotopic signatures, and developing such framework is the central research goal this project will undertake. this career project will leverage recent analytical developments in the field of non-traditional stable

isotopes to i) conduct a detailed study of the mass-dependent isotope fractionations that characterize the hfse titanium, zirconium, and hafnium in subduction environments; and ii) utilize these isotopic variations for better understanding the processes leading to their fractionation and fluxes during formation of continental crust. to achieve this, the research team will generate a series of combined ti-zr-hf isotopic datasets from key geologic components and petrologic processes characterizing the "subduction factory" and that are known to influence the chemistry of arc-related magmatic systems. isotopic fractionations at the bulk-rock and mineral scales will be determined in various global localities of orogenic peridotites, mid ocean ridge basalts, high-pressure/low-temperature subduction complexes, lower-crustal arc cumulates, and arc-related basalts and differentiated volcanic rocks, to understand hfse mass-transfer and isotopic fractionations across the entire subduction cycle. samples will be measured using high-accuracy methods involving calibrated double-spikes and mc-icp-ms measurements. in addition to the broader scientific impacts that will result from this research, the pi will develop educational activities that foster greater equity, "diversity", and inclusivity within the geosciences starting from a pre-college stage. these include the development of an afterschool bilingual program for hispanic/latinx high-school students in collaboration with the tucson unified school district (tUSD), active recruitment of urm undergraduates into meaningful research experiences, and training of diverse graduate students and postdocs. as a result of this project, the pi will also develop an accessible on-line resource for researchers and students interested in learning more about non-traditional stable isotopes, constructed with active student involvement. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Effects of top scavenger declines?from microbes to ecosystems

Awardee: Regents of the University of Idaho

Amount: \$677,575.00

Abstract: unless first consumed by a predator, all animals enter the carrion pool when they die. scavengers and microorganisms play a critical role in returning carcass-derived nutrients to the soil where they get recycled and used for plant uptake and growth. the impact of carrion inputs on nutrient cycling, food web dynamics, and ecosystem carbon balance remains a mystery. with global declines of many species including scavengers, it is essential to quantify how the quantity and quality of carrion-derived nutrients shapes plant community structure and ecosystem dynamics. tasmanian devils are an ideal and charismatic species with which to study the effects of scavenging on ecosystem processes. they are one of a few carnivores worldwide that consume bones. by accelerating the cycling of key plant growth-limiting nutrients that would otherwise remain locked in bone material for years, tasmanian devils provide a critical ecosystem function. in recent years, the emergence of a highly transmissible cancer ? devil facial tumor disease, or dftd ? has dramatically reduced devil population sizes in eastern tasmania and has spread throughout the island, threatening this iconic species with extinction. researchers will use this tragic situation to test whether devil-scavenging impacts can be detected on an ecosystem scale and how devil population declines result in a shift in the role of other scavenger species. this project will provide training opportunities for us graduate students and post-doctoral scholars in an international setting. through education and outreach activities, researchers will highlight the linkages that exist between scavengers, bio\*\*diversity\*\*, and ecosystem resiliency. few studies have directly investigated the effects of non-plant inputs on energy transfer within food web networks. as a result, there is a considerable knowledge gap in understanding how carrion and scavenger guilds govern biogeochemical cycling at an ecosystem scale. in tasmania, the east to west spread of dftd, a lethal, transmissible cancer, threatens devils with extinction and has created a population density gradient across the island (from 0% to 100% of carrying capacity). the resulting 'natural experiment' offers a rare opportunity to study how apex scavenger declines alter energy transfer within food webs and nutrient flows through carrion, soils, and plants. high-frequency monitoring and sampling stations will

be established at five study sites that span the dftd gradient and capture four experimental treatments: (1) full scavenger access (staked prey carcass); (2) devil exclusion (fenced prey carcass allowing access to all scavengers but devils); (3) reconstructed devil latrines to capture nutrient pulses from localized scat; (4) and soil-only controls to monitor background c and nutrient availability. devil and mesopredator densities at carcasses will be estimated using camera arrays; invertebrate densities will be assessed using appropriate insect traps. stable isotope tracing will be used to track how carcass-derived nutrients influence microbial community **\*\*diversity\*\*** and soil carbon formation. plant productivity (npp), leaf quality, seedling recruitment, and fine root biomass will be estimated at each site and across the continental dftd gradient. using temporal and spatial variation in the extent and timing of devil population declines, a series of scaled experiments will be used to: (1) determine how variation in scavenger densities affects local soil biogeochemistry; (2) investigate how carrion and scavenging networks induce shifts in the metabolic efficiency of microbial communities and decomposition rates of new plant litter inputs; (3) test the scale at which scavenging by devils is detectable; and (4) integrate findings from field and laboratory experiments to predict how bio**\*\*diversity\*\*** loss will affect ecosystem function over the next 50 years. the project will support a team led by an early-career female scientist, involve international collaboration and provide training at the graduate student and postdoctoral levels. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: How and when did the Mongolian Altai (de-)form? Implications for intracontinental deformation

Awardee: New Mexico Institute of Mining and Technology

Amount: \$676,882.00

Abstract: the mongolian altai are an approximately 2000 km-long mountain range in western

mongolia that are part of a vast mountainous region in central asia referred to as the central asian orogenic belt. understanding how a mountain system that is located >1000 km from a modern tectonic plate boundary originally formed is important as the altai play an important role in regulating asian climate and bio\*\*diversity\*\* and in controlling the distribution and reorganization of earth materials through erosion and sediment transport. this study will test how the earth's crust deforms into mountains in the middle of tectonic plates rather than at the edges. the pis will use thermochronology (the study of mineral cooling histories) to measure the timing of mountain development and conduct field-based studies of sedimentary rocks to study changes in erosion and deposition patterns caused by mountain uplift. these results will be compared to numerical models testing different ways to form mountains in the middle of tectonic plates. this research will provide important societal outcomes by 1) supporting the training of graduate and undergraduate students in stem fields including minority and underrepresented students at a hispanic serving institution, 2) increasing participation of women in stem as both principal investigators and graduate students within this project, 3) increasing public scientific literacy through undergraduate education and education outreach, 4) developing partnerships between american and mongolian scientists, and 5) the development of online interactive field tours for undergraduate education. recent large-scale, interdisciplinary projects have led to major advances in our understanding of the rates, relative timing, and periodicity of tectonic plate margin processes that define orographic landscapes. however, our understanding of plate interior orogenesis is less evolved, as intracontinental orogens defy models of orogenesis as a plate-boundary driven process. the mongolian altai are part of one of the largest intracontinental orogenic systems?the central asian orogenic belt, and yet limited data exist to explain the origin of this mountain system. this project will test specific models of intracontinental orogenesis in the mongolia altai, each of which predict a different timing, rate, and style of uplift. this research will integrate bedrock and detrital thermochronology, sedimentology and basin analysis, and geomechanical modeling to document the timing of onset of intracontinental orogenesis in the mongolian altai; understand fundamental (rheological, geodynamic, inherited)



controls on the formation of an orographic landscape in this region; and to understand the possible conditions that produce intracontinental deformation from plate boundary forces and the timescales on which this deformation occurs. these outcomes will allow testing of whether the mongolian altai are relict topography from a mesozoic suture zone, are a geodynamic feature of isostatic or dynamic processes, or formed due to localized deformation from cenozoic plate boundary stresses. field and analytical data will provide direct observations to test these hypotheses that can be further constrained by numerical models that interrogate the geomechanical plausibility of these processes. this study will not only provide the first basement thermochronologic dataset from a ~800 km along strike zone within the mongolian altai and the first detrital thermochronologic dataset from the entire altai system (2000 km strike length), but will integrate this dataset with work in contemporaneous sedimentary basins and geomechanical modeling to put these data in a well-constrained geologic context. the proposed research will also improve our understanding of what processes drive formation of intracontinental orogens globally, a major outstanding question in the field of tectonics.

this project is jointly funded by the tectonics program in the division of earth sciences and the established program to stimulate competitive research (epscor). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Sea Level and Topographic Evolution (SLATE): Exploring the feedback between sea level and sediment redistribution

Awardee: University of Wisconsin-Madison

Amount: \$676,866.00

Abstract: sea-level changes are of wide interest because they affect flood hazards, reorganize coastlines, influence volcanic eruptions, and reflect changes in climate. the proposed work will remove a barrier for understanding sea-level change by developing a new model that captures the

effects that sediment redistribution and sea-level change have on one another. this will provide a new tool for understanding the controls on sea-level change and flood hazards near large rivers, which are home to many coastal cities, of relevance to nsf's coastlines and people (cope) initiative. these efforts will be paired with four education and outreach tasks focused on sea-level change, including the development of a new university course on sea-level change, training of students in pedagogy and mentorship, public outreach through the university of wisconsin geology museum, and a five-year outreach program to k-12 students from underrepresented groups in stem. the goal of this project is to improve our understanding of the feedback between sea level and sediment redistribution. although it has long been known that sea level and sediment redistribution influence one another, the quantitative strength of this feedback remains a matter of contention. the proposed work is aimed at closing this knowledge gap through the development of a novel model that couples earth's topographic evolution to sea-level change. this will be used to explore the controls on the sediment-sea level feedback by quantifying the sensitivity of sea-level changes to marine sediment transport, the sensitivity of lowland rivers to sea-level change, and the effects of sediment redistribution on estimates of global mean sea level and global ice volume at the last interglacial period, an analogue for modern climate. this will clarify the sensitivity of sea-level change to sediment erosion and deposition—a common feature of earth's coasts—and provide a basis for improving projections of future sea-level change. this will support education, outreach, and **\*\*diversity\*\*** initiatives through the training of two phds students, the mentoring of undergraduate students, and a new five-year outreach program with k-12 students from underrepresented groups in stem. the project is co-funded by the geomorphology and land-use dynamics program and the marine geology and geophysics program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: CAREER: Tunable Graphene Microelectrodes for Real-time Biological Sensing

Awardee: University of Cincinnati Main Campus

Amount: \$675,001.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). with the support of the chemical measurement and imaging (cmi) program in the division of chemistry, ashley ross of the university of cincinnati is studying how graphene, a single layer of carbon atoms arranged in a two-dimensional honeycomb lattice, can be used to sense neurochemicals. by controlling the direction of the carbon atoms in the honeycomb and placing different kinds of atoms on the surface of the graphene, dr. ross and their research team will work toward making electrodes that can electrically communicate in an effective way with chemicals that are key to understanding the nervous system. this new approach with graphene electrodes offers the possibility of systematically studying how tuning the orientation of the honeycomb edge and the surface chemistry of graphene can be used to make electrodes capable of sensing neurochemicals better than methods known for 40 years. such tunable electrodes are expected to offer extremely rapid sensing of changes in the amounts of neurochemicals within very tiny areas of the body, which would be very valuable to understanding the way messages are sent and received by the nervous system. this new route to making tailored and rapid sensing of neurochemicals may shed light on the way in which a variety of cells are given and receive instructions to initiate, stop, or regulate biological responses. importantly, the new graphene fiber electrodes have the potential to give a

glimpse into the immune response and its programming by neurochemicals, by detecting fast changes in their amounts in whole organs. the project is anticipated to have a long-term impact on sensing by providing new measurement tools and an understanding of how the surface of the electrode and the structure of neurochemicals influence their detection. the impact of the project is to be broadened by building on an on-line discussion platform and seminar series, titled "analytical chemistry \*\*diversity\*\* colloquium?", to increase engagement and to nationally promote the work of underrepresented scientists in analytical chemistry. in addition, this project will develop multidisciplinary and discussion-based modules to be incorporated into courses to improve scientific literacy, create an environment of inclusion, and excite students from diverse backgrounds about analytical chemistry. there is a current knowledge gap in electrochemical sensing about enabling correlation and prediction of how changes in electrode structure and chemistry impacts the interface between solution-phase analytes having different structures and the electrode surface. the ability to precisely control and correlate how specific chemical and structural properties of the electrode impact detection of electroactive biomolecules will significantly influence our understanding of electrode-analyte interactions to enable exquisitely designed electrode surfaces for improved real-time biological sensing. in this project, we will advance knowledge of analyte-electrode interactions with fast-scan cyclic voltammetry because it is the primary electrochemical method used to probe real-time neurochemical signaling; therefore, this approach will have a major impact on dynamic neurochemical sensing. this project will focus on synthesizing and characterizing tunable graphene fiber microelectrodes to measure how carbon surface orientation and alignment, functionalization, surface energy, and three-dimensional structure impact electrochemical detection of neurochemicals. this proposal will ultimately enable expansion of real-time neurochemical sensing to beyond the brain to study nervous system regulation of immunity, communication along the gut-brain axis, and more, by providing significantly improved electrodes that enable ultra-sensitive and high-temporal-resolution measurements. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's

intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Engineering Interacting Photons in Superconducting-Circuit Lattices

Awardee: University of Maryland, College Park

Amount: \$675,000.00

Abstract: photons are particles of light which exist all across the electromagnetic spectrum, from radio and microwaves to visible and ultra-violet light. by making use of superconductors, which carry current without generating heat when cooled to very low temperatures, it is possible to make microwave circuits where, unlike in most room-temperature devices, the photons live for very long times and stay confined in small regions in space. since these photons stay put instead of flying away, they become more like conventional particles such as electrons, and the full might and **\*\*diversity\*\*** of microwave engineering can be used to control how they see and interact with the world. by controlling how these photons interact with each other and the world around them, this project will probe the fundamental building blocks of the materials around us and learn about how the environment in which a particle lives affects its properties. the project will also build upon the recently-initiated virtual amo seminar, of which the pi is a board member, to develop an auxiliary small-group program series aimed at engaging non-physicists and undergraduate students in online research seminars in a meaningful way and facilitating communication in the ever-broadening quantum workforce. among this project's specific research goals is to harness arrays of superconducting microwave resonators to produce microwave metamaterials in which photon-photon interactions can be mediated by superconducting qubits. building on previous theoretical work showing that these metamaterials can access unconventional band structures, such as lattices with gapped flat bands and also much more general mathematical objects such as tree-like and hyperbolic graphs, the pi will implement unconventional microwave lattices and incorporate qubits to mediate interactions. investigation will begin with one-dimensional lattices and

move toward higher-dimensional structures during the course of the project. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: Sentinels: A plug-and-play RNA sensing technology platform for surveillance and response to emerging viral diseases

Awardee: William Marsh Rice University

Amount: \$673,890.00

Abstract: cells can be programmed to sense infectious agents and, in response, actuate biomolecular programs to alert, protect the host, or destroy the pathogenic target. engineering cells in this manner would provide a transformative approach to address the threat of emerging viral diseases. the goal of this project is to develop a novel pathogen detection platform that can be easily reprogrammed to sense new threats, and in response, produce any protein output. this technology will forward our ability to engineer sentinel cells for diverse diagnostics and therapeutic applications. this project will also provide educational and training opportunities aimed at increasing the number and **\*\*diversity\*\*** of high school students and undergraduates pursuing careers in biomolecular and cellular engineering, and related stem fields. as part of this project open-source web-based design tools for designing sentinel cells will be created through a student-led initiative. rna-based sensors present a particularly attractive option for programming cells to detect pathogens because they rely on designable rna base pairing interactions and enable detection of rna encoded genomes (genotypes) and mrnas (phenotypes) of both the pathogen and host, allowing for potentially more accurate readouts of the infection status. however, there is currently a lack of genetically-encoded rna detection platforms that can interface rna inputs to biomolecular outputs,



precluding the design of cellular devices that execute sentinel programs in response to specific rna signatures. to address this, biomolecular and synthetic biology strategies to create plug-and-play rna sense-and-respond platforms will be explored. devices will be created that detect different virus associated rna molecules, and, in response, activate diverse biomolecular programs to alert and destroy viruses. this will find direct applications for sentinel cell design and could be easily utilized for other applications in basic science, synthetic biology, and metabolic engineering. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Excellence in Research: Effect of Hydration on the Thermo-elastic Properties of Mantle Minerals and the Geophysical Implications.

Awardee: Delaware State University

Amount: \$672,584.00

Abstract: earth's deep interior is not accessible to direct sampling. as temperature and pressure increase with depth, man-made instruments become unusable. the most direct observations arise from studying vibrations generated by earthquakes, called seismic waves. the waves travel within the earth and are collected at the surface using seismographs. the seismic signal is analyzed to inform the structure and composition of earth's interior, as sonography is used in medical imaging. the velocity of seismic waves depends on the type of rocks they encounter. seismological studies combined with experimentation allow identifying rocks in the earth's mantle. it was shown that at depths of 410 to 660 km (255 to 410 miles) - in the so-called transition zone - two dense minerals are present: wadsleyite and ringwoodite. these minerals can incorporate large amount of water in their structure under the form of oh molecules (hydroxyls). the transition zone may contain as much water as that contained in the oceans. this has implications for earth's mantle thermal convection, which drives plate tectonics. yet, it is unclear how much water is stored in the transition zone. this is

partly due to uncertainties on how hydroxyls affect seismic-wave propagation in minerals. here, the researchers investigate how water incorporation in wadsleyite and ringwoodite affects the velocity of seismic waves. they synthesize in the laboratory minerals with various compositions and water contents. they carry out ultrasonic measurements at the extreme pressures and temperatures prevailing in the earth. these experiments are performed at a national synchrotron facility, to ensure specimen quality and measure their size by radiography during the measurements. the study outcomes are critical to better understand the properties of the transition zone. it has implications for the understanding of thermal convection in the earth. this project promotes multidisciplinary collaborations across earth sciences, physics, chemistry, and mathematics. it provides support for a post-doctoral associate and training for undergraduate students at delaware state university (dsu). dsu is a historically black university and a predominantly undergraduate institution. the project offers unique opportunities to students from groups underrepresented in science. it fosters **diversity** and inclusion in geosciences. it is co-funded by nsf directorate for geosciences and historically black colleges and universities - excellence in research (hbcu-eir) program. experimental and theoretical studies indicate that wadsleyite and ringwoodite can incorporate up to 2-3 weight percent of hydroxyl (oh-) in their structures. up to 1.5 weight percent of water was measured in a ringwoodite crystal trapped in a diamond which originated from the transition zone. water incorporation strongly affects mineral physical and chemical properties ? such as electrical and thermal conductivity, melting and flow ? as well as elastic wave propagation. here, the researchers synthesize polycrystalline samples of wadsleyite and ringwoodite containing controlled structural water. they use the 2000-ton uniaxial split-cylinder apparatus at stony brook university. the quality of the hot-pressed specimens is verified using x-ray diffraction, scanning transmission electron microscopy, bulk density measurements, and bench-top acoustic velocity measurements. specimen elastic wave velocities is then quantified by ultrasonic measurements at high pressure and temperature, in the mineral stability fields. these measurements are carried out at the 6-b-mb beamline of the advanced photon source (argonne national laboratory). the beamline is equipped

with a cubic anvil high-pressure apparatus coupled with in situ ultrasonic interferometry, x-ray diffraction and imaging. specimen water content is measured before and after the high-pressure experiments by infrared spectroscopy, secondary ion mass spectrometry, and using the electron probe micro-analyzer techniques. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Testing models of early Earth crust formation and tectonics

Awardee: Pennsylvania State Univ University Park

Amount: \$671,727.00

Abstract: plate tectonics is the fundamental process governing earth's dynamics, including natural hazards such as earthquakes and volcanoes. plate tectonics is a result of convection in earth's mantle. however, why mantle convection results in plate tectonics on earth, but not the other rocky planets in the solar system that also have convecting mantles, is not well understood. likewise, it is also not well known when plate tectonics started on earth. the goal of this proposal is to use numerical models of mantle convection and the formation of earth's early crust to constrain when plate tectonics might have started. observations of the chemical composition of rocks formed 3-4 gyrs ago provide key constraints on the tectonic processes operating at this time. the investigator's models will test both plate-tectonic and non-plate-tectonic scenarios for the generation of early crust against these observations, and thus assess what tectonic processes are compatible with the ancient geologic record. the results of this work will have broad significance across the geosciences. constraining the tectonic processes that operated on the early earth sheds light on how plate tectonics developed, and potentially why it is absent on other solar system planets. this work also further helps constrain on how earth's continents formed, with implications for the climate state of the early earth and possible environments for life. the proposal also makes significant contributions

to science education. it supports a graduate student who will carry out much of the proposed work, therefore furthering their research career. the project also contributes to undergraduate education through the development of a remotely taught summer short course on data analysis and visualization. this short course will be targeted at geoscience students from minority serving institutions, with the goal of helping promote **\*\*diversity\*\*** in the geosciences. the project also includes undergraduate research internships for students to be selected from the short course participants. these research internships will give students from underrepresented groups firsthand research experience, which is critical for progressing in their careers as geoscientists.

whether the early earth was characterized by a ?mobile lid? mode of tectonics, featuring subduction and surface plate motion, or a ?stagnant lid? mode where subduction is absent, is highly debated. geochemical observations of hadean and archean felsic crust provide important constraints on the tectonic processes operating at this time. however, there is still significant ambiguity, as both subduction and non-subduction, i.e. melting at the base of a thick crustal plateau, models have been proposed to explain the formation of earth?s early felsic crust. here, geodynamical models integrating new data provided by hf isotopes recorded in zircons will test the subduction and plateau melting models, from the hadean until ~ 3.5 ga. hf isotopes in zircons from many archean cratons suggest that the mafic crustal source of earth?s earliest felsic rocks (> 3.5 ga) persisted at the surface for 100s of myrs. additional petrological evidence indicates that the earliest felsic crust still preserved today formed from shallow (<30 km) melting of mafic protocrust. these observations will be integrated into two-dimensional mantle dynamic models, to test plateau melting and subduction scenarios. the modeling work will also explore the fundamental issue of whether subduction was feasible on the early earth. global models of mantle convection including crustal buoyancy and grain size evolution will be used to assess whether crustal buoyancy prevents subduction, or drastically alters its dynamics, at early earth conditions, and whether slab melting can occur when subduction is active. the results of the work will provide vital new constraints on the tectonic processes that operated on the early earth, and thus shed light on when plate tectonics might have begun. this has major

implications for the evolution of the earth as a whole, including the dynamo, crust, and even the atmosphere and oceans. the proposal also involves a significant educational component, including training of a graduate student, and a numerical modeling summer short course and reu program, geared towards students from underrepresented groups in the geosciences. a lack of programming and quantitative skills, as well as research opportunities, can be a barrier for diverse students advancing in the geosciences; the educational program developed here will seek to help address this problem. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SBP: CAREER: Multiple Identities & Intergroup Interactions: A Dual Pathway Model

Awardee: Duke University

Amount: \$668,325.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). people define themselves in terms of social categories that lead to seeing similarities and differences with others. these social identities can involve being part of specific groups (for example, female) and having specific social roles (for example, mother). thinking about one's multiple identities simultaneously (for example, female, mother, scientist) has been shown to lead to increased creativity and flexible thinking. the current project examines: 1) the interpersonal benefits that may occur when individuals each consider their own multiple identities as they interact with others, and 2) the mindset and conditions that promote these interpersonal benefits. as the u.s. population becomes increasingly diverse, multiracial, and multi-ethnic, it becomes increasingly important to understand and maximize the benefits of perceiving oneself in terms of having multiple identities. the project consists of a series of studies to examine pathways that produce interaction benefits. a primary pathway involves having experiences that lead to considering one's multiple identities rather than only a single identity. another pathway involves having increased contact with

others whose identities differ from one's own, which should encourage a multiple identity mindset. these studies examine people from different groups, different ages, in different contexts, and they utilize experimental, survey, and longitudinal methods. the predictions concern whether multiple identities can: coexist simultaneously across the lifespan, be invoked or changed, vary across contexts, and also yield benefits even when some of the identities evoke negative beliefs or stereotypes. this project also provides a variety of training opportunities for the next generation of scholars, including underrepresented students. outcomes additionally include developing programming for local science museums and implementing university-level assessments that can inform campus **diversity** efforts. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: DNA Uptake By Naturally Competent Archaea

Awardee: University of Minnesota-Twin Cities

Amount: \$666,225.00

Abstract: microorganisms can acquire genetic material directly from their environment through a process called transformation. these organisms belong to two broad groups, the bacteria and the archaea. transformation is well studied in bacteria, but little is known about how this works in archaea, despite the fact that archaea represent at least a third of the bio**diversity** on earth and catalyze essential reactions in both global biogeochemical cycles in large-scale industrial and municipal bioreactors. to address this deficiency, this proposal will be the first characterization of transformation in a member of the archaea. through this work, the necessary genes and proteins needed to carry out this process will be identified. these results may further efforts to study organisms from the archaea through genetic techniques. this research has the potential to impact directly and positively research in any process that archaea catalyze. additionally, transformation is

important in natural populations, and the results generated here will help develop a broader understanding of gene flow in the environment. finally, the techniques developed as part of this research will directly contribute to the education of the next generation of scientists through graduate student training and enhancing hands-on experimentation in undergraduate and graduate classrooms. this project will characterize the process of natural transformation - the direct uptake and genomic incorporation of dna from the environment by competent organisms - in the archaeal domain. this will be accomplished by identifying and characterizing components of the archaeal dna uptake machinery involved in three distinct steps of transformation: extracellular binding of dna, transport across the cell membrane, and maintenance of dna in the cell cytoplasm. identifying the genes and proteins involved in these steps will facilitate in silico predictions of an organism's ability to take up environmental dna. this project will leverage transposon mutagenesis, in vitro biochemical analysis, and phenotypic assays to characterize transformation in *methanococcus maripaludis*, a model organism for the study of members of the archaeal domain. to further facilitate the characterization of archaeal transformation machinery, the work in this proposal will develop and utilize a system for live cell fluorescent imaging of anaerobic archaea to analyze protein localization and protein-protein interactions in competent archaea. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Microbiota Role in Intestinal Regeneration

Awardee: University of Puerto Rico-Rio Piedras

Amount: \$661,175.00

Abstract: little is known about why some animals can regenerate certain tissues or organs, while other species cannot. this research explores regeneration in a novel organism, the sea cucumber *holothuria glaberrima*. these animals have an incredible ability to regenerate lost structures and this

study will focus on the regeneration of the intestine. in recent years, the microbial environment associated with organisms, or microbiota, has been shown to play important roles in the development and proper function of an organism. this project aims to determine the possible role of the microbiota on the process of intestinal regeneration. for this study, the bacteria and other microorganisms that are associated with the regenerating intestine will be characterized to determine if and which species might be modulating intestinal regeneration. moreover, the project provides "hands-on" research training to undergraduate students as a way of guiding them toward scientific research careers and help increase the **\*\*diversity\*\*** of the scientific community. the microbiota within the digestive tract has been shown to modulate energy metabolism and immunity in both vertebrate and invertebrate species. however, little is known of their role in organogenesis and in particular in the regeneration of new organs following loss or injury. this proposal aims to extend our knowledge of the microbiota role in developmental and regenerative processes. the proposal brings together two research scientists with different areas of expertise that will join forces to focus on the characterization of holothurian intestinal microbiota and its function in the regeneration of the holothurian digestive tract. to determine the possible effects of the microbiota, state of the art technology including rna-seq and 16rrna sequencing together with more traditional microbiota analyses will be utilized. the proposed project will: (1) characterize the intestinal microbiota of two different species of holothurians, that inhabit different environments and use different feeding methods and determine the spatial and temporal changes in the microbiota during intestinal regeneration. (2) determine the role of the microbiota by modifying the microbiota using antibiotics and antifungal agents. (3) identify the host genes that are under the control of the microbiota in normal and regenerating animals by performing transcriptomic analyses of normal and regenerating animals treated with specific antibiotic agents. the outcome of the proposal will be a clear description of how the microbiota modulates intestinal regeneration, a characterization of species that play a major role in the process and the target genes involved in the process. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation



using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: IntBIO: Disentangling the genetic, biomechanical, and deep-time factors underlying mammalian skeletal diversity

Awardee: University of California-Berkeley

Amount: \$656,957.00

Abstract: understanding the relative contributions of genetic and environmental factors involved in the evolution of life (commonly framed as "nature versus nurture") is paramount to determining how bio\*\*diversity\*\* is maintained at different scales in space and time. this project examines the role of nature versus nurture in shaping skeletons and their characteristics, such as evolutionary innovations in locomotion and eating. this multi-faceted project incorporates student research teams assembled from a broad spectrum of educational backgrounds and aims to provide opportunities for students with financial need, those from community colleges, and those from underrepresented backgrounds. a mentoring-research cooperative network composed of faculty, educational program directors, and postdoctoral, doctoral, and undergraduate researchers will provide training at all participant levels. research findings will be shared broadly through an educator short course and accessible online educational materials. among the greatest challenges and opportunities for biology in the 21st century is the integration of knowledge from dispersed scientific disciplines into a generalized framework. this project focuses on the intersection of genetic heritability, biomechanics, and deep-time evolutionary patterns to disentangle the relative contributions of each factor in allowing carnivorans (dogs, cats, bears, and relatives) to become the most widespread and diverse mammalian predators in post-dinosaur earth. to gain insights into the genetic underpinnings of skeletal \*\*diversity\*\* and variation, the team will use a mouse model to construct a heritability map of phenotypic variation and covariation. this model then will be applied to carnivoran species to test hypotheses that explain skeletal variation in this group. deep-time patterns over the past 55 million

years will then be analyzed in conjunction with long-term patterns of environmental changes such as thermal maxima and ice ages. the expected outcome is an integrated framework to explain the generation and evolution of skeletal variability in a group of diverse and adaptable animals. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: CAREER: Catalytic Activation of Alkenyl C-H Bonds

Awardee: The Scripps Research Institute

Amount: \$656,000.00

Abstract: with support from the chemical catalysis (cat) program in the division of chemistry, keary engle of the scripps research institute is developing new catalytic processes to upgrade chemical feedstocks containing alkenes (molecules that contain a carbon-carbon double bond ( $C=C$ )) to more complex value-added molecules for materials, agrochemical, and chemical biology/medicinal chemistry applications. palladium-based catalysts that are capable of selecting specific alkene carbon-hydrogen bonds ( $C-H$ ) bonds and activating these for  $C-X$  bond formation are being studied. insight into how these catalysts work is also being investigated to differentiate key features from related catalytic transformations. in parallel, dr. engle and his research team are leading synergistic activities to expand access to cutting-edge educational experiences for underserved students and to enhance the **\*\*diversity\*\*** and global competitiveness of the science, technology, engineering, and mathematics (stem) workforce. these efforts include developing open-access graduate courses and learning resources, expanding programming offered through a stem pipeline consortium that serves

diverse undergraduate students from local two- and four-year colleges in san diego, and involving undergraduate and high school interns from historically underserved groups in research activities. overall, this research program is helping to improve the efficiency and sustainability of industrially relevant chemical processes, while bolstering the future stem workforce of the united states.

catalytic reactions that convert carbon-hydrogen bonds into new carbon-carbon and carbon-heteroatom bonds enable the rapid synthesis of valuable target compounds with reduced waste generation compared to traditional approaches. keary engle and his team at the scripps research institute are developing palladium-catalyzed C(alkenyl)-H activation reactions and studying the factors that promote C(alkenyl)-H activation versus other reaction manifolds that typically emerge from alkene-palladium(II) species. these catalytic transformations are simultaneously being optimized to convert readily accessible mono- and disubstituted alkene starting materials into more highly-substituted alkene products that are otherwise difficult to prepare with defined regio- and stereochemistry. activities further include mechanistic studies, directing group investigations, and the use of alkene isomerization strategies to understand the catalytic process and to broaden the reactivity to include a significant variety of alkene substrates for these catalytic systems. this multidisciplinary project will integrate insights from mechanistic organometallic chemistry, and organic synthesis, providing a holistic and innovative training experience for a diverse group of high school students, undergraduates, ph.d. students, and postdoctoral fellows. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: BPC-AE: STARS: Catalyzing Action-Oriented Academic Communities for Broadening Participation in Computing

Awardee: North Carolina State University

Amount: \$652,289.00

Abstract: it is critical to address the longstanding issue of underrepresentation of women, black, and hispanic students in computing degree programs to provide an equitable foundation for all to participate in our society and the global economy as controllers and creators of technology, and to advance the preparation of a diverse, innovative, and competitive tech workforce. building on the prior success of the stars computing corps alliance for broadening participation in computing, the goal of the stars catalyst project is to: 1) increase the number of women, black, and hispanic students that persist in computing degree programs, and 2) advance the careers of students and faculty from groups that have been historically underrepresented in computing. through research and evaluation around stars catalyst activities, this project will advance knowledge about practices designed to increase persistence and support career advancement in computing for college computing students and faculty, particularly for those from underrepresented and intersectional groups in computing. the stars catalyst alliance is a collaborative effort across temple university, north carolina state, kent state, florida state university, morgan state, and university of north carolina charlotte. the stars computing corps alliance for broadening participation in computing (bpc) engages computing faculty and students at colleges, universities, and community colleges in a

community of practice with a shared commitment to take action to advance **diversity**, equity, and inclusion in computing. stars computing corps conferences, communities, and networks create significant institutional and human resources that can expand bpc research to a larger audience of researchers, educators, administrators, cs departments, and k-20 students, and can dramatically increase the number of people taking action in bpc efforts. prior results show that the stars computing corps alliance increases intentions to persist in computing among stars students and faculty, with enhanced outcomes for black students and faculty. this project will significantly extend the stars alliance to expand upon those impacts, by 1) including new partners that expand the reach of stars and that emphasize participation of black and hispanic students and faculty, particularly from emerging hispanic serving institutions and community colleges, 2) creating new program elements that test new and propagate evidence-based bpc practices within computing departments, and 3) leveraging partnerships to support identity-focused affinity groups, and 4) developing stars alumni groups employed in industry positions to promote transition to and retention within the tech workforce. extensions to the stars leadership corps program, stars launch program, and the stars celebration conference will serve to develop and propagate evidence-based approaches aimed at improving the teaching and learning of computing for black and hispanic students and build evidence of their effectiveness, and the respect research conference will continue to advance peer-reviewed bpc scholarship. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Baylor College of Medicine

Amount: \$652,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a

highly competitive, federal fellowship program. grfp helps ensure the vitality and \*\*diversity\*\* of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity  
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Title: Creating a Novel Museum-Based Resource for Neuroscience: Mass whole-slide imaging of the R. Glenn Northcutt Collection of Comparative Vertebrate Neuroanatomy and Embryology

Awardee: Harvard University

Amount: \$651,747.00

Abstract: this project will enable online access to a unique, irreplaceable resource for comparative studies of the evolution and development of the vertebrate brain. the r. glenn northcutt collection of comparative vertebrate neuroanatomy and embryology, housed in harvard's museum of comparative zoology (mcz), is the world's largest and most taxonomically diverse collection of histological preparations of developing and adult vertebrate brains mounted on glass microscope slides. it is of particular interest and relevance to the current generation of neuroscientists who use molecular and genetic approaches to elucidate mechanisms underlying evolutionary innovations, but the slides are fragile and access to them is difficult and time consuming. by utilizing a whole-slide-imaging workflow developed through a novel collaboration with harvard's center for brain science, the project will allow professional scientists, educators and students to easily and routinely access the slides' content via high-resolution digital images. such access will facilitate use of the slides in research and education and complement novel technologies for studying brain structure, development and function. it will facilitate collaborations between the neuroscience and bio\*\*diversity\*\* communities and, together with other projects that seek mass digitization and sharing of biological collections, it will enhance the ability of natural history institutions to more fully serve both science and society beyond their traditional constituencies. indeed, the project's imaging workflow and associated training components offer an exemplar method for rapid and cost-effective digitization that can be used by other institutions, whose slide holdings number in the millions, most of which remain dark data. the project will use a high-throughput, semi-automated slide scanner to make high-resolution digital images of the approximately 33,000 glass microscope slides in the northcutt collection. when completed, the project will provide online access to approximately 500,000 serial sections and whole-mount preparations of adult brains and embryos of more than

240 genera and 270 species of living vertebrates. a cost-effective whole-slide imaging workflow will be utilized to process as many as 360 slides/week while yielding excellent image resolution (0.2 and 0.4  $\mu$ m/pixel at 40x and 20x magnification, respectively). a digital image of each slide will be served to potential users via two online portals: mczbase, the museum of comparative zoology's permanent specimen database; and morphosource, an nsf-supported online repository for specimen digital imagery. both portals will be configured with girder and slideatlas, two open-source software tools for whole-slide image viewing, downloading and analysis. in addition, for as many as 20 species widely used to teach comparative vertebrate anatomy, digital images of a subset of histological sections labelled to point out principal brain regions will be uploaded to brainmaps, an online resource for vertebrate neuroanatomy. finally, the project will produce several resources for training both students and professionals in methods for mass digitization and computer-assisted visualization of slide collections regardless of subject matter. these resources include four "how-to" videos, two online tutorials, undergraduate and graduate student internships and a graduate-level course in museum studies. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: IUCRC Phase II: Iowa State University: Center for Bioplastics and Biocomposites [CB2]

Awardee: Iowa State University

Amount: \$651,714.00

Abstract: the center for bioplastics and biocomposites (cb2) at iowa state university (isu), university of georgia (uga), washington state university (wsu), and north dakota state university (ndsu) seeks to develop and build on an industry/university cooperative research center (i/ucrc) that focuses on bioplastics and biocomposites. the mission of cb2 is to develop fundamental knowledge related to bioplastics and biocomposites, to disseminate research-based findings to industry to promote

sustainability, and to educate future scientists and engineers. as such, there is an expressed industrial interest in leveraging research efforts to accelerate systematic development of standardized material and processing data for these novel plastics and composites. the center focusses on the development of jobs in the area of sustainable manufacturing and the conversion of agricultural and woody crops to bio-based materials that contribute to job creation in the united states. the center also strives to support education and **\*\*diversity\*\*** through engagement of undergraduate and graduate students in research on sustainable materials. the goal of cb2 is to improve the basic knowledge of synthesis, processing, properties, and compounding of bioplastic and biocomposite materials, to develop reliable materials characteristics data for industrial partners, and to support large-scale industrial implementation of renewable materials. the vision of the center is to develop knowledge that will facilitate the production of an array of high-value products, including plastics, coatings, adhesives, and composites, from renewable feedstocks. the materials are compatible with current industrial manufacturing systems and promote rural development as well as national growth. the goals of the phase ii are fourfold: 1) expand the knowledge and develop the science for recycling and end of life treatment of sustainable materials, in particular as they are mixed with petrochemical plastics; 2) expand membership by engaging new companies that have expressed a need for recycling and end of life treatment; 3) develop fundamental knowledge on sustainable materials; 4) prepare students to join the workforce equipped with the knowledge and skills required by industry. the team of researchers includes experts in the fields of polymer processing, polymer chemistry, materials science, and crop utilization. wsu's research focuses on utilizing industry-relevant technology platforms to develop bio-based composites, coatings and adhesives, and polymers for various industry applications, as well as to recycle bio-based composite materials. isu's research focuses on agricultural biomass valorization, monomer and polymer development, adhesives and coatings, chemical recycling and upcycling, and packaging and construction materials markets. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts

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Matched Words: diversity

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Title: CAREER: Simulating Mesoscale Quantum Dynamics and Non-linear Microscopy

Awardee: Southern Methodist University

Amount: \$650,000.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). with support from the chemical theory, models and computational methods program in the division of chemistry, doran bennett of southern methodist university is working to uncover the quantum mechanical processes by which molecular materials conduct energy. next generation technology development stems from advances in our ability to control, manipulate, and redirect energy. dr bennett's group will extend computer simulations of quantum process from the traditional molecular-scale to the nanometer-to-micron scale, (i.e. the "mesoscale") that is relevant to molecular materials. these rigorous computational models are expected to establish how specific materials absorb and deploy energy from light, providing essential information to those looking to

engineer novel materials. this research will combine chemistry, computation, and advanced mathematics, stem fields with severe levels of gender and race disparities. in conjunction with his research, dr. bennett will launch an intensive, wrap-around summer research program to reach greater numbers of science majors from underserved groups in an effort to achieve greater excellence through **\*\*diversity\*\***. doran bennett?s research under this award will address the pressing need for new computational tools to support an emerging scientific frontier studying mesoscale (10 nm ? 1 ?m) excited-state dynamics in molecular materials. rapidly developing synthetic and spectroscopic toolboxes are expected to enable structural control and the establishment of spatially-resolved probes of mesoscale processes. dr. bennett and his group will leverage the locality of electronic excited-states to simulate the photophysics of molecular materials within a formally exact (spin-boson) equation-of-motion called the adaptive hierarchy of pure states (adhops). dr. bennett will extend adhops to simulate excited state dynamics in the presence of complex vibrational environments of realistic molecular materials (e.g. involving many frequencies of vibration and timescales of relaxation). he and his team will also endeavor to develop the corresponding computational methods for simulating spatially resolved non-linear spectroscopy. these efforts are expected provide the community with new theoretical tools for interpreting spectroscopic measurements and predicting excited state dynamics in synthetic molecular materials. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CRCNS Research Proposal: Computations for spatial-chromatic interactions and their physiological implementation in primary visual cortex

Awardee: University of Maryland, College Park

Amount: \$649,791.00

Abstract: color and form are often treated as separable features of an image. one can recognize

shapes in achromatic photographs and conceptualize the color of an object abstracted from shape. yet color-specific processing is embedded throughout the visual pathway from the first stage of the visual pathway, where three different types of light sensors (?cones?) with sensitivity to different parts of the visual spectrum initially convert light into electrical impulses. the color of a given point can in principle be determined by comparing the activation of the three different cone types, but the separate color channels are maintained until the primary visual cortex (v1), where they are finally combined in neurons that concurrently have sensitivity to different spatial patterns. indeed, while it was initially thought that color and form were processed through separate pathways within v1, recent experiments have highlighted that a surprising fraction of v1 neurons mix them together in a **\*\*diversity\*\*** of ways. exactly how the mixing occurs, and for what purpose, are critical open questions in understanding human vision, and have been difficult to answer because such mixing is too complicated to characterize using traditional approaches. this project combines large-scale recording of v1 neural activity during tailored ?spatio-chromatic? visual stimulation with new computational approaches that offer an unprecedented high-resolution description of color processing within v1 while allowing determination of the underlying function of spatio-chromatic mixing in supporting natural color vision. the project also provides opportunity for cross-disciplinary training in neurophysiological and machine-learning based statistical modeling of undergraduate and graduate students. this project is a tight combination of visual neurophysiology, data-driven computational modeling, and simulation. the investigators perform large-scale multi-electrode recordings across cortical lamina to determine the transformations of spatio-chromatic representations from cortical inputs (where color channels are separate) to cortical outputs (where they are mixed). these recordings are interpreted using nonlinear data-driven models that can provide high-resolution spatio-chromatic maps of the stimuli driving each v1 neuron, and distinguish the underlying computations being performed at each stage. such characterizations are pushed to achieve cone-resolution by leveraging novel model-based eye-tracking that can account for small eye movements with an order-of-magnitude finer sensitivity than standard approaches. the first aim

determines the set of principles governing how spatial and chromatic information is combined in v1, which sets the foundation for processing throughout the visual pathway. the second aim determines whether these rules are the same in the area of cortex processing the center-of-gaze (fovea), which is responsible for high-acuity color vision. finally, the last aim establishes a population decoding framework for linking spatio-chromatic sensitivity of individual v1 cells to the larger systems-wide goals of the visual cortex in processing natural color vision. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Alterations in Marine Bivalve Shell Formation by Environmental Stress

Awardee: Texas A&M University Corpus Christi

Amount: \$648,557.00

Abstract: shellfishes use shells to protect themselves from predators and obtain nutrients from the water. shells are tough since the compounds in them are harder than rocks. however, the toughness of shells can be easily affected by environmental conditions during the shell formation. shells can become fragile when the shell formation occurs in adverse conditions, such as high carbon dioxide (co2) level or low salinity in water. with the effects on shells, the production of some shellfish species with high market values, such as the oysters, will be possibly declined in the coastal areas. the research goal of this career proposal is to understand how the co2 and salinity of water modify the eastern oyster shell formation from a genetic level so that a method to help the oysters overcome the environmental effects during the shell formation. the result of this study will be applied to oyster aquaculture in the gulf of mexico. the project will also help with restoration of shellfish habitats on the coast. in addition, the project will involve the training of students from historically underrepresented groups in science at texas a&m university ? corpus christi via the educational goals of the project. the project will also provides research opportunities to community college



students, as well as research opportunities for middle/high school science teachers in the biological sciences. It is well known that the shell development during the early life stages of bivalves is vulnerable to environmental stressors, but there is little understanding of the genetic responses of bivalves to environmental changes during shell development. The research goal of this career project is to determine the molecular mechanisms by which bivalve shell formation is altered under ocean acidification (OA) and salinity fluctuation. The proposed approach is to 1) characterize changes in oyster shells under the stress of OA and salinity fluctuation by measuring the shell morphological changes, analyzing changes in shell composition, and identifying changes in matrix protein production of the shells; 2) identify the signaling pathway for shell formation response to OA and salinity stress by conducting transcriptomic analysis and calcium imaging with the primary cell cultures from the mantle tissue of the eastern oyster; and 3) enhance the tolerance of the eastern oyster shell formation to the environmental impacts by creating mutagenesis and transgenic strains. The education goals of the proposed project are to increase **diversity** in higher education and biological research, focusing particularly on encouraging hispanic/latino students to pursue advanced degrees in STEM fields. The approach will be to 1) create an innovative class for undergraduate and graduate students that involves multiple off-campus experts and facilities in teaching and student-learning outcome assessment; 2) providing research opportunities to undergraduate students and community college students; and 3) organizing a summer biological science section for middle/high school students and a training section for elementary/middle school teacher education. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Awardee: Texas A&M University Corpus Christi

Amount: \$648,557.00

Abstract: shellfishes use shells to protect themselves from predators and obtain nutrients from the water. shells are tough since the compounds in them are harder than rocks. however, the toughness of shells can be easily affected by environmental conditions during the shell formation. shells can become fragile when the shell formation occurs in adverse conditions, such as high carbon dioxide (CO<sub>2</sub>) level or low salinity in water. with the effects on shells, the production of some shellfish species with high market values, such as the oysters, will be possibly declined in the coastal areas. the research goal of this career proposal is to understand how the CO<sub>2</sub> and salinity of water modify the eastern oyster shell formation from a genetic level so that a method to help the oysters overcome the environmental effects during the shell formation. the result of this study will be applied to oyster aquaculture in the gulf of mexico. the project will also help with restoration of shellfish habitats on the coast. in addition, the project will involve the training of students from historically underrepresented groups in science at Texas A&M University - Corpus Christi via the educational goals of the project. the project will also provide research opportunities to community college students, as well as research opportunities for middle/high school science teachers in the biological sciences. it is well known that the shell development during the early life stages of bivalves is vulnerable to environmental stressors, but there is little understanding of the genetic responses of bivalves to environmental changes during shell development. the research goal of this career project is to determine the molecular mechanisms by which bivalve shell formation is altered under ocean acidification (OA) and salinity fluctuation. the proposed approach is to 1) characterize changes in oyster shells under the stress of OA and salinity fluctuation by measuring the shell morphological changes, analyzing changes in shell composition, and identifying changes in matrix protein production of the shells; 2) identify the signaling pathway for shell formation response to OA and salinity stress by conducting transcriptomic analysis and calcium imaging with the primary cell cultures from the mantle tissue of the eastern oyster; and 3) enhance the tolerance of the eastern oyster shell formation to the environmental impacts by creating mutagenesis and transgenic strains.

the education goals of the proposed project are to increase **\*\*diversity\*\*** in higher education and biological research, focusing particularly on encouraging hispanic/latino students to pursue advanced degrees in stem fields. the approach will be to 1) create an innovative class for undergraduate and graduate students that involves multiple off-campus experts and facilities in teaching and student-learning outcome assessment; 2) providing research opportunities to undergraduate students and community college students; and 3) organizing a summer biological science section for middle/high school students and a training section for elementary/middle school teacher education. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Evolution of the gene regulatory network for pharyngeal segmentation

Awardee: University of Colorado at Boulder

Amount: \$645,487.00

Abstract: the bones and cartilages of the jaws, face, neck, and inner ear develop from embryonic structures called pharyngeal arches. defects in pharyngeal arch development underlie many human birth defects. the pharyngeal arches of non-human vertebrates also form most of the head skeleton, including the gills of aquatic vertebrates. though the pharyngeal arches form similarly in all vertebrates, they ultimately give rise very different head skeletons in different vertebrate groups. how such variation is achieved using the same basic set of genes and developmental processes is unclear. the project seeks to elucidate the aspects of pharyngeal arch development shared by all vertebrates, and those that differ between major groups. this information will serve two purposes. first, it will shed light on the genetic and developmental changes that led to the evolution of new vertebrate groups. second, it will help identify the causes of genetic and environmentally-induced disruptions human craniofacial development. this project will also support the creation and staffing of

a large, interactive zoo exhibit entitled "hidden links: discovering your inner invertebrate", that will be seen by over 300,000 visitors annually, including 57,000 grade school students. the exhibit will expose visitors to key biological concepts such as evolution, phylogenetics, genetics, segmentation, and development. the work will also support the training of three ph.d. students, several undergraduates, and provide research projects for 1-2 high school students per year. robust, paired pharyngeal arches (pas) are a defining feature of vertebrates. pas form most of the breathing and feeding structures of the vertebrate "new head", and variation in pa number and derivatives is a major contributor to vertebrate morphological \*\*diversity\*\*. though pas play a key role in shaping the vertebrate head, the genetic mechanisms driving pa development are poorly understood. even less is known about how they have been altered during evolution to yield different oropharyngeal phenotypes. the pas form in an anterior-to-posterior sequence when bilateral endodermal outpocketings called pharyngeal pouches (pps) contact overlying ectoderm. studies in zebrafish, medaka, and mouse have identified a small, conserved set of genes that drives pp development in model vertebrates. however, how these genes interact differs between teleosts and mouse. when during evolution these gene regulatory differences arose, and if they contribute to differences in oropharyngeal morphology, is unknown. to better understand the genetic bases of vertebrate oropharyngeal \*\*diversity\*\*, this work will reconstruct the ancestral gene regulatory network for pp/pa development (the pp grn). this information will then be used to deduce how and why the pp grn has been altered in modern lineages. to do this, the pp grn of the sea lamprey, *petromyzon marinus*, and the frog, *xenopus laevis* will be interrogated using crispr/cas9 mutagenesis and pharmacological perturbations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: REU Site: Undergraduate Research Pathways That Broaden and Strengthen the Geosciences

Awardee: Macalester College

Amount: \$642,244.00

Abstract: the keck geology consortium reu will offer undergraduate research experiences for 14 undergraduate students per year to help students: (1) improve their understanding of the earth through authentic research; (2) develop disciplinary and personal skills needed by professional earth scientists; (3) develop their confidence and identity as scientists through greater understanding of the intellectual and practical work of science; and (4) refine their career plans and prepare them for graduate study using intentionally designed research experiences and mentoring. gateway projects, designed for rising sophomores, will engage students in a mix of field and laboratory work to investigate societally relevant questions, expose them to the breadth of the discipline, and to career opportunities in the earth sciences. students in the advanced research program (rising juniors) will participate in a four-week summer project involving a mix of field and laboratory investigations, followed by an academic year-long project at their home campuses, that focuses on important problems in the discipline. both programs include analytical, professional development components, and conference presentations designed to help students learn cutting-edge approaches, as well as to develop their professional knowledge and skills. mentor workshops, curricular materials, and technology are used to support the work of student participants and project mentors. the principal goal of keck geology consortium programs is to broaden the **\*\*diversity\*\*** of the geoscience workforce and to prepare students for careers in the geosciences. undergraduate participants, especially those from underrepresented minorities, will be recruited from both consortium and non-consortium institutions. the gateway program is designed to further existing efforts at the consortium institutions to broaden the participation of underrepresented groups within the geosciences and stem. with an emphasis on year-long research experiences, structured research curricula, and mentor training, the consortium programs provide a distinctive model for undergraduate research. this project also endeavors to advance the evaluation of undergraduate research experiences with further development of a research knowledge and skill survey and to

facilitate community-wide engagement with ?science identity? formation with a goal of simultaneously strengthening reu?s and geoscience programs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Digitization TCN: Collaborative Research: Bringing Asia to digital life: mobilizing underrepresented Asian herbarium collections in the US to propel biodiversity discovery

Awardee: Missouri Botanical Garden

Amount: \$642,096.00

Abstract: asia is the largest continent on earth, and includes the world?s tallest mountains, lowest landscapes, and habitats ranging from arctic tundra to tropical rainforests and mangroves to deserts. the plants of this region are incredibly diverse in their identities and functions. more than one-third of the world?s 350,000 plant species grow in asia and include tiny alpine cushion plants, medicinal herbs, ancient crops, and some of the planet?s tallest rainforest trees. but documentation of this **\*\*diversity\*\*** remains inaccessible and research about it is difficult because most herbarium specimens of asian plants have not been digitized. the all asia thematic collections network (tcn) will mobilize online 15 million specimens of asian plants currently housed in the us and around the world. the project will especially focus on digitizing specimens from the unique and critically endangered bio**\*\*diversity\*\*** hotspots of southeast asia and the himalaya-hengduan region. these mobilized digital data will accelerate research to conserve endangered plant species and understand the interacting effects of evolution and global environmental change on plant species **\*\*diversity\*\***. the project will apply state-of-the-art informatics tools and high-throughput digitization methods to efficiently and affordably digitize an unprecedented number of herbarium collections. this effort will connect and build long-lasting relationships among 25 large and small consortium institutions in the u.s., europe, and asia. the focal areas from which specimens will be digitized

encompass five bio\*\*diversity\*\* hotspots that include ~20% of the world's vascular plant flora and historically spanned 3 million km<sup>2</sup> of primary vegetation that now covers less than 300,000 km<sup>2</sup>. fundamental bio\*\*diversity\*\* data for these bio\*\*diversity\*\* hotspots are lacking, along with the necessary baselines required to characterize species' identity, range, and responses to ongoing climatic change. the overall goals of the all asia tcn are to rapidly digitize herbarium specimens of asian plants to advance bio\*\*diversity\*\* discovery and provide critical baseline assessments essential for establishing floristic change in the anthropocene. the project will accomplish this by (1) digitizing 3 million asian vascular plant specimens from u.s. herbaria; (2) developing and applying novel informatics tools and high-throughput digitization methods to massively scale herbarium digitization; (3) aggregating and mobilizing the digitized records from the project with those by international partners in china, france, the netherlands, and russia to establish a single online all asia portal of ca. 15 million specimens; and (4) enhancing opportunities for early career learners in science, technology, engineering, and mathematics by stimulating synergies between bio\*\*diversity\*\* and computer scientists who will use design thinking principles to create real-world informatics solutions to bio\*\*diversity\*\* challenges. to stimulate curiosity in plant \*\*diversity\*\* and botanical exploration among the general public, the consortium members will host several asia-themed notes from nature virtual expeditions to facilitate additional specimen digitization by citizen-scientists. digitized specimen data mobilized through this project will be shared and made available through idigbio.org. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Supramolecular Chemistry at the Interface of Lipid Bilayers and Water

Awardee: Tulane University

Amount: \$641,520.00

Abstract: this award is funded in part under the american rescue plan act of 2021 (public law 117-2).

with support from the macromolecular, supramolecular and nanochemistry program in the division of chemistry, nathalie busschaert of tulane university will study the fundamental supramolecular chemistry behind small molecules that interact with lipids in biological membranes. lipids are an important class of biological compounds and play a role in a variety of physiological functions, such as energy storage, providing a hydrophobic barrier, and signal transduction. there is therefore a need for small molecules that can interact with certain types of biological lipids. the biggest challenge, however, is that lipids mostly reside in membranes as 'lipid bilayers' that possess unusual physical properties complicating the development of lipid-binding molecules. dr. busschaert aims to design novel small molecules that can selectively bind to one type of lipid over other types of lipids and study the effect of various physical membrane properties on this binding event using model liposome-based systems. the project is anticipated to help establish general guidelines for the design of molecules that can selectively bind to specific lipids within lipid bilayers, which can have a broader impact on the field of supramolecular chemistry by exploring lipids as an unusual target, help elucidate lipid biochemistry and biophysics, advance human health and provide fundamental knowledge for any application involving membranes. this work is expected to have a further broader impact on the participation of women in stem fields, as dr. busschaert will oversee a number of supramolecular chemistry inspired activities to increase the participation of women and minorities in stem at every level of education. the central hypothesis of the project is that lipid head-groups are comparable to traditional supramolecular targets such as phosphate anions and ammonium cations, but that the unusual physical properties of lipid bilayers need to be considered when designing lipid-binding molecules. so far, there have only been a few reports of small molecules binding selectively to certain types of lipid head-groups. however, in most cases the binding of the host molecules with the lipid of interest was determined in organic solution or in one type of liposome. such investigations ignore the lipid **diversity** in biological membranes and do not take into account the effects of the unique physical properties of lipid bilayers. the binding of lipid



head-groups takes place at the membrane-water interface, which makes it an unusual type of supramolecular interaction. the interface region is partially hydrated and is therefore presents a different situation from that observed with supramolecular interactions in water and or in organic solution. furthermore, lipid bilayers display a fluid, liquid crystalline state that displays neither solution kinetics nor solid state dynamics. the central hypothesis will be tested by synthesizing a variety of compounds designed to bind to specific lipid head-groups, and then characterizing the binding of these compounds with model liposome-based systems using a variety of techniques, including nuclear magnetic resonance (nmr), uv-vis spectroscopy, surface plasmon resonance and isothermal titration calorimetry. these activities are designed to help identify the effect of hydrophobicity, physical membrane properties (e.g., lipid shape, acyl chain length, membrane curvature), and multivalency on binding to lipid bilayers. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: CAREER: Diversity in Learning Contexts and the Emergence of Abstract Reasoning

Awardee: University of California-San Diego

Amount: \$636,044.00

Abstract: relational reasoning is the ability to go beyond direct, perceptual experience to engage in abstract thought. it a defining feature of human cognition and critical for scientific thinking. however, young learners often struggle to prioritize abstract concepts, like same and different, over salient, but often less informative properties, like color or shape. the investigator will explore how distinct learning environments may shape children?s tendency to engage in relational reasoning to better understand what circumstances facilitate (or suppress) this ability. this project will engage in cross-cultural work to examine if and how naturally-occurring differences in environmental input influence the early expression of abstract thought. additional research will assess whether specific learning environments may be manipulated to facilitate skills for abstraction in children. this work challenges existing theories that posit the gradual, linear emergence of relational reasoning, and will generate an empirical foundation for thinking broadly about cognitive **\*\*diversity\*\***. further, establishing competence in abstract reasoning provides an incentive for designing learning environments to support recognition of these concepts from an early age. the proposed work tests the claim that although relational reasoning emerges early, children tend to neglect abstract similarity due to a learned bias to attend to object properties. this account predicts that variation in children?s environmental input should lead to distinct cognitive biases and corresponding

differences in the expression of abstract thought. the investigator will apply a three-pronged strategy to assess this account. aim 1 will evaluate the robustness of early competence in relational reasoning in 18-30-month-olds in two different cultural contexts to assess whether their previously reported success results from genuine conceptual understanding. aim 2 will characterize differences in object- and relational-focus in 3-year-olds across additional cultures and document effects on reasoning. this will evaluate claims that differences in lexical bias and context-sensitivity influence the emergence of abstract thought. aim 3 will assess the causal role of contextual factors on reasoning in children by manipulating features of the learning environment. together, these aims test the claim that early challenges associated with relational reasoning do not result from a lack of competence, but rather a difference in tendency that stems from children's failure to recognize when to apply their knowledge. this approach promotes the investigation of diverse populations and challenges the prevailing view that children's reasoning universally develops as a bottom-up, emergent process. findings from this project will advance our understanding of how regularities in the environment may set the developing child on different learning trajectories. this project is co-funded by the sbe/bcs science of learning and augmented intelligence, the discovery research prek-12 (drk-12), and the ehr core research (ecr) programs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Developing noble gases as tracers of metamorphic dehydration

Awardee: Pennsylvania State Univ University Park

Amount: \$635,630.00

Abstract: the habitability of earth is controlled by the distribution of volatile elements (e.g. water, carbon dioxide) between surface (atmosphere + hydrosphere) and interior reservoirs (mantle + core). metamorphism during burial and heating of oceanic plates at subduction zones regulates the

supply of water into the earth's mantle, critically affecting how the mantle flows. however, the specific pathways and fluxes by which water is transported beyond arc volcanoes are uncertain. while direct tracing of subducted water is made difficult by its small number of isotopes, the noble gases are elementally- and isotopically-rich, are fractionated by physical processes and are ideal tracers for the movement of metamorphic fluids. application of the noble gases as tracers of the deep water cycle requires development of a linkage between noble gas composition and the magnitudes of water loss during subduction. this project will result in a systematic characterisation of the distribution and composition of noble gas isotopes in ancient samples of subducted oceanic crust, establishing the framework for noble gases to be used as tracers of metamorphic fluids. the integrated research and education program proposed here will result in: 1) quantification of the key physical processes that control subduction-processing of volatiles; 2) career-enhancement for an early career scientist and a graduate student, and 3) broadened participation and enhanced **\*\*diversity\*\*** in petrological research via a series of formative research institutes targeting applicants from minority-serving institutions. earth's upper mantle contains an indelible elemental abundance pattern of heavy noble gases (ar, kr, xe) that is strikingly similar to seawater. because this is a unique composition in the solar system, the only credible explanation is that a non-disrupted, seawater-like noble gas signature survives the subduction process, generally thought to exclude more than 95% of input volatiles. given that the noble gases are between 100 and 100,000 times more soluble in fluids than crustal minerals, even minor amounts of phase separation during release and transport of metamorphic fluids will fractionate the noble gas composition of subducting rock. how, then, do noble gases escape removal and significant fractionation during subduction? and, can the noble gases be used to quantitatively trace the subduction of water? this project will address these questions through the integration of noble gas compositions, mineralogically-bound h<sub>2</sub>o contents and thermodynamic estimates of pressure and temperature from exhumed subduction-related rocks. the proposed research will systematically test the overarching hypothesis that noble gas composition is principally controlled by the extent of metamorphic dehydration during

subduction. at the core of the educational component of this career program is the development and implementation of a series of summer institutes dedicated to enhancing **\*\*diversity\*\*** in petrological research. this program will result in the petrological training of a cohort of undergraduates, many of whom will come from minority-serving institutions. petrological and geochemical datasets collected as part of the proposed research program will be used to nurture interest, and increase comprehension of undergraduate students, from a diverse array of institutions and backgrounds, in metamorphic petrology. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Applying Student Knowledge for Success in Cybersecurity and Data Science

Awardee: Brookdale Community College

Amount: \$633,935.00

Abstract: this project will contribute to the national need for well-educated scientists, mathematicians, engineers, and technicians by supporting the retention and graduation of high-achieving, low-income students with demonstrated financial need at kean university, the new jersey institute of technology, fairleigh dickinson university, brookdale community college, and union county college. in particular, it responds to areas of national need in cybersecurity and data science by increasing the number of students graduating in computer science (cs) and information technology (it). moreover, the project will build regional workforce strength and contribute to the knowledge base on the role of student competence and belonging in ensuring persistence to degree attainment. over its five-year duration, a total of 256 students will benefit, receiving scholarships to complete cs or it degrees. project components include scholarship support for students, undergraduate research and/or professional experience opportunities prior to graduation, and generation of new knowledge through research on economic realities for students and impact on career trajectories in cybersecurity and data science. students in this program will be prepared to enter the scientific workforce or graduate school as competent, highly trained individuals with a background in teamwork and research. furthermore, they will contribute to increased professional **\*\*diversity\*\*** in the fields of cs and it, and serve as role models to members of their communities.

the students recruited for this program will participate in workshops, take advantage of cohort experiences, and interact closely with faculty who will provide i) academic advising, ii) guidance for navigating higher education and postgraduate opportunities, and iii) supervision of teamwork, research, and working professional experiences. through undergraduate research opportunities and experiences from participation in faculty research programs and/or existing summer research and



internship programs, these individual and cohort experiences will provide a basis for overall intellectual growth and promote increased student confidence, retention, and timely degree completion. these academic outcomes are in turn expected to allow students to successfully navigate common attrition points including financial hardship and professional identity development for post-graduate employment and continued education. the project's academic environment includes student-faculty advising and undergraduate research activities, using the affinity research group (arg) model and peer-mentoring. the use of teamwork, collaboration and student-motivated question and answer sessions will positively support research in the field of computer science and information technology regarding educational impact and retention, particularly for minorities, female, and first-generation students. this project is funded by nsf's scholarships in science, technology, engineering, and mathematics program, which seeks to increase the number of low-income academically talented students with demonstrated financial need who earn degrees in stem fields. it also aims to improve the education of future stem workers, and to generate knowledge about academic success, retention, transfer, graduation, and academic/career pathways of low-income students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: HDR DSC: Building Capacity in Data Science through Biodiversity, Conservation, and General Education

Awardee: Lewis and Clark College

Amount: \$633,278.00

Abstract: solving environmental challenges relies heavily on computer science and statistical skills applied to large data sets. however, these knowledge, skills, and abilities are not evenly distributed across u.s. colleges, students, or faculty. this project works to transform environmental education by

creating, implementing, and evaluating a data science training program for undergraduate students who are interested in conservation and management in urban and wild areas. faculty from both the university of arizona and lewis and clark college co-teach a foundational data science course that utilizes public data and addresses pressing environmental concerns relevant to student interests and identities. exceptional students subsequently participate in a more focused cooperative course as data science interns for conservation stakeholders. professional development workshops in data science education for instructional faculty, some of whom work in institutions serving primarily low-income students and students of color, prepare faculty to implement data science educational modules at their respective institutions. these critical resources and pathways allow broad communities to harness the data revolution. the workforce demand for data analysts and data scientists exceeds the current capacity for higher education to produce this skilled workforce. the overall goal of this project is development of scalable, portable data science education that can be readily incorporated into existing programs concentrating on stem (science, technology, engineering, and mathematics), with a focus on ecology, bio\*\*diversity\*\*, and conservation. the project achieves this goal by creating multiple curricular data science on-ramps for a broad range of students early in their undergraduate training, through general education courses and foundational major courses using inclusive and expansive pedagogy techniques more common in liberal arts education. the expected outcomes from these activities are (1) development of reusable data science modules and courses that can be deployed into existing undergraduate general education and major curricula, (2) the ability for a broad range of conservation interested students to access real-world data science training they are passionate about at an early stage of their education, and (3) training and support mechanisms for undergraduate educators who wish to add data science to their curricula. the products of this proposed multi-institutional data science corps program are designed to be generally extensible to other higher educational institutions and majors through open data and open science, providing capacity to rapidly deploy data science training. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's

intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: A Data-Driven Employer-Academia Partnership for Continual Computing Curricular Change

Awardee: Purdue University

Amount: \$632,615.00

Abstract: this project aims to serve the national interest by improving the supply of well-prepared computer science professionals capable of addressing the needs of american employers in the public and private sectors. this project intends to build a national partnership between employers and academia to help identify and mitigate gaps between the competencies of computing graduates and the expectations of potential employers. the project will survey computer science educators and practitioners to develop a model that defines the competencies expected by potential employers. the project team then plans to test the model at three institutions of higher education in alabama ? the university of alabama, tuscaloosa, tuskegee university, and shelton state community college. finally, the project team intends to develop tools and methods for institutions to identify and implement competency-based educational approaches for computer science across the nation. the project plans to use three interconnected strands of evidence-based activities to institute transformational change in the involved communities. first, a national strand will engage u.s. faculty in developing competency-based curricula informed by industry practitioner feedback. second, a local pilot strand intends to create transformative curricular change based on student competencies using an evidence-based change model in the three alabama institutions. sociologists and computing faculty on the team will help to understand, predict, and reduce barriers to competency-based employment of computing graduates from marginalized communities in the heart of the impoverished alabama black belt. the unique perspective relative to **\*\*diversity\*\***, equity, and inclusion needs should serve as a model for other computing departments. the third strand will

develop competency-based surveys for practitioners and academics to identify and refine specific competencies that are hoped to drive continual curricular change. outcomes, including the change process, national workshops, and experiences from the local process will help with transferability in the computing education community. in addition to informing curricula, the project will provide valuable data for educational researchers to help close the gap between employers and higher education. finally, as the competency approach to curricular design is relatively new in computing and engineering disciplines, lessons from this project will have the potential to transform curricular review and design in other stem disciplines. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the institutional and community transformation track, the program supports efforts to transform and improve stem education across institutions of higher education and disciplinary communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Understanding Context: Propagation and Effectiveness of the Concept Warehouse in Mechanical Engineering at Five Diverse Institutions and Beyond

Awardee: Tufts University

Amount: \$631,082.00

Abstract: an increase in the number and **\*\*diversity\*\*** of graduates in science, technology, engineering, and mathematics (stem) fields is important for the nation's competitiveness. concept-based active learning strategies have been shown to improve students' academic performance and increase the number who choose to stay in stem programs. however, scientific proof that these strategies are effective is not enough to make sure instructors use them in courses. it is also necessary to understand and find ways to get instructors to adopt proven practices. in this project new online concept-based materials for mechanical engineering courses in statics and

dynamics will be developed. the project team will study why instructors decide to use the materials, and how factors at five different types of institutions affect these decisions. the project will help to show how circumstances at different institutions affect both instructor adoption as well as student learning and motivation. it will help inform ways to support widespread use of the evidence-based instructional practice. thus, it will also help more students stay in and graduate from engineering programs. the goal of this project is to increase the adoption of concept-based active learning throughout undergraduate engineering programs. it builds upon the project team's previous success in developing the web-based concept warehouse instructional resource for chemical engineering. the resource contains hundreds of short questions to engage students in concept-oriented thinking, to assess their conceptual knowledge, and to provide extensive concept-based active learning tools. the project will expand concept warehouse to include content in mechanical engineering. participating institutions include research-intensive and hispanic-serving institutions, as well as a two-year college. a systems approach will be used to examine how elements of the educational context, such as size and departmental culture, influence instructor uptake and the resulting student learning. a mixed-methods research design will include the use of data analytics, instructor interviews, student focus groups, observations, classroom video, and pre/post concept inventory scores. the research plan will also address ways in which student backgrounds and demographics (e.g., underrepresented minorities; first-generation status) interact with institutional settings to affect student learning and engagement. workshops and faculty community building activities will be used to promote propagation of the enhanced evidence-based instructional practices. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Digitization TCN: Collaborative Research: Bringing Asia to digital life: mobilizing underrepresented Asian herbarium collections in the US to propel biodiversity discovery

Awardee: New York Botanical Garden

Amount: \$629,237.00

Abstract: Asia is the largest continent on earth, and includes the world's tallest mountains, lowest landscapes, and habitats ranging from arctic tundra to tropical rainforests and mangroves to deserts. The plants of this region are incredibly diverse in their identities and functions. More than one-third of the world's 350,000 plant species grow in Asia and include tiny alpine cushion plants, medicinal herbs, ancient crops, and some of the planet's tallest rainforest trees. But documentation of this **diversity** remains inaccessible and research about it is difficult because most herbarium specimens of Asian plants have not been digitized. The All Asia Thematic Collections Network (TCN) will mobilize online 15 million specimens of Asian plants currently housed in the US and around the world. The project will especially focus on digitizing specimens from the unique and critically endangered bio**diversity** hotspots of Southeast Asia and the Himalaya-Hengduan region. These mobilized digital data will accelerate research to conserve endangered plant species and understand the interacting effects of evolution and global environmental change on plant species **diversity**. The project will apply state-of-the-art informatics tools and high-throughput digitization methods to efficiently and affordably digitize an unprecedented number of herbarium collections. This effort will connect and build long-lasting relationships among 25 large and small consortium institutions in the U.S., Europe, and Asia. The focal areas from which specimens will be digitized encompass five bio**diversity** hotspots that include ~20% of the world's vascular plant flora and historically spanned 3 million km<sup>2</sup> of primary vegetation that now covers less than 300,000 km<sup>2</sup>. Fundamental bio**diversity** data for these bio**diversity** hotspots are lacking, along with the necessary baselines required to characterize species' identity, range, and responses to ongoing climatic change. The overall goals of the All Asia TCN are to rapidly digitize herbarium specimens of Asian plants to advance bio**diversity** discovery and provide critical baseline assessments essential for establishing floristic change in the Anthropocene. The project will accomplish this by (1) digitizing 3 million Asian vascular plant specimens from U.S. herbaria; (2) developing and applying

novel informatics tools and high-throughput digitization methods to massively scale herbarium digitization; (3) aggregating and mobilizing the digitized records from the project with those by international partners in china, france, the netherlands, and russia to establish a single online all asia portal of ca. 15 million specimens; and (4) enhancing opportunities for early career learners in science, technology, engineering, and mathematics by stimulating synergies between bio\*\*diversity\*\* and computer scientists who will use design thinking principles to create real-world informatics solutions to bio\*\*diversity\*\* challenges. to stimulate curiosity in plant \*\*diversity\*\* and botanical exploration among the general public, the consortium members will host several asia-themed notes from nature virtual expeditions to facilitate additional specimen digitization by citizen-scientists. digitized specimen data mobilized through this project will be shared and made available through idigbio.org. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: BRITE Relaunch: Manufacturing Multilayers of Molecularly-Bonded Inorganic Nanointerfaces for Accessing and Tuning Novel Properties

Awardee: Rensselaer Polytechnic Institute

Amount: \$627,998.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). nanocomposites ? which combine two or more distinct materials where at least one of the materials has dimensions of 100 nm or less ? are everywhere and are crucial for a wide variety of applications, ranging from automobiles, aircrafts and spacecrafts, buildings, sports equipment, travel packaging, to energy devices and electronics. the proportion of each material in a nanocomposite can be controlled to produce a composite material with properties that differ from each of the original components. a prominent goal is a combination that produces a material that is

both lightweight and has high mechanical strength. nanocomposites can also lead to extraordinary electrical or hardness properties that are not seen in the individual constituents. this boosting research ideas for transformative and equitable advances in engineering (brite) relaunch project aims to expand the boundaries of nanocomposite design and synthesis with a focus on these electrical and hardness properties. this project will advance the manufacturing process for these nanocomposites, expand knowledge and techniques related to the characterization of these materials, and develop models for the relationship between the structural variations and the properties so that they can be predicted and controlled through the manufacturing process. the knowledge gained will support the design and manufacturing of a new group of nanocomposites with properties that cannot be obtained from either conventional nanocomposites or natural biomaterials. this research will directly expose graduate and undergraduate students to multiple enriching collaborations with theorists and experimentalists in the usa and sweden. results from this work will enhance existing undergraduate and graduate courses on electronic properties, materials characterization and advanced structure. k-12 outreach efforts will include: engaging with high-school students and teachers; and supporting students from underrepresented sections of the society to encourage them to build careers in stem-related fields. mixing component materials in specific configurations allows access to property combinations that are not realized in individual materials, and the property enhancements are generally governed by the simple rules of mixtures. the researched work involves a merger of interface science, molecularly-engineered materials discovery, and nanomanufacturing. the overarching goal is to establish a platform for the manufacture of a completely new class of high-interface-fraction multilayered nanomaterials with inorganic nanolayers glued with organic nanolayers to realize unusual properties beyond the rules of mixtures. this includes materials with giant magnetoresistance and superhardness. such structures offer new possibilities to access, amplify and tune novel properties from superposition of effects from multiple nanoglued interfaces, and even realize a scenario wherein the interface properties become the materials' properties. manufacturing such nanocomposites with unprecedented



interface-dominated properties is anticipated to transformatively impact and expand the frontiers of a **\*\*diversity\*\*** of emergent technologies. specifically, this project will: synthesize nanoglued inorganic multilayers by hybrid atomic/molecular layer deposition techniques for different nanoglue structures and chemistries; characterize the thermal, chemical, and microstructural stability of the hybrid multilayers; unearth the effects of different facets of nanoglue structure and chemistry, and inorganic layer features, on mechanical and electrical properties; and develop models of nanoglue-induced property-enhancements to enable the realization of novel property combinations. the results are anticipated to open up new vistas for materials design and manufacturing beyond rule of mixtures, transcend crystallographically-constrained inorganic-organic hybrid materials, and facilitate synthetic materials and properties that are not accessible in current materials. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Using Whiptail Lizards to Understand the Integration of Environmental and Host Genetic Effects on Host-Associated Microbiota

Awardee: Clemson University

Amount: \$623,931.00

Abstract: animals, including humans, harbor large numbers of different microbes on and in their bodies ? so called host-associated microbiota. recently, scientists have begun to realize that host-associated microbiota are important determinants of host health. microbes in an animal?s gut, for instance, help digestion and can even help determine whether the animal is lean or obese. meanwhile, microbes on an animal?s skin can influence everything from wound healing to susceptibility to cutaneous disease. despite the importance of host-associated microbiota to host health, there is a surprising amount of variation in the microbiota on one host relative to another. how do these differences emerge? more specifically, are these differences a result of nature (i.e.,

host genetics) or nurture (i.e., host environment)? because most animals are genetically unique, it can be hard to determine whether inter-individual differences in host-associated microbiota are a result of host genetics, environment or both. in whiptail lizards, there are entire populations of genetically identical clones. what's more, these clones are closely related to other, sexually reproducing whiptail lizard species where each individual lizard is genetically unique. by comparing inter-individual variation in host-associated microbiota across different environments in clonal lizard populations versus sexually reproducing lizard populations, it will be possible to assess the relative importance of both host genetics and environment on host-associated microbiota. this research also provides an opportunity to train undergraduate students in research and scientific communication to help train the next generation workforce in stem. the strategy for this project is to use 16s rna gene sequencing to characterize and compare intraspecific variation in the bacterial and archaeal gut and skin microbiota of four hybrid parthenogenetic *Aspidoscelis* species and their bisexual parents. microbiota of each lizard complex (parthenogen + bisexual parent(s)), will be examined within a single vegetation community (low environmental variation), across different vegetation communities (intermediate environmental variation) and, for a subset of systems, across broad geographic ranges (high environmental variation). the first hypothesis is that variation will be smaller in parthenogens as compared to their bisexual parents. the second hypothesis is that inter-individual variation in lizard microbiota is driven by the environment, and that microbiome variation will be smaller at lower levels of environmental heterogeneity. determining the underlying causes of inter-individual variation in host-associated microbiota will identify rules governing host-associated microbial community assembly and, by extension, host health, fitness and ecological success. results from this work will have implications for both understanding microbial community assembly and guiding host conservation. as an example, knowledge of the factors that promote healthy host microbiomes will help to clarify trade-offs between preserving landscape **diversity** versus host genetic **diversity** during reserve selection. undergraduate students who are supported by this proposal will have the chance to perform research and to also develop

podcasts about biology research to broaden participation and to train students for careers in the sciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Algebraic Framework of Compositional Functions for New Structure, Training, and Explainability of Deep Learning

Awardee: University of Texas at San Antonio

Amount: \$622,955.00

Abstract: deep learning is a method of machine learning inspired by the human brain. data is fed to a multi-layered (deep) network of trainable 'neurons' and the network is then trained to model complex relations and processes. deep learning has had impressive success in applications such as image recognition and natural language processing. and yet, there are few theoretical guarantees to the method, to provide assurances in regards to performance features such as error and to explain its success. this is an impediment to broader application of deep learning, as many potential applications require guarantees for safety, reliability, and accuracy. this project pursues a solid mathematical foundation for a better understanding of the explainability of deep learning, to enable more efficient neural network design and training algorithms that benefit a wide range of applications. the project also includes a significant educational component that is designed to foster interdisciplinary education by engaging undergraduate and graduate students from the investigators' departments (applied mathematics, electrical engineering, computer science, mathematics) in the proposed multidisciplinary research. the project includes plans to promote **\*\*diversity\*\***, equity and inclusion in stem education at the university of california santa cruz and the university of texas at san antonio, which are both hispanic serving institutions. the overarching goal of this project is to develop a unified algebraic framework and approximation theory for deep neural networks so that the framework is applicable to a wide spectrum of problems including regression, solving differential

equations, designing optimal feedback control, and computer vision. the proposed research is motivated by the fact that most complicated and high dimensional input-output relations in real-world applications can be represented as compositions of simple low-dimensional functions. thus, compositional functions, including deep neural networks, serve as a natural way to describe complex high dimensional functions. representing compositional functions as layered acyclic graphs, the project will explore the compositional features of the problems to be solved by machine learning; study the error propagation in layered acyclic graphs; and investigate the interconnection between the compositional features and the fundamental issues of machine learning, such as the error bounds in universal approximation, deep neural network design and training, and validation and explainability. the algebraic framework, approximation theory, and computational algorithms to be developed in this research project should advance the design, training, and mathematical foundations of deep learning. they seek also to be directly applicable to a wide spectrum of applications including feedback control design and computer vision, which are included in this project, as well as other important machine learning applications, such as regression and data-driven modeling of dynamical systems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Statistical Mechanics of Cellular Structures

Awardee: Northeastern University

Amount: \$622,756.00

Abstract: nontechnical summary this career award supports theoretical and computational research integrated with education to gain a unified understanding of the physical properties of cellular materials. from honeycombs to foams to biological cells, materials with cellular structures are ubiquitous in nature. to advance understanding of cellular materials, the pi will use an

interdisciplinary approach that combines knowledge and techniques from physics, geometry, and biology. organ surfaces are covered with dense layers of cells, acting as physical barriers. while normally non-migratory, cells can undergo active rearrangements during basic processes such as embryo development, morphogenesis, repair, and remodeling. in these events, the cell layer transitions from a solid-like state to a fluid-like state. this striking transition is traditionally studied in the context of cells on a flat surface. however, most organ surfaces are naturally non-flat, and comprised of curved surfaces such as spheres, saddles, or cylinders. how surface curvature affects cell motion remains largely unknown. to address these questions, the principal investigator will study how cells move collectively on a curved surface and the role of curvature on whether they behave like a solid or a fluid. these investigations will generate predictions that can be tested experimentally in living embryos and lab-cultured tissues. the knowledge gained from biological tissues will serve as an inspiration for the pi to investigate the origin of rigidity in other cellular structures. these include the meshwork of forces in a solid or a mechanical network constructed by randomly connecting springs. the goal is to develop design principles for cellular structures to exhibit unusual mechanical properties and take advantage of them to design functional materials that do not readily occur in nature. this career award also supports educational activities tightly integrated with the research. the goal is to increase **diversity** and retention of students taking physics classes for the very first time, whether in high school or college. the pi will collaborate with k-12 stem educators to design unconventional yet accessible teaching modules for introductory physics classes. the modules will be based on biophysics, epidemiology, and biology while drawing connections to the fundamental physical concepts taught in introductory physics. these modules, which differ greatly from conventional "textbook examples", will provide students an eye-opening experience on the applicability and impact of physics concepts. technical summary this career award supports integrated theoretical and computational research, outreach, and education with the aim to advance the fundamental understanding of the statistical mechanics and collective behavior of cellular materials, including biological tissues, foams, granular packings, and their force networks. in the

biological context, the project will investigate the nature of the jamming/unjamming transition in multicellular collectives constrained on a curved surface and elucidate the origin of coherent angular motion that arises as a unique consequence of non-zero gaussian curvature. in non-biological cellular structures, the pi will investigate the consequence of mechanical dualities. the objective will involve deriving an effective hamiltonian in the force space for disordered granular solids based on the dual correspondence between self-stress states and floppy modes. the framework will be the basis for exploring the force-network ensemble of disordered grain packings. the pi proposes to leverage the duality of self-stresses and floppy modes to design disordered mechanical metamaterials with phononic bandgaps. this career award also supports educational activities tightly integrated with the research. the goal is to increase **\*\*diversity\*\*** and retention of students taking physics classes for the very first time, whether in high school or college. the pi will collaborate with k-12 stem educators to design unconventional yet accessible teaching modules for introductory physics classes. the modules will be based on biophysics, epidemiology, and biology while drawing connections to the fundamental physical concepts taught in introductory physics. these modules, which differ greatly from conventional "textbook examples", will provide students an eye-opening experience on the applicability and impact of physics concepts. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RUI:Test and Measurement Strategies for the Development of Biological Nanovalves

Awardee: Wheaton College

Amount: \$622,070.00

Abstract: with support from the chemical measurement and imaging program in the division of chemistry and co-funding from the interfacial engineering program in the division of chemical, bioengineering, environmental, and transport systems, dr. daniel burden, dr. lisa keranen-burden,

and their group in the chemistry department at wheaton college are developing a new set of laser-based tools that combine ultrasensitive microscopy with electrical measurements and protein engineering to monitor the movement of charged species through nanopores wherein protein toxins are used as nanovalves. their studies seek answers to questions such as what molecular sizes, shapes, and charge states are allowed to flow through the nanoscale valve interior, and what chemical modifications to the nanovalve are necessary to make it switchable on demand from the fully-on state to the fully-off state. the insights gained will likely be useful for a broad range of applications, including selective access to the interior of cells to fight infections, nanoscale separations, and chemical sensors. the research team is also working to enhance the size and **\*\*diversity\*\*** of the pool of qualified candidates for advanced stem degrees by investing in undergraduate research. elements of the research are integrated into the undergraduate curriculum, summer research opportunities, and public outreach activities in the surrounding community. measurement methods in ion-channel electrophysiology have traditionally been used to monitor the movement of charged species through nanopores. however, many translation events are electrically silent and cannot be detected. furthermore, an understanding of the sizes, shapes, charge states, and flow rates of species that can be transported (or blocked), as well as their relationship to nanovalve gating mechanisms, is critically important for developing future applications within the field. the burden group is investigating whether the alpha-hl toxin protein can be chemically modified to reversibly halt or permit molecular flow on demand. they also hypothesize that the size and rate of transported molecules will shift markedly upon triggered valve closure. they are developing measurement tools based on wide-field fluorescence microscopy, single-molecule confocal microscopy, and ion-channel electrophysiology to test a range of nanovalve constructs, with the ultimate aim of monitoring molecular transport across lipid membranes in a chip-based bilayer apparatus in real time. the pis are working with multiple undergraduate students, reaching out particularly to first-generation college-bound african-american or latino students from the chicago area. the pis are also actively working with outreach publishers to improve communicating research

outcomes to the public. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Belmont Forum Collaborative Research: Biosphere and Land Use Exchanges with Groundwater and soils in Earth system Models (BLUEGEM)

Awardee: Michigan State University

Amount: \$621,706.00

Abstract: this award provides support to u.s. researchers participating in a project competitively selected by a 9-country initiative on global change research through the belmont forum. the belmont forum is a consortium of research funding organizations representing over 55 countries focused on support for transdisciplinary approaches to global environmental change challenges and opportunities. it aims to accelerate delivery of the international research most urgently needed to remove critical barriers to sustainability by aligning and mobilizing international resources. each

partner country provides funding for their researchers within a consortium to alleviate the need for funds to cross international borders. this approach facilitates effective leveraging of national resources to support excellent research on topics of global relevance best tackled through a multinational approach, recognizing that global challenges need global solutions. this award provides support for the u.s. researchers to cooperate in consortia that consist of partners from at least three of the participating countries. the research teams will work to identify sustainable pathways to help alleviate the increasing and unprecedented pressure on the natural resources that interact to provide sustainable life support systems and essential benefits to societies such as food production and water quality and quantity. the impacts of changes in land management and urbanization will be evaluated to develop sustainable soils and groundwater management options that will help create and maintain sustainable terrestrial ecosystems. the project seeks to explore the evolution of groundwater, irrigation, and climate during the anthropocene (1900-2100), to better understand their interdependencies, foresee their potential changes, and identify possible social consequences. the team will assess these factors to identify sustainable pathways with respect to water resources, food security, bio\*\*diversity\*\*, and human well-being and socio-economic activities. the team will combine advanced numerical modeling of biophysical and social systems, as well as participatory methods with stakeholders, to address establish the fingerprint of interactions and irrigation on global and regional climate, water resources, biosphere, and soil carbon pools. the project results will provide improved projections of global and regional climate, water resources, biosphere and soil carbon pools, fully taking into account the influence of groundwater irrigation and groundwater-soil moisture interactions. the team will integrate local and regional knowledge and expertise as well as socio-economic data to refine the land use and irrigation scenarios used in state-of-the-art climate projections and to explore pathways for sustainable critical zone management. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: REU/RET Site: University of Hawai`i Institute for Astronomy

Awardee: University of Hawaii

Amount: \$620,829.00

Abstract: this research experiences for undergraduates (reu) program will offer individually mentored research experiences at the forefront of astronomical exploration to foster and enhance the careers of a diverse cohort of aspiring professionals in science, technology, engineering, and math (stem). the site will also include educators through the research experiences for teachers (ret) program. the institute for astronomy (ifa) at the university of hawaii reu/ret program will benefit society by training a diverse demographic in research skills needed in a stem career. they will achieve **\*\*diversity\*\*** by recruiting pacific islanders and minority students from professional organizations supporting african american, hispanic, and native american scientists. participants will learn about the impact that astronomical facilities have on indigenous people and the importance of communication between scientists and the public. progress towards achieving the desired societal outcomes will be assessed by conducting independent, external, quantifiable, surveys and interviews with the participants just before the program begins, at its mid-point, and after the program ends. many past students reported that this program was a key factor in their decision to attend graduate school or pursue a career in stem, and it is expected that new ret participants will multiply the program's effectiveness by bringing a modern astronomical research perspective to their classrooms. the method is based on past experience but will now be focused on diversifying the student demographics through targeted recruitment and restricting the program to students from non-research universities and colleges. with 50 mentors pursuing a broad range of astrophysical research, the participants will be immersed in the ifa's world-class research environment. the experience will also include activities that promote professional development. participants will visit observatories on mauna kea, complete research projects based on data from these facilities and participate in observations. in addition to the mentoring process, students will participate in a stem-specific professional development course

providing background and skills required for a stem career. a set of reports in the form of a research paper serves to develop the participants' writing skills. finally, the participants develop their presentation skills by preparing poster and oral presentations and then giving them to broad audiences. the participants are supported to present their research in poster or oral form at a professional meeting after the program ends. in the long term, the program will advance knowledge by sparking a lifelong pursuit of knowledge in a stem career in participants who will then bring their renewed excitement to their classrooms. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Transitioning MorphoBank to a sustainable, permanent home for phenotypic data in phylogenetics research

Awardee: Phoenix Bioinformatics Corporation

Amount: \$617,216.00

Abstract: scientists use the tools of phylogenetics to study this **\*\*diversity\*\*** and ask questions about how species evolve and how they are interrelated. such research addresses fundamental questions about the characteristics of living organisms, and helps scientists and the general public understand when, where and how traits like flowers and behaviors like the ability to fly first arose. such questions can be answered by collecting data on the detailed morphology, anatomy or other traits of the phenotype of many different species, organizing the data into ?matrices? and using the data to build phylogenetic trees that reconstruct evolutionary changes over time. these matrices and phylogenetic trees are the foundation for new discoveries in a wide range of scientific disciplines including animal and plant biology, bacteriology, anthropology and paleontology. morphobank is the only web-based software package for this work, and before it existed, researchers built matrices on their personal computers, a practice that limited the ability to collaborate and communicate, and to

disseminate and reuse data. because morphobank serves as an archive as well as a research tool, this software allows phylogenetics research to advance more quickly by facilitating the combination of old and new data. morphobank guarantees that integrated data are readable by both computers and humans and makes its data freely available to anyone worldwide, thereby opening up a new avenue for the public to access the direct products of scientific research. morphobank is a broadly used community tool to support basic biological research. recognizing that the tool must be sustained long term, in 2018 morphobank began the transition from grant-based support to a sustainable membership-based financial model in partnership with the non-profit scientific database organization, phoenix bioinformatics. over the next three years morphobank's leadership team will complete a transition to full membership support. morphobank will do this by growing its membership support from university libraries and museums while maintaining the core software and continuing to serve a growing us and international research community. the award will support software maintenance, data curation and scientific leadership, while morphobank ramps up its membership support sustainability plan. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Demand-driven science: the role of knowledge partnerships in improving the public value of conservation science

Awardee: Arizona State University

Amount: \$616,784.00

Abstract: in recent years, conservation scientists have recognized the importance of partnerships with stakeholders outside of academe to innovate and realize measurable conservation outcomes. knowledge partnerships represent a form of knowledge production that can advance public value outcomes. while public value is an important concept in science and innovation policy research and

management, there is little research on how partnerships between institutions can deliver public value, especially in conservation science. we propose to study how and when the supply of and demand for conservation knowledge are linked. in particular, we seek to examine, 1) what are the mechanisms by which the demand for knowledge informs the production and supply of science in conservation?; 2) what role do knowledge partnerships play in linking the supply of and demand for conservation knowledge, and what effect does the design of these partnerships have on their ability to deliver public value?; and 3) how can research projects and knowledge partnerships be designed to avoid public value failures, improve the connection between the production and use of science, and thus increase the public value of scientific activity? our proposed research builds on our recent work on determinants of the supply of public value outcomes in conservation science. by analyzing experiences of knowledge users and the possibilities inherent in knowledge partnerships as a distinct organizational form, we aim to understand the organizational configurations best suited for facilitating demand-driven conservation science. our proposed research will provide a model and tools for achieving and enhancing public value outcomes in conservation science and related fields. the identification of indicators of public value success is directly translatable and adaptable to governmental, private and non-profit organizations. this research will provide guidelines on how to design knowledge partnerships for public value and will offer new models of institutional partnerships to address complex social and ecological aspects of bio\*\*diversity\*\* conservation, thus enabling solutions that are relevant, culturally sensitive, economically viable and nimble. our proposed research will provide an evidence-based approach for maximizing public value outcomes in the production of conservation science. realizing public value outcomes in research entails structuring scientific research collaborations to meet established knowledge needs rather than producing knowledge for which there is no demand. public value outcomes in research also entails structuring institutions to provide incentives for public value outcomes; and structuring and scaling research programs and collaborations for impact based upon approaches documented to have the best potential for success. in examining the communication and translation processes that link

knowledge users to knowledge producers, we will focus specifically on those who often have not been included in these processes. with public value creation as the guiding principle, we will uncover lessons for the design of research projects, partnerships and knowledge-producing organizations. we will produce a framework for understanding how the processes of scientific research can be transformed to be more inclusive of stakeholders and improve the connection between the production and use of science, thus increasing the public value of scientific activity. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: BRITE Pivot: Tissue Research Advances for New Surgeries-Facilitating Organ Reconstruction with Mechanics

Awardee: Virginia Polytechnic Institute and State University

Amount: \$615,998.00

Abstract: this boosting research ideas for transformative and equitable advances in engineering (brite) pivot project will develop tissue mechanical property data and advanced computer modeling approaches to improve surgeries specific to transgender people. this work will mechanically characterize tissue from human genitalia. this work will leverage the researchers' existing expertise in evaluating the mechanics of soft tissues, such as ligaments and tendons. specifically, this work will make a computer model of how these tissues behave at the microscopic level based on data from measurements of actual tissue. the model will be used to evaluate differences among genital tissues of all genders. this work will improve our understanding of reproductive biomechanics of all persons. the results may ultimately improve healthcare by including this engineering assessment of tissue properties in surgical planning and procedures, including gender confirmation surgeries. this project will also promote inclusion in the engineering biomechanics research community through dialogue about conceptualization of gender, both within research and within the research

community. this research focuses on providing the first scientific-based data for gender confirmation surgeries that alter the genitalia of individuals with gender dysphoria to conform to their desired gender. state-of-the-art mechanical testing will be conducted on tissues from human genitalia to fully characterize their elastic and viscoelastic properties that are crucial for the success of surgeries including those for gender confirmation. novel mathematical and computational models will be developed to capture both the similarities and differences between male and female genitalia. through this brite pivot project, the principal investigator will gain new expertise in advanced numerical techniques for reducing the computational complexity of numerical simulations for gender confirmation surgeries. efficient and robust computational tools will lead to the development of novel engineered tissues and guidelines for gender confirmation surgeries, addressing the extant healthcare challenges of transgender people. the outcome of this project will thus promote gender **\*\*diversity\*\*** and equality in medical research while also changing the assumption of binary genders in the research community. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Redefining the footprint of deep ocean methane seepage for benthic ecosystems

Awardee: California Institute of Technology

Amount: \$615,832.00

Abstract: this research examines the role of deep-sea organisms in determining the fate and footprint of methane, a potent greenhouse gas, on pacific continental margins. the investigators are evaluating the deep ocean methanosphere defined by the microbial communities that consume methane and the animals that directly feed on or form symbioses with methane-consuming microbes. they are also investigating animal communities that gain energy indirectly from methane,



as well as those that take advantage of carbonate rocks, the physical manifestation of methane consumption in seafloor sediments. the study of methane seeps in the deep waters of both alaska (4400-5500 meters) and southern california (450-1040 meters) is enabling comparisons of the methanosphere under different food-limitation and oxygen regimes. by applying diverse chemical, isotopic, microscopy, and genetic-based analyses to seep microbes and fauna, this study is advancing understanding of the contribution of methane to deep-sea bio\*\*diversity\*\* and ecosystem function, information that can inform management and conservation actions in us waters. in addition to training for graduate and undergraduate students at their home institutions, the investigators are collaborating with the alaska native science and engineering program (ansep). they are recruiting alaskan undergraduates to participate in the research, contributing to ansep's online resources that promote interaction between scientists and middle and high school students, and participating in ansep's annual residential career exploration in marine science programs to engage middle school students in learning about deep-sea ecosystems and the variety of career pathways available in marine related fields.

microbial production and consumption of methane is dynamic and widespread along continental margins, and some animals within deep-sea methane seeps rely on the oxidation and sequestration of methane for nutrition. at the same time, understanding of methane-dependent processes and symbioses in the deep-sea environment is still rudimentary. the goals of this study are to 1) examine the \*\*diversity\*\* of animals involved in methane-based symbioses and heterotrophic consumption of methane-oxidizing microbes and how these symbioses extend the periphery of seeps, contributing to non-seep, continental slope food webs; and 2) determine whether carbonates on the seep periphery sustain active methanotrophic microbial assemblages, providing a localized food source or chemical fuel for thiotrophic symbioses, via anaerobic oxidation of methane, or free-living, sulfide-oxidizing bacteria consumed by animals. the investigators are addressing these goals by surveying, sampling, and characterizing microbes, water, sediments, carbonates and animals at a deep seep site on the aleutian margin and a shallow site off southern california. shipboard experiments and laboratory analyses are using molecular,

isotopic, geochemical, and radiotracer tools to understand transfer of methane-sourced carbon from aerobic methanotrophs under multiple oxygen levels, pressures, and photosynthetic food inputs. this approach offers a wide lens by which to examine the methane seep footprint, allow reinterpretation of past observations, and identify new scientific areas for future study. improved characterization of the deep continental margin methanosphere informs climate science, bio\*\*diversity\*\* conservation, and resource management. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Temporal dynamics of microbial and viral function and adaptation in hydrothermal vents

Awardee: Carleton College

Amount: \$614,024.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). this project is funded by the biological oceanography and the ocean education programs (division of ocean sciences) and the systematics and bio\*\*diversity\*\* science cluster (division of environmental biology). microbes and viruses living near deep-sea hydrothermal vents act as filters for carbon, sulfur, iron, and other essential elements that emerge from the seafloor and flow into the global oceans. however, due to the challenges associated with sampling the deep sea, most studies to date have captured only snapshots of these communities, leaving significant knowledge gaps about how microbes and viruses adapt, evolve, and respond to changes in this environment. the researchers use infrastructure from the ocean observatories initiative to conduct high-resolution monitoring of genetic changes over five years to investigate microbial communities? function, ecology, and evolution at hydrothermal vents, which are thought to be one of the most ancient habitats on earth. data from this project are expected to be a valuable scientific resource for these

and other researchers to address future questions. for example, it will inform our understanding about the early evolution of life on earth and how microbes and their viruses respond to anthropogenic disturbances like deep-sea mining and climate change. this project engages and trains undergraduate students as scientific partners at all stages of the research process, facilitating their entry into scientific networks. additionally, a new course guides college students in examining science within its cultural, political, and social context. the project also includes a program with a local elementary school to increase science literacy among young students. the main objective of this project is to understand the ecological and evolutionary forces that mold hydrothermal vent microbial and viral populations over time. this project uses instruments from the ocean observatories initiative regional cabled array (ooi rca) at axial seamount in the northeast pacific ocean to collect hydrothermal fluid and dna samples at regular intervals, approximately every 10-20 days over five years, to yield a time series of microbial and viral abundances and metagenomes. the specific scientific aims of this project are to: 1) identify environmental drivers of microbial community composition and function through time-series analyses of 16s rrna amplicon and metagenomic datasets combined with chemistry, ph, and temperature data; 2) use single nucleotide variant and gene content variation over time in metagenome-assembled genomes to investigate evolutionary dynamics of microbial populations; and 3) assess models of viral population dynamics by tracking micro\*\*diversity\*\* within viral and microbial metagenomes over time. comparative samples and data collected from other vent sites are used to determine the generalization of the results. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Excellence in Research: From genomics to ecophysiology: the adaptive metabolic strategy of heterotrophic marine *Cyclobacterium* species

Awardee: Hampton University

Amount: \$613,265.00

Abstract: the majority of microbial bio\*\*diversity\*\* in the ocean lies within the realm of the rare biosphere. these rare microbes are essential for ecosystem dynamics and play a central role in the carbon cycle from assimilation, storage, transformation, export, and remineralization of the largest pool of organic carbon on the planet. the members of bacteroidetes, are emerging as key players in the degradation of high molecular weight dissolved organic carbon (dom). in this research project, *cyclobacterium marinum atlantic-is*, a member of bacteroidetes and part of the rare biosphere, will be studied to determine how *c. marinum atlantic-is* adjusts its growth in response to different dom present in the marine environment. this project will examine how *c. marinum atlantic-is* adjust its growth in response to different dom present in the marine environment and thus will enhance the understanding of microbial degradation of complex carbohydrates and the molecular processes involved in the usage of different organic carbons. this research has implications for understanding functional ecological significance of rare bacterial taxa in ocean ecosystems. this study actively engages undergraduate students of color. students will gain knowledge and skillsets spanning molecular biology methods, microbial physiology, and quantitative data analysis. this training will contribute to student retention in stem, increase \*\*diversity\*\*, and workforce development. this project will strengthen research capabilities of the principal investigator and build research capacity at a historically black college and university (hbcu). a partnership between the hbcu and woods hole oceanographic institution will be established. the annotated draft genome of *c. marinum atlantic-is*, which was collected from benthic water of the atlantic ocean, contains higher than expected number of polysaccharide utilization genes, hydrolases, and transport-related proteins that would allow the bacterium to survive under famine conditions and bloom when dom is abundant. in addition, it contains a large number of regulatory genes, which could be pivotal for the generation of swift and adaptable metabolic responses to changing dom in the environment. the principal investigator will test the hypothesis that *c. marinum* with its large number of polysaccharide utilization genes, transporters, and regulatory genes is able to adapt to changing carbon sources in

oligotrophic oceans. this hypothesis will be tested by combining transcriptomics, proteomics, and physiological approaches to understand the expression of various transporters and regulatory networks that trigger the use of select polysaccharides and polymeric glycans thought to be abundant in the ocean. in particular, the expression of numerous transporter systems in response to different carbon sources and the speed of response to changing carbon sources will be determined. ultimately, this research will enhance the understanding of heterotrophic bacteria in the ocean and their ecophysiology. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: ATETV presents: Technician Navigator

Awardee: Pellet Productions, Inc.

Amount: \$611,023.00

Abstract: in its 2019 report on the skilled technical workforce, the national science board noted that skilled technical workers represent 13% of the u.s. workforce aged 25 and older. furthermore, these workers "contribute to all parts of the economy and the science & engineering enterprise" by exercising "critical thinking, design, digital, math, and coding skills to work as auto mechanics, health care technicians, electricians, welders, computer systems analysts and administrators, and operators of "smart" infrastructure." this project will bring awareness to the educational pathways leading to work and career opportunities in the skilled technical workforce, bolstering connectedness among ate students - and more generally all students in the two-year sector, educators, and industry stakeholders. a stem-capable and competitive workforce leads to innovation, success in industry, new discoveries in research and development, and advancements in stem achievements. this ultimately yields a more economically prosperous nation, renewed global competitiveness, and greater economic security and prosperity, all of which are goals of the ate program. technician navigator will produce an atetv repository of authentic original content produced by current practicing technicians for future technicians that will include blogs, videos, audio materials, and forums. these materials will inform and engage students, families, and educators. through virtual events and one-on-one sessions developed by faculty and industry representatives, technicians will guide prospective students through the college decision-making process, supporting them through enrollment. creating contextual experiences to increase the quality, quantity, and **\*\*diversity\*\*** of a skilled technical workforce is at the heart of this project. contextual experiences meet prospective students where they are instead of trying to attract their attention, and then use a series of connected experiences that incrementally guide them along their journey to enrolling in technician education programs at community and technical colleges. this will be a first-of-its-kind experiential resource designed to attract and recruit students into technician education programs and walk them through the process of enrolling in technician education programs. it is expected that technician

navigator will serve the ate community as a tested model for student recruitment with digital tools and resources for use in other ate community outreach efforts. content and contextual experiences will establish a community, connect people and programs, and generate excitement and interest through authentic materials and experiences. this project is funded by the advanced technological education program that focuses on the education of technicians for the advanced-technology fields that drive the nation's economy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: New Approaches to Catalyst Screening and Development

Awardee: University of Nebraska-Lincoln

Amount: \$607,249.00

Abstract: this research project builds on a platform being developed by the university of nebraska research team to exploit enzymes as catalytic reporters to facilitate reaction discovery and catalyst optimization. this approach is termed in situ enzymatic screening. the method utilizes "reporting enzymes" to provide real-time information on the relative rates for a set of parallel organic/organometallic reactions of interest. parallel screening methods are of interest to chemists in academia and industry as they enable the identification of fundamentally new transformations of novel catalysts for targeted reactions. there is a particular need for focused screening in process chemistry groups in the pharmaceutical industry, where reaction optimization is critical. this project seeks to develop new enzymatic screening tools that are applicable across a range of temperatures and that take advantage of phosphate ester functionality for which enzymatic screens are not yet available. the project will also help build the future stem (science, technology, engineering, and mathematics) workforce by training a diverse group of undergraduate and graduate students in an interdisciplinary research environment at the chemistry/biology interface, including elements of



organic, organometallic, analytical, and enzymatic chemistry. this project will further explore and develop an information-rich parallel screening method, termed in situ enzymatic screening (ises), that uses enzymes as biomacromolecular sensors to provide read-out directly to the experimentalist. this research builds upon the team's earlier proof-of-concept studies that led to the first examples of catalytic asymmetric allylic amination chemistry with nickel, an earth-abundant metal, and that uncovered a useful new transformation for **diversity**-oriented synthesis known as thiocyanopalladation/carbocyclization. this proposal seeks to fully launch the "phosphate-ises" and "thermal-ises" screening platforms. the former goal is motivated by the emergence and importance of substrates bearing dialkyl phosphate functionalities, an important functional group both for transition metal coordination and for specific chemistry. these new enzymatic screening platforms have been built by expressing and testing candidates for screening enzymes that recognize dialkyl phosphates and/or that operate at elevated temperatures. preliminary results point to enzymes that produce a uv/vis signal under such conditions, enabling the screening of candidate metal-ligand combinations at elevated temperatures or in reactions where dialkyl phosphate functionalities are critical. these methods are being developed with specific targeted chemistry in mind, particularly the catalytic asymmetric synthesis of alpha-halovinyl amino acids as potential mechanism-based inhibitors for plp (pyridoxal phosphate) enzymes. this synthetic goal builds on recent developments in this laboratory in which quaternary, alpha-(1-fluoro) vinyl amino acids were synthesized for the first time. the scientific broader impacts of this work include opening new avenues for the catalyst discovery process and for green and sustainable chemistry. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Edge CMT: Polygenic traits of heat stress phenome in coral "dark genes" from genome to functional applications

Awardee: Carnegie Institution of Washington

Amount: \$603,400.00

Abstract: in this project, the researchers will use genomics, genetics, and cell biology to understand the function of coral genes during heat stress. thermal stress often causes the "bleaching" (whitening) of corals that is harming reefs worldwide and is a threat to marine biodiversity. genes are the functional unit of dna and how the coral reacts to heat stress is called its phenotype. there are many genes involved in achieving the heat response phenotype and they will be studied in this project. this is important because the function of many of these and other genes and how they influence the phenotype of corals are not understood. in addition, many of the coral stress genes are unknown in other organisms (i.e., they arose in corals), and therefore present the opportunity to discover the function of novel genes. this research is important because it will help in the understanding of how both known and novel genes function, which can aid in the conservation of coral reefs- a resource that is important for national security and economic growth. lastly, this project will fund early career scientists and lead to broader impacts through the training and education of a diverse workforce in science. the overarching goal of this proposal is to determine the mechanistic drivers of the stress response in multicellular organisms, with a focus on the ecologically important corals. to achieve this goal, application of an end-to-end approach that extends from genes to phenotypes, to cell biology, using multi-omics and network methods with both holobiont and single cell data will be applied. this work will elucidate the coral stress phenome in species with differing reproductive strategies and geographical origins to determine the functions of both known and unknown (dark) genes. generating this knowledge base will transform coral biology and more broadly, provide a research platform for testing hypotheses about the resilience of other ecosystems, marine and terrestrial, which is particularly important under accelerating climate change. this project aims to increase the understanding and predictive capability of how key properties of living systems emerge from the interaction of genomes. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's

intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Testing the reduction of aerobic habitat as a common kill mechanism for major mass extinction events

Awardee: Stanford University

Amount: \$602,541.00

Abstract: the project will study the response of marine animal ecosystems to environmental change using three mass extinction events from the geological record as study systems. specifically, the project will test the hypothesis that a large proportion of extinction during these events can be explained by the stresses that elevated temperatures and reduced oxygen availability place on animal respiration. geochemical data will be used to constrain computer simulations of changing ocean conditions during these mass extinction events. results from laboratory studies on animal respiration will then be paired with fossil data to assess whether differences in extinction intensity in space and across taxonomic groups can be explained by spatial variation in environmental change or differences among taxonomic groups in their ability to withstand environmental change. the project will provide interdisciplinary training to a group of graduate students and post-docs. it will further impact stem education through the creation of a website that will allow access to model results so that students can visualize and explore model output to understand cause-effect relationships between continental configuration, ocean conditions, and biological **\*\*diversity\*\***. the investigators will also offer short-courses on earth system modeling and data interpretation at major conferences that will be recorded for asynchronous use. the project will also involve the development of a podcast series addressing how we reconstruct the ancient earth system and use these reconstructions to better understand the present and predict the future. in this project, the hypothesis will be tested that the loss of habitat through constraints on aerobic respiration under climate change and ocean deoxygenation can explain the magnitude, taxonomic selectivity, and

latitude variation in intensity for the late devonian (frasnian-fammenian), end-permian, and end-triassic mass extinction events. paleoredox and paleoclimate proxy data and geochemical indicators of diagenetic alteration will be used for both global average and local conditions before and after each major event combined with predictions from earth system models and occurrence data from the fossil record of marine animals to separate aspects of extinction that can be explained by physiological stress from those that require other explanations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: LTREB Renewal: The reorganization and resynchronization of biogeochemical cycles after an unprecedented tundra fire

Awardee: University of Notre Dame

Amount: \$600,000.00

Abstract: fire has been historically rare in the arctic tundra, but is projected to increase in severity and frequency in a future warmer world. the rarity of fires in this biome has made it challenging to measure, understand, and predict the consequences of fire on important ecosystem services such as species **diversity** and ecosystem carbon cycling. furthermore, the impacts of fire last a long time-- years to decades-- by altering critical biogeochemical cycles that are important for long term ecosystem recovery. since fire severity can dramatically reduce soil nutrient availability, it is hypothesized that ecosystem recovery is dependent on both burn severity and post-fire soil resources. this project continues a ten-year project studying the effects of fire on terrestrial carbon cycling in alaskan tundra ecosystems. the research combines long-term ecological observations, a nutrient addition experiment, and improvement of an ecosystem model. training and workforce relevant skills for both undergraduate students and graduate students are being provided. a children's book will be published to reach the general public, as well as a youtube video. a large

amount of data about ecosystem processes is being contributed to public databases. this research will acquire and synthesize a multi-decadal record (2008-2026) of ecosystem function from the unprecedented 2007 anaktuvuk river fire on the north slope of alaska. eddy covariance fluxes and biomass harvests will measure temporal changes in ecosystem carbon fluxes and stocks across a burn severity gradient (severe-, moderate-, and un-burned tundra), while nutrient fertilization experiments at the severe- and un-burned tundra sites will determine the role of nutrient availability on the rate of ecosystem recovery. these records will inform a coupled biogeochemical model (i.e. the multiple element limitation [mel] model) to improve predictions of the long term impacts of fire on arctic ecosystem carbon cycling. the development of the mel model will provide a powerful tool for scientists, land managers, and policy makers to quantify the future impacts of fire in this rapidly-changing region. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: III: Medium: Collaborative Research: Self-Supervised Recommender System Learning with Application Specific Adaption

Awardee: University of California-Davis

Amount: \$600,000.00

Abstract: in the era of big data, to effectively help people get their desired information, recommender systems are widely adopted by various online platforms. recommender systems aim to provide users with high-quality recommendation services. in addition to e-commerce, other potential applications include precision medicine to recommend targeted patient treatment, friend recommendation in online social networks, decision support, e-learning, etc. however, various data quality problems and model learning challenges will create great obstacles for recommender system deployments in the real world. to address these challenges, this project explores to develop new

techniques for learning recommender systems that don't rely on supervision information like manual label or annotation, which can be costly to obtain. this is referred to as the recommender system self-supervised learning, which provides a promising learning paradigm that can discover the supervision signals from the data itself without the need of costly manual annotation. as an effective technique, self-supervised learning will enable recommender systems to work well in a variety of challenging application scenarios to provide people with high-quality and fair recommendation services for almost all the existing online platforms mentioned above. this project focuses on developing a general recommender system framework with self-supervised learning, and investigating its various extensions. this project will develop unified and extensible principles, methods, and technologies for recommender system learning, and study the general applicability and benefit of recommender system self-supervised learning. the recommender system tasks studied in this project are extremely challenging due to many reasons: (1) lack of supervision information, which renders many existing recommendation models to be ineffective; (2) inherent data biases, which can lead to unfair treatment to the minority user groups; (3) the cold-start problem, which concerns on the issue of inferences for subjects with little collected information; and (4) recommender system dynamics, which reflects the changing characteristics or behaviors of the users. this project will address these challenges on learning representations for recommender systems with a novel and extensible graph neural network model. based on the state-of-the-art self-supervised learning techniques, e.g., data augmentation which aims to significantly increase the **diversity** of data available for training models without actually collecting new data, and contrastive learning which intends to learn succinct data representations such that similar samples stay close to each other, while dissimilar ones are far apart, the proposed model can be pre-trained with self-supervised learning, which will be further transferred to address the problems studied in this project via effective fine-tuning. specifically, this project will focus on studying four main tasks: (1) fairness-oriented recommender systems pre-training and fine-tuning, (2) cold-start recommender system learning via data augmentation; (3) inter-platform recommender system contrastive learning;

and (4) lifelong dynamic recommender system learning via self-supervised model tuning. in terms of broader impacts, besides the recommendation tasks as investigated in this project, advances in such research studies have transformative potentials for fundamental development in reforming the current and future ai model fairness, trustworthiness, and lifelong learning studies in broad applications. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity



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Title: III: Medium: Collaborative Research: Self-Supervised Recommender System Learning with Application Specific Adaption

Awardee: Florida State University

Amount: \$600,000.00

Abstract: in the era of big data, to effectively help people get their desired information, recommender systems are widely adopted by various online platforms. recommender systems aim to provide users with high-quality recommendation services. in addition to e-commerce, other potential applications include precision medicine to recommend targeted patient treatment, friend recommendation in online social networks, decision support, e-learning, etc. however, various data quality problems and model learning challenges will create great obstacles for recommender system deployments in the real world. to address these challenges, this project explores to develop new techniques for learning recommender systems that don't rely on supervision information like manual label or annotation, which can be costly to obtain. this is referred to as the recommender system self-supervised learning, which provides a promising learning paradigm that can discover the supervision signals from the data itself without the need of costly manual annotation. as an effective technique, self-supervised learning will enable recommender systems to work well in a variety of challenging application scenarios to provide people with high-quality and fair recommendation services for almost all the existing online platforms mentioned above. this project focuses on developing a general recommender system framework with self-supervised learning, and investigating its various extensions. this project will develop unified and extensible principles, methods, and technologies for recommender system learning, and study the general applicability and benefit of recommender system self-supervised learning. the recommender system tasks studied in this project are extremely challenging due to many reasons: (1) lack of supervision information, which renders many existing recommendation models to be ineffective; (2) inherent data biases, which can lead to unfair treatment to the minority user groups; (3) the cold-start

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Matched Words: diversity

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Title: Gravitational Wave Transient Astrophysics with LIGO

Awardee: Georgia Tech Research Corporation

Amount: \$600,000.00

Abstract: in the five years since the historic discovery of gravitational waves unlocked the dawn of a new kind of astrophysics, gravitational waves have continued to probe the cosmos and reveal some of the most obscure mysteries of the universe. according to the theory of general relativity,

gravitational waves are tiny oscillations of the curvature of space-time produced by the acceleration of massive astrophysical objects, such as colliding black holes or neutron stars. the information these waves carry is different and complementary to that of photons, neutrinos and cosmic rays -- this is the era of multi-messenger astrophysics. the nsf-funded laser interferometer gravitational-wave observatory (ligo) is currently the most sensitive gravitational wave-detector in the world. following its first discovery of gravitational waves in 2015, ligo and its sister project virgo together have now detected dozens of binary black hole collisions, and are exploring the origins and nature of black holes that were once only theorized about. the landmark 2017 multi-messenger observation of binary neutron star (bns) merger gw170817 yielded a wealth of additional discoveries, and has prompted the field to grow at an even more rapid pace. this award supports ligo science performed at the georgia institute of technology for the detection, characterization and astrophysical interpretation of gravitational-wave transients in ligo data, towards a new frontier in science and a deeper understanding of the universe. the team supported by this award has a long record of contributing to mission-critical tasks and publications of the ligo scientific collaboration, and will continue to engage in core ligo science through a combination of morphology-independent techniques, template-based approaches, and multi-messenger strategies. the team will enable ligo science by developing data analysis infrastructure, studying the impact of data quality and participating in the analysis of candidate events using three algorithms in use by the ligo scientific collaboration: bayeswave, a model-independent code for waveform reconstruction and event characterization; rift, a code for rapid parameter inference using template families and numerical relativity waveforms; and pygrb, for the detection of coincidences with astrophysical events such as gamma-ray bursts. the team will also explore novel approaches for understanding special astrophysical targets, such as neutron-star post-merger events, black hole hyperbolic encounters, and coincidences with neutrino events. the award will benefit from the collaboration of a synergistic team at the georgia tech center for relativistic astrophysics which includes experts in computational astrophysics, cosmology, particle astrophysics, astronomy, the college of computing, a strong

outreach program in atlanta enhanced by the ties to the ligo scientific collaboration, and a firm commitment to **\*\*diversity\*\***, equity and inclusion and the engagement of women in stem. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: SaTC: CORE: Medium: Making Crypto Too BIG To Break

Awardee: Northeastern University

Amount: \$600,000.00

Abstract: this project aims to build new cryptosystems with strong security guarantees, by making the secret keys and/or communication large. the unifying technique is to overwhelm the adversary with information to ensure that it cannot store enough of it to break the scheme, even given significantly more resources than the honest users. the project's novelties are new cryptosystems where: (1) security holds even if an adversary compromises the machine storing the secret key and exfiltrates large amounts of data, (2) security does not rely on any unproven mathematical assumptions, but instead just requires either a large key, or large amounts of communication between the honest participants. the project's impacts are: (a) the design of more secure systems in the real world, (b) synergizing, unifying and abstracting techniques from many diverse areas of computer science, and (c) mentoring undergraduates, graduate students and postdocs with an emphasis on fostering **\*\*diversity\*\***. the design of cryptographic schemes and protocols traditionally strives to make secret keys and communication as small as possible. in this project, the investigators argue that there are several important settings where it is possible to dramatically improve security by making secret keys and/or communication large, while still allowing the resulting scheme to be quite practical. the project focuses on three such settings. the first setting considers an adversary who breaks a cryptographic scheme by outright stealing the corresponding secret key. a promising approach to mitigate against such attacks is to make cryptographic keys intentionally

huge, to prevent an adversary from exfiltrating them in their entirety. this project suggests novel research directions towards bringing such schemes closer to reality. the second setting studies cryptosystems with information-theoretic (it) security, that are provably secure even against attackers with unlimited computational power. while such cryptosystems are known to require a large key, the project studies how to make them practical by ensuring that they are stateless and read only small portions of their large keys at every use. the third setting studies it-secure protocols, where the protocol communication is made intentionally large, so that it becomes infeasible for the attacker to store it all. the honest participants process the communication in a streaming manner using much less storage than the adversary. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: SaTC: CORE: Medium: Making Crypto Too BIG To Break

Awardee: New York University

Amount: \$600,000.00

Abstract: this project aims to build new cryptosystems with strong security guarantees, by making the secret keys and/or communication large. the unifying technique is to overwhelm the adversary with information to ensure that it cannot store enough of it to break the scheme, even given significantly more resources than the honest users. the project's novelties are new cryptosystems where: (1) security holds even if an adversary compromises the machine storing the secret key and exfiltrates large amounts of data, (2) security does not rely on any unproven mathematical assumptions, but instead just requires either a large key, or large amounts of communication between the honest participants. the project's impacts are: (a) the design of more secure systems in the real world, (b) synergizing, unifying and abstracting techniques from many diverse areas of computer science, and (c) mentoring undergraduates, graduate students and postdocs with an

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Matched Words: diversity

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Title: Fortifying Cybersecurity and Computing Education

Awardee: Prince George's Community College

Amount: \$599,839.00

Abstract: the need for a highly skilled cybersecurity and it workforce is well documented and unequivocal. ?demand for security skills, once limited primarily to government and the defense industry, has spread throughout the economy? (burning glass, 2019). ?job growth is predicted to

continue to outpace the number of available qualified workforce? (cyberseek.org, 2020). community and technical colleges respond to this need through their education of the skilled technical workforce. this project aims to strengthen and grow a specific component of that workforce, namely the nation's cybersecurity/computing professionals. the project's approach is to work to increase the quality of the requests for external support that these institutions seek to improve cybersecurity education at their campuses. towards this end the project investigators plan to attract a **\*\*diversity\*\*** of community and technical college teams, composed of faculty, grant writers, and selected administrators and staff and provide team-based professional development designed to increase the competitiveness and innovativeness of each teams' proposed efforts in support of the education of the cybersecurity/computing skilled technical workforce. in each year, up to twelve community and technical college teams of two faculty members and a grant writer will be accepted through an application process to participate in this team-based professional development and mentoring program. each team will be carefully matched with and supported by a seasoned mentor who has been trained through a series of coaching sessions by the leadership team. essential elements of the program, including mentor training, pre-workshop mentee preparation, a multi-day workshop, and post-workshop webinars coupled with team mentoring throughout the entire process, are designed to help participants crystalize their innovative ideas and develop competitive proposals for external support. this project is funded by the advanced technological education program that focuses on the education of technicians for the advanced-technology fields that drive the nation's economy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: RI: Medium: Submodular Information Functions with Applications to Machine Learning

Awardee: University of Texas at Dallas

Amount: \$599,594.00

Abstract: a growing number of machine learning applications involve selecting subsets of data. examples include selecting smaller subsets from a much larger dataset to label (to save labeling costs) and to train (to reduce computational costs), or selecting a summary of a video or a photo collection to ease viewing by a person. submodularity is a natural way to address these problems because it naturally models many aspects like **diversity**, representation, and coverage. in this project, the pis will study a rich class of submodular information measures that model not only **diversity**, representation, coverage but also constructs such as relevance and irrelevance to certain target concepts. one application of this is selecting a data summary with certain user specifications -- e.g., a summary relevant to a given query or under a privacy constraint (a photo summary relevant to a specific person or one which avoids certain personal information). another application is to interactively select data samples to label in the presence of rare classes or while avoiding outliers (e.g., cancerous images as rare classes for medical imaging tasks). advances in this field can have implications in many areas including data summarization, reducing labeling efforts (in tasks like medical imaging), and reducing the carbon footprint for training deep learning models on massive datasets. the underlying mathematical model proposed in this project is a rich class of functions called ``submodular information measures``, which includes submodular mutual information, submodular conditional gain, submodular multi-set mutual information, directed submodular mutual information, and combinatorial independence. specifically, the pis will investigate and develop: (1) rich theoretical properties and instantiations of these submodular information measures; (2) optimization algorithms, approximation bounds, and hardness results of the associated optimization problems; (3) applications of the submodular information measures in data summarization, data subset selection, active learning, clustering, and diversified partitioning. while pursuing these activities, the pis will involve undergraduate and under-represented high-school students in this research to inspire them to pursue careers in ai/ml and other stem-related fields. this award reflects nsf's statutory mission and has been deemed worthy of support through



evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Deconstructing the Fitness Tradeoffs that Limit Viral Host Range

Awardee: North Carolina State University

Amount: \$599,448.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). this research project will explore how viruses adapt to multiple host species. viruses have a remarkable capacity to adapt to novel environments, but their potential to infect new hosts is not necessarily limitless. adapting to a novel host is largely thought to decrease pathogen performance or fitness in other hosts, limiting the range of hosts a given pathogen can infect. understanding how these tradeoffs could therefore provide major insights into how best to control and manage viral pathogens. this research project will develop new computational methods to estimate pathogen fitness across different environments and scales. these methods will be applied to study viral fitness tradeoffs in tomato spotted wilt virus (tswv). tswv is a major pathogen of several important crops and its wide range of plant hosts has allowed it to become a major agricultural threat worldwide. in addition, the project will involve undergraduate and graduate students in the research, and develop a virtual environment in which students can interact and respond to a series of simulated epidemic threat scenarios. studying how tswv adapts to novel hosts will therefore provide insight into how a generalist virus with an already broad host range evolves, how fitness tradeoffs between hosts limit simultaneous adaptation to multiple hosts, and whether selection can resolve these fitness tradeoffs over time, leading to further host range expansion. through this project, the researchers will develop new phylodynamic birth-death models for studying adaptive evolution. these methods will be used to estimate the transmission fitness of pathogens in different environments and can even reveal how particular mutations influence fitness. along with developing these methods, the researchers will conduct an extensive field survey of tswv genomic **\*\*diversity\*\***

across multiple hosts to determine the fitness of individual viral genotypes on a panel of crops and native plant hosts. by combining the newly developed phylodynamic methods with empirical measures of viral fitness on different hosts, the researchers will then be able to explore how fitness tradeoffs shape the host range of a generalist viral pathogen and how these fitness tradeoffs evolve over time. viral isolates will also be further experimentally passaged between alternate hosts in the lab to explore how selection can breakdown or resolve fitness tradeoffs between alternate hosts. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Attracting the Next Generation Cybersecurity Workforce

Awardee: Massachusetts Bay Community College

Amount: \$598,712.00

Abstract: this project will address the well-documented need for skilled cybersecurity technicians in the metrowest and greater boston regions of massachusetts. moreover, the project team aims to increase the racial and gender **\*\*diversity\*\*** of the overall cybersecurity workforce that will satisfy those local workforce demands. a replicable and sustainable educational ecosystem will be developed that will recruit, retain, and graduate students in the cybersecurity program at massbay community college. through collaborations with regional industry and high school partners, the program will encourage high school students to pursue degrees, and careers, in cybersecurity. retention efforts will ensure that students majoring in cybersecurity achieve a mastery of the knowledge and the practical skills needed to meet industry expectations. students will be provided with mentoring, career advice and support, and internship opportunities to ensure their success and entry into the cybersecurity workforce. the educational experience provided by massbay will be based on the development of a "cyber range," which is an internet-based computer network platform that provides students with hands-on experience in cybersecurity. exercises will be developed to

give high school and college students practical experiences in cybersecurity. these exercises will be developed in collaboration with industry partners, using their security products, to provide students with real-world experiences in cybersecurity. the project's cyber range will be used to create workshop activities for high school students, develop training materials to instruct and educate students to become peer-mentors, and offer train-the trainer workshops to high school teachers and massbay faculty. high schools, youth serving organizations, and industry partners will use the cyber range to host cyber competitions, hackathons, mentoring, and internships to make students aware of and motivate them to pursue degrees in cybersecurity. this project is funded by the advanced technological education program that focuses on the education of technicians for the advanced-technology fields that drive the nation's economy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: HSI Implementation & Evaluation Project: Alverno College STEM Community Impact Program (SCIP)

Awardee: Alverno College

Amount: \$598,322.00

Abstract: with support from the improving undergraduate stem education: hispanic-serving institutions (hsi program), this track 2: iep aims to increase retention and graduation of stem majors through focused community engagement activities to enhance stem identity. as a women's college serving primarily first-generation, low-income students, more than half women of color, alverno college will use this project to broaden participation of underrepresented minorities and women in stem, who lag in stem degree attainment and stem workforce participation. increasing racial/ethnic and gender **\*\*diversity\*\*** in stem is a recognized strategy to expand the stem workforce. this project utilizes evidence that women and underserved students in stem are motivated by directly

experiencing the ways that stem benefits their communities. the project will directly engage 400 students enrolled in stem courses, including approximately 125 stem majors, in activities that connect supportive communities to stem curricular and co-curricular experiences. the project engages all stem majors in introductory and capstone community-service activities. it extends peer mentoring to all stem majors and raises the profile of community engagement. the project engages our external community in a cooperative relationship, recognizing the intersection between stem and students' social/community identities. the project will leverage the importance of family support to students of color and women in college success, choice of major and career. a professional mentorship network between current stem students and alumni will capitalize on evidence that professional latinx/ hispanic role models influence stem success. ongoing faculty development in culturally responsive teaching and a formalized administrative support structure will expand project impact across the college.

alverno's project will advance knowledge by investigating the impact of a community engagement program on stem identity, improving retention and graduation into stem careers. the program will measure the association between level of engagement in project activities and college retention, and will analyze participant reflections to understand stem identity development. this work will identify which aspects of the program had the greatest impact on decisions to enter and remain in stem and to pursue stem-related careers. it is anticipated that 100% of stem majors will participate in community engagement activities and that graduates will develop realistic expectations of stem which is critical in meeting community needs. alverno's project will provide a scalable, replicable model for other hsis to adapt. the hsi program aims to enhance undergraduate stem education, broaden participation in stem, and build capacity at hsis. achieving these aims, given the diverse nature and context of the hsis, requires innovative approaches that incentivize institutional and community transformation and promote fundamental research (i) on engaged student learning, (ii) about what it takes to diversify and increase participation in stem effectively, and (iii) that improves our understanding of how to build institutional capacity at hsis. projects supported by the hsi program will also draw from these approaches to generate new

knowledge on how to achieve these aims. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Studies of Chalcogen Bonding-Mediated Assembly towards Porous Crystalline Frameworks, Hierarchical Assemblies, and Multicomponent Materials

Awardee: Colorado School of Mines

Amount: \$597,586.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). non-technical abstract: discoveries of new materials have led to seismic advances in our societies. these advances typically occur through breakthroughs with one of two key components of materials: the repeating individual molecular or atomic building block or the way individual components are connected. such materials can be considered analogous to a brick wall, with the bricks as the repeating blocks, and the mortar connecting them together. while an enormous **\*\*diversity\*\*** of building blocks is known, only a handful of established modes of connectivity exist. generally, each different mode of connectivity allows the creation of an entire new class of materials. perhaps the best example for this is the field of nanoporous frameworks, which are sponge-like materials containing voids slightly larger than individual molecules. nanoporous frameworks containing similar bricks, but connected through different mortars, show vastly different behaviors, each type exhibiting a unique combination of properties. with support from the solid state and materials chemistry program in the division of materials research, the principal investigator and their research group develop a new class of nanoporous frameworks enabled by a recently discovered mode of connectivity. in doing so, the principal investigator advances our knowledge of connectivity in materials, particularly by advancing the understanding of this nascent connectivity, realizing unparalleled structural complexities in materials, and developing a class of materials with a

hitherto unseen set of properties. to help teach the core concepts of how building blocks assemble into materials, the investigators also develop and disseminate an inexpensive and highly modular model kit exercise. this level-adaptable game uses multi-colored modeling clay and toothpicks to teach students how the bricks and mortar work together to form materials. to reduce inequalities in upper-division chemistry offerings between research universities and urm-serving primarily undergraduate institutions (puis), the principal investigator develops and offers a hybrid upper-division physical organic course that is simultaneously taught face-to-face at colorado school of mines and remotely to students at institutions across colorado. technical abstract: the manner of bonding between constituent atoms or molecules invariably influences the properties of materials. perhaps no material family is more emblematic of this than synthetic porous frameworks, wherein the properties, and thus utility, of a given subclass rely heavily on the directionality, dynamic reversibility, and net strength of the intermolecular interactions used. therefore, the discovery and characterization of alternative modes of intermolecular assembly that may give rise to complementary material classes are of great interest. the primary objective of this project is to explore if chalcogen bonding, a recently defined non-covalent interaction, can deliberately and reliably assemble molecular tectons into low-density crystalline framework materials, towards the realization of a new class of frameworks: chalcogen-bonded organic frameworks, i.e. chofs. empirical and computational studies of chalcogen bond-mediated assembly in model systems establish a set of quantitative guidelines for the rational design of permanently porous chofs with topologies predictively assembled from the molecular tecton structure and crystallization conditions. these insights lead to compositionally hierarchical and ordered multi-component materials, elusive features in established framework classes. solution-phase association studies, such as nmr spectroscopy and itc, and dft-based calculations are used to quantify chalcogen bonding between synthesized tectons; the atomic structure of assembled frameworks is characterized by single-crystal xrd. an inexpensive and highly modular model kit exercise using modeling clay and toothpicks is developed and disseminated to students with the intent to teach core concepts of

molecular assembly and crystal engineering. to reduce inequalities in upper-division chemistry offerings between research universities and urm-serving puis, the principal investigator develops and offers a hybrid upper-division physical organic course that is simultaneously taught face-to-face at colorado school of mines and remotely to students at institutions across colorado. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: Cell biology of cnidarian-dinoflagellate symbiosis: Signaling, regulation and host response pathways

Awardee: Oregon State University

Amount: \$597,545.00

Abstract: coral reef ecosystems are bio\*\*diversity\*\* hotbeds that provide valuable environmental and economic services to half a billion people globally, including millions in the us. reefs are faced with almost complete destruction by the end of the century due to global warming unless humanity can cap global temperature rise. coral biologists are working together to develop a broad array of solutions to help with the coral reef crisis. as a part of these efforts, discovery has a critical role to play. corals are an intimate symbiosis between the coral animal and millions of single-celled algae that reside inside of coral cells. the algae provide photosynthetically derived sugars to the host in return for nutrients and a habitat. dysfunction of the symbiosis, caused by global warming and other human-caused impacts, is the driver of coral bleaching and is causing widespread reef degradation globally. this award will examine the cellular and molecular mechanisms governing the coral-algal partnership. the researchers will use state-of-the-art cellular and molecular tools to discover the

chemical signals exchanged between the partners. they will describe the role of the algae in early development of the host and explore the mechanisms of inter-partner regulation during healthy symbiosis and bleaching. the award includes extensive education and outreach aims. undergraduate, graduate student and postdoctoral fellow training is central to the work. finally, the researchers will engage directly with the public, both in oregon and florida, through a variety of activities aimed at illustrating the importance of corals to science and society. many cnidarians, including corals and anemones, engage in a symbiosis with photosynthetic dinoflagellates (family symbiodiniaceae) that together form the trophic and structural foundation of the coral reef ecosystem. despite the importance of corals to coral reefs and the threatened state of coral reef health in an era of climate change, we have an incomplete understanding of how the partnerships are established, regulated and maintained. the researchers will examine inter-partner signaling and regulation during onset, maintenance and breakdown of cnidarian-dinoflagellate symbioses. experiments will be conducted largely in a laboratory-based sea anemone-symbiodiniaceae model system. the team will carry out the following specific aims: aim 1: characterize algal-host signaling dynamics during onset, maintenance and breakdown of symbiosis by molecular glycan profiling of different symbiont species and by using a unbiased dna aptamer technique to identify surface determinants of symbiotic algae. aim 2: describe the spatio-temporal patterning of symbionts in hosts and their impact on host development and growth by examining the role of symbiosis on polyp development and exploring the dynamics of symbiont invasion in developing polyps. aim 3: examine the role of host response pathways in regulation of symbiosis by measuring changes in nadph oxidase activity and sphingosine rheostat signaling in host tissues both during onset of symbiosis and in dysbiosis. the researchers will develop a course-based undergraduate research experience (cure) based on the sea anemone-symbiodiniaceae model system and they will examine the effectiveness of the cure in student learning and in building of science identity. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: Statistical tools for learning about trait evolution across species

Awardee: Florida Atlantic University

Amount: \$596,571.00

Abstract: research on evolutionary biology has been centered on understanding trait variation across species and its contribution to the extraordinary bio\*\*diversity\*\* observed on earth. however, this venture is complicated by a deficiency in computational tools that can effectively navigate evolutionary relationships among species or incorporate large and diverse trait datasets generated

by modern experimental studies. hence, the objective of this project is to expand existing toolkit through the design of a suite of novel statistical and machine learning methods for studying trait evolution across species. these tools will be thoroughly tested through computer simulations, compared to alternative state-of-the-art approaches, and applied to publicly available datasets to address specific evolutionary problems. all tools and datasets generated by the project will be freely and widely disseminated to the scientific community, providing researchers with a powerful framework in which to answer a variety of exciting questions about trait evolution across the tree of life. the project will also advance the participation of underrepresented groups in science and engineering through recruitment of female hispanic high school and undergraduate students to the research team. additionally, the project leaders will design and teach hands-on courses in evolutionary genomics and bioinformatics for retired senior citizens in the local community and for native american communities across the country.

elucidating the processes underlying trait variation across species is a fundamental problem in evolutionary biology, and one for which existing tools lag far behind modern datasets. the current project will address this issue through the design of statistical and supervised machine learning approaches for robustly and accurately predicting the general and specific evolutionary mechanisms by which traits evolve across species. in particular, the tools developed will properly account for species phylogenetic relationships, integrate diverse omics and other trait data, and create new avenues for testing specialized evolutionary hypotheses. availability of these methods will facilitate studies of associations between traits related by a phylogeny, processes and forces driving the evolution of such traits, and adaptive trait evolution arising from different types of structural variations. moreover, findings from applications of these tools to empirical datasets will illuminate connections across different levels of biological organization and diverse biological systems. finally, the developed tools will be applicable to a wide range of ever-increasing genomic, transcriptomic, and other modern omics and trait data, promoting future research in the processes shaping the distribution of traits across species and their roles in evolutionary innovation. results from the project will be available at

<http://assisgroup.fau.edu/>. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Statistical tools for learning about trait evolution across species

Awardee: Florida Atlantic University

Amount: \$596,571.00

Abstract: research on evolutionary biology has been centered on understanding trait variation across species and its contribution to the extraordinary bio\*\*diversity\*\* observed on earth. however, this venture is complicated by a deficiency in computational tools that can effectively navigate evolutionary relationships among species or incorporate large and diverse trait datasets generated by modern experimental studies. hence, the objective of this project is to expand existing toolkit through the design of a suite of novel statistical and machine learning methods for studying trait evolution across species. these tools will be thoroughly tested through computer simulations, compared to alternative state-of-the-art approaches, and applied to publicly available datasets to address specific evolutionary problems. all tools and datasets generated by the project will be freely and widely disseminated to the scientific community, providing researchers with a powerful framework in which to answer a variety of exciting questions about trait evolution across the tree of life. the project will also advance the participation of underrepresented groups in science and engineering through recruitment of female hispanic high school and undergraduate students to the research team. additionally, the project leaders will design and teach hands-on courses in evolutionary genomics and bioinformatics for retired senior citizens in the local community and for native american communities across the country. elucidating the processes underlying trait variation across species is a fundamental problem in evolutionary biology, and one for which existing tools lag far behind modern datasets. the current project will address this issue through the

design of statistical and supervised machine learning approaches for robustly and accurately predicting the general and specific evolutionary mechanisms by which traits evolve across species. in particular, the tools developed will properly account for species phylogenetic relationships, integrate diverse omics and other trait data, and create new avenues for testing specialized evolutionary hypotheses. availability of these methods will facilitate studies of associations between traits related by a phylogeny, processes and forces driving the evolution of such traits, and adaptive trait evolution arising from different types of structural variations. moreover, findings from applications of these tools to empirical datasets will illuminate connections across different levels of biological organization and diverse biological systems. finally, the developed tools will be applicable to a wide range of ever-increasing genomic, transcriptomic, and other modern omics and trait data, promoting future research in the processes shaping the distribution of traits across species and their roles in evolutionary innovation. results from the project will be available at <http://assisgroup.fau.edu/>. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Data-Driven Inversion of Subduction Zone Topography using Tectonic Geomorphology

Awardee: Colorado State University

Amount: \$595,128.00

Abstract: the development of earth's topography impacts the flux and routing of surface water, sediment, and nutrients to oceans, affects feedbacks between the solid earth and atmosphere, and impacts the evolution and **\*\*diversity\*\*** of species. earth's topography is also a primary observable of tectonic activity. for example, nearly every earth science student learns to identify deep ocean trenches and adjacent mountain belts as the surface expression of active subduction, where one

tectonic plate dives beneath another. it follows that we should, in principle, be able to use subduction zone topography (or that of any other active orogen) to understand the underlying geodynamic processes involved in its construction. while scientists have made great strides in this direction, recovering tectonic signals directly from topography remains a crucial challenge. this research will develop and apply new methods to narrow this knowledge gap through a case study of the calabrian subduction zone in southern italy. this study will clarify the role of topography as a recorder of subduction zone dynamics and improve understanding of the landscape response to geodynamic forcing by disentangling crustal, mantle, and earth surface contributions to topographic change. the new methods and results will be relevant for better understanding the context of earthquake hazards along these dynamic plate boundaries. through a three-pronged educational outreach program, this project will engage traditionally underrepresented groups in primary research, develop community education modules, and host workshops to train professionals to use the scientific and educational materials developed. this study will conduct a plate boundary-scale paleo-geodetic experiment realized through the development and application of a novel data-driven bayesian inversion of tectonic geomorphology measurements and fluvial topography. this approach will be used to test the hypothesis that the recent and rapid rise of topography above the calabrian subduction zone is driven by mantle dynamics associated with slab tearing and asthenospheric flow around torn slab edges. this study will compile existing and generate new datasets on long-term erosion rates, the magnitude and age of uplifted marine and river terraces, and fault slip and kinematics. this project will train two ph.d. students and three undergraduates through participation in field and lab work, data analysis, modeling, outreach, writing, and national conferences. the integrated education plan will focus on three related components: (1) an undergraduate training network (utn), (2) development of community educational resources, and (3) targeted outreach and training. the utn will recruit three undergraduate students, emphasizing those from underrepresented groups, to participate in a multi-year program to foster the development of next-generation leaders in earth science through participation in research and outreach. working with experts at the geodesy



tools for societal issues (getsi) program and science education research center (serc), community educational resources developed will focus on field geodesy and tectonic geomorphology techniques and datasets generated during this study. outreach and training of the generated scientific and educational materials will be bolstered through participation in getsi-sponsored outreach and the hosting of workshops at national conferences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Understanding the conservation and restoration potential of retired agricultural land:  
An ecoinformatics approach

Awardee: University of California-Santa Barbara

Amount: \$593,418.00

Abstract: the conversion of land both to and away from agriculture is a central component of global environmental change, with implications for both people and natural systems worldwide. in developed countries including the us, land area in agricultural production is contracting leaving millions of hectares of former or "retired" agricultural land often nested in a mosaic of productive and semi-natural lands. it remains unclear whether, where, and when retired agricultural lands are beneficial to bio\*\*diversity\*\* and ecosystem services in these landscapes. given the ubiquity of agricultural landscapes and the dramatic bio\*\*diversity\*\* declines therein, such a gap is crucial to fill. using a combination of data-driven methods, this research will advance understanding of the drivers of revegetation and the potential conservation value of retired agricultural lands, which can help policy-makers and scientists manage these lands for the well-being of human and natural communities. the training component of this career award will include curriculum development and workshops on the application of data-driven techniques to ecological and environmental problems targeted at high school through phd students. this research will leverage remote sensing, causal

inference, and connectivity modeling methods applied to intensively managed agricultural landscapes to 1) elucidate the mechanisms governing revegetation and succession on retired agricultural lands, 2) understand how the spatial distribution of retired lands influences landscape fragmentation and connectivity, and 3) test whether retired land functions as a net source or sink of crop pests. the education component will engage local high school and first year undergraduates in hands-on research and training in spatial ecology and data-driven environmental science, and train professional master's and phd students in managing, processing and analyzing large spatial datasets and data products to address tractable but complex agricultural ecology questions. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: CAREER: Dynamics of Fragile Interfaces

Awardee: University of California-Santa Barbara

Amount: \$593,000.00

Abstract: this faculty early career development (career) grant will develop bio-inspired models and experimental approaches for soft materials used in biomedical devices, such as silicone implants, that in operation require the outer surface of the device to slide against living cells and tissues. some current designs may induce inflammation by unintentionally increasing friction, with some aggressively-textured soft implants linked to cases of chronic inflammation and even cancers. this project investigates the dynamics of soft material interfaces guided by the hypothesis that sliding surfaces in nature reduce friction through a delicate balance of fracturing and rapidly re-healing crosslinks between macromolecules in aqueous solutions. this work will develop

biomedically-relevant material systems of different polymer network density and structure, with the long-term goal of creating low-friction interfaces for soft biomedical devices. this project will train undergraduate and graduate students in interdisciplinary research across biology, engineering, mechanics, and physics. these research efforts will be strengthened by engaging students from underrepresented groups through high school outreach activities, including hands-on demonstrations and workshops for local science teachers, undergraduate research opportunities in partnership with minority-serving institutions, and **diversity**-focused scientific seminars for graduate students and postdoctoral scholars. these research efforts address a gap in knowledge and understanding of lubricity in soft aqueous gels and biotribology using engineering tools with molecular specificity, materials characterization techniques, and custom-built instrumentation. the specific research objectives are: (1) develop new models of aqueous gel networks that fracture whilst retaining low shear, (2) synthesize new materials and surface architectures based on hydrogels and weak, self-healing crosslinks to test these hypotheses with in situ experiments, and (3) develop reliable, responsive, and resilient biotribological interfaces for multifunctional purposes and (4) design responsible biodegradable materials by exploring degradation properties and behavior for sustainability purposes. establishing and demonstrating the utility of fragile interfaces to provide robust protection and lubricity will extend the study of the mechano-dynamics of fragile interfaces into new fields from biology to chemistry, and medicine using solid mechanics tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: RET Site: Inquiry Driven Engineering Activities using Bioengineering Examples (IDEA-BioE)

Awardee: University of Kansas Center for Research Inc

Amount: \$586,645.00

Abstract: the ret site idea-bioe at the university of kansas will provide middle school mathematics and science teachers an opportunity to participate in research focused on bioengineering at ku. it will also provide guidance on how to translate this experience into engineering design modules that enable teachers to reach and motivate girls and students from minority groups to consider engineering as a career choice. the project will develop long-term relationships with the middle school community of the district to create a "pipeline" for more diverse engineering students in the future, through working with teachers in this targeted school district with a very high percentage of minorities and economically disadvantaged students. the ret site will also integrate educational psychology constructs, to reach a diverse demographic. the effort will have a significant impact on the \*\*diversity\*\* of the engineering student body in kansas, a midwestern state that typically has had very low representation from minority communities in engineering. partnering with the pre-service teaching candidates in ku's stemteachku program will also allow the project to reach beginning science and mathematics teachers early in their careers. dissemination efforts will be focused on publishing lesson modules, and translating modules and evaluation into research articles and case studies in various engineering education and educational psychology journals. dissemination will also be possible via a virtual learning network (vln). next generation science standards (ngss) emphasize the incorporation of engineering design principles and practices into the pre-college curriculum. however, interest in engineering among pre-college students, especially among students from racial and ethnic minority groups, is often low (relative to other stem fields such as medicine), in part due to students' lack of understanding as to the nature of engineering. the ret site will

present a group of 36 pre-service and in-service middle school science teachers with research opportunities that connect complex principles in engineering design (ed) with phenomena and applications from everyday life, in order to engage middle school students with engineering principles while also designing curricular modules with **\*\*diversity\*\*** and inclusion in mind. engineering faculty will provide research experience in various biomedical problems. through partnerships with researchers and educators in the school of education and human sciences, idea-bioe ret participants will also gain knowledge on how their ed modules and lesson plans can be designed to address issues of **\*\*diversity\*\*** and inclusion. final ed modules will also focus on including the promotion of self-efficacy, the provision of relevant models (i.e., women in engineering from a variety of racial/ethnic backgrounds), and incorporation of messages relevant to occupational values. recent research also shows that teachers need additional support and professional development opportunities in order to integrate engineering design practices into their classes, particularly those practices that bridge traditional domains. therefore, this ret site also focuses on presenting bioengineering as an independent discipline which will showcase rationale design and implementation while also highlighting innovation, patenting, and engineering economics, topics which are more specific to engineering disciplines. this project is jointly funded by the division of engineering education and centers (directorate for engineering), and the established program to stimulate competitive research (epscor). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: IntBIO Collaborative Research: An integrative approach for projecting insect responses to a rapidly changing climate

Awardee: University of California-Davis

Amount: \$582,412.00

Abstract: projecting species' responses to climate change at continental scales is a current 'grand challenge' of ecological research. insects are sensitive indicators of both climate and land-use change and recent studies indicate widespread declines in many geographic regions. to predict changes across entire ranges, a variety of species distribution models have been developed, but rarely account for regional variability, ecological interactions or a species' potential to adapt to changing conditions. this project spans multiple institutions situated in the united states' southwest, polar north, and temperate eastern regions. a series of physiological experiments will be

implemented for five widespread butterfly species with populations sourced from different biomes within each of their ranges. caterpillars will be subjected to a range of conditions mimicking past, current and future climates. their development rate, survivorship, immune response, and genetic structure and gene expression (which genes are actively coding for proteins) will be measured and used to build models that predict distributional shifts. data collected by community (?citizen?) scientists will be used to validate the models. this project requires substantial cross-disciplinary collaboration, and a central goal is to recruit diverse trainees at the graduate and undergraduate levels and train them in the ?science of team science?. project trainees will develop independent research ideas that align with and expand the project?s scope and travel between and work at collaborating institutions as an inter-lab exchange to learn new techniques and be exposed to different research philosophies. finally, the project has significant management implications for insect bio\*\*diversity\*\* conservation. projecting responses to climate change at continent scales is a current ?grand challenge? of ecological research. insects are the most diverse and ecologically important terrestrial animal taxon and are strongly affected by climate change. to predict changes, species distribution models (sdms) have been widely implemented across many taxa. sdms, however, rarely account for ecological interactions, plasticity or evolutionary adaptive potential owing to the extensive physiological and ecological data required to parameterize such models. the biology of lepidoptera, particularly butterflies, is extremely well observed, thus it is logistically feasible to build upon past knowledge and collect additional data that enables mechanisms to be more seamlessly integrated into sdms. multiple populations for each species will be sourced from different biomes across its range. caterpillars will be reared in common gardens under a range of temperature conditions mimicking past, current and future climates. their development rate, survivorship, immune response, genetic structure and gene expression will be measured and used to build models that predict future distributions. distribution data collected by community (?citizen?) scientists will be used to validate and improve models and allow robust estimates of uncertainty. this award reflects nsf's statutory mission and has been deemed worthy of support through

evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Expanding Precision Agriculture Education and Certification to Secondary Students

Awardee: Parkland College

Amount: \$581,377.00

Abstract: with this award, parkland college intends to build on the success of two prior nsf projects in precision agriculture and unmanned aircraft systems to develop a pathway for secondary students to earn a college credential while gaining industry experience. in coordination with industry leaders, community partners, and secondary education organizations, the project will create apprenticeship opportunities and stackable certificates to prepare secondary students for jobs in precision agriculture and adjacent sectors. the stackable certificates will combine coursework in precision agriculture and unmanned aircraft systems and be designed specifically for high school students. participants will complete this curriculum while obtaining industry experience through apprenticeships with industry partners. the project will focus on increasing the **\*\*diversity\*\*** of the agriculture workforce by increasing involvement of female and minority secondary students. food security and agricultural exports are a major part of the us economy. thus, improving training opportunities in agriculture is essential to continuing the strong presence of us agriculture on the world stage. the goals of the project are to establish a new early college and career academy program; establish work-based learning opportunities with regional employers; and increase participation of traditionally underrepresented students in agriculture. the precision agriculture sector continues to modernize and the importance of well-trained students is becoming increasingly critical. many precision agriculture companies struggle to fill open positions as the workforce ages out and the younger generation is drawn away from careers in agriculture. creating new pathways to encourage secondary students to explore careers as technicians in precision agriculture will ensure the availability of a robust workforce. project participants will be well prepared to enter and advance

in the growing precision agriculture industry. by developing credentials and apprenticeship opportunities for secondary students the project will be educating future technicians in line with industry needs. furthermore, the project's focus on increasing the number of women and minorities in precision agriculture will strengthen and diversify an important american industry. the deliverables and best practices developed through the project will be disseminated through coordination with multiple industry partners and a statewide secondary education organization. additionally, the pi and co-pi will attend and present at conferences relevant to agriculture education, agribusiness, and unmanned aircraft systems conferences throughout the grant period. this project is funded by the advanced technological education program that focuses on the education of technicians for the advanced-technology fields that drive the nation's economy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RCN: Patterns, Places, People: A Network for Scalable Airborne Observation of Socio-Environmental Systems

Awardee: University of Maryland Center for Environmental Sciences

Amount: \$579,974.00

Abstract: addressing many of the challenges society faces, including climate change, food and water insecurity, and bio\*\*diversity\*\* loss, requires a better understanding of the interactions between people and their environment. important interactions depend on scale (e.g., individuals, communities, government) and environmental conditions, suggesting the value in a landscape perspective. landscapes include people with diverse perspectives and experiences, and there are many different fields of research relevant to understanding how humans and their non-human counterparts interact with changing environments. for this reason, the study of socio-environmental systems (ses) can benefit from transdisciplinary cooperation that engages stakeholders in the

development of scientific research that recognizes and leverages the social and behavioral dynamics of ecological systems. this research coordination network (rcn) project will develop the landscape exchange network for socio-environmental systems research (lens), which will leverage detailed observations from the national ecological observatory network's airborne observation platform (neon aop) to study ses across the united states. lens will build a network of researchers and stakeholders with interest in the neon sites currently observed by the aop. lens will collaboratively work to understand the variability in ses across neon sites and to address environmental outcomes of societal concern to lens membership. broader impacts of this project will include training a graduate student and engaging approximately 1 million people that live within or in close proximity to neon aop landscapes. addressing privacy and ethical concerns, issues of environmental justice, and other concerns of large- and small-holder land-owners and -managers within these landscapes will be central to the work of the rcn. to improve capacity for ses research, societal understanding of ses, and environmental outcomes, this project will initiate and coordinate an rcn for socio-environmental systems research. lens will (objective #1) characterize ses represented in the landscapes surveyed by the neon aop. as these ses are characterized, and in collaboration with neon domain managers, lens will identify and engage stakeholders in network activities from aop landscapes. with scientist and stakeholder members, lens will (objective #2) develop strategies that support an effective translational ecology approach in these landscapes. in doing so, lens will (objective #3) develop and communicate methods for using aop data in ses research using the translational ecology approach. these objectives will be met through a combination of virtual and in-person meetings, data discovery and sharing, development of an online repository of aop-related computational tools, and production of communication products. the network will create and openly share an accessible, curated and transdisciplinary repository of data relevant to ses in the aop landscapes, and will strengthen inter-institutional pathways for translational ecology employing aop. these broader impacts will be a new model for engagement of the public in scientific research. this project is being jointly funded by the macrosystems biology &

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Title: Seismological Investigations of Earthquakes and Deep Earth Structure

Awardee: University of California-San Diego Scripps Inst of Oceanography

Amount: \$579,568.00

Abstract: this project will use decades of records of seismic waves generated by thousands of

earthquakes all over the world to learn about both earthquakes and deep earth structure. analyses of earthquakes will focus on the high-frequency components of the seismograms, which provide key constraints on the energy radiated by earthquakes and information about the speed and complexity of fault ruptures. these results should help improve forecasts of damaging ground motions produced by strong earthquakes. planned analyses for earth structure will examine sharp changes in seismic wave velocities that occur at depths of 50 to 400 miles below the surface that are related to changes in crystal structure or the presence of fluids, such as water or magma. a related project will examine scattering of seismic waves, which provides clues regarding small-scale variability in rock properties at depths extending from the surface to earth's liquid core. these results will help in understanding the internal composition of the earth and its relation to tectonic processes. the project will support undergraduate, graduate, and postgraduate students and involve them in research. educational components include graduate student and postdoc support, as well as sponsoring an undergraduate summer intern in a long-standing and successful sio program designed to increase student **\*\*diversity\*\***. systematic analyses of large datasets recorded by both permanent and temporary seismic stations all over the world provide rich opportunities to study problems concerning earthquakes and earth structure. planned research includes innovative investigations of upper-mantle discontinuity structure within and near the transition zone and the lithosphere-asthenosphere boundary, observing and modeling of seismic scattering to characterize small-scale compositional heterogeneity in the mantle, and spectral analyses of earthquake radiation to constrain earthquake rupture dimensions and dynamics. some key questions this project plans to examine include: (1) what is the role of the low-velocity layer (l<sub>v</sub>) above the 410-km discontinuity in mantle convection and water recycling? (2) what causes the mid-lithospheric discontinuity (mld) observed under many continental cratons? (3) how variable is the sharpness and roughness of the 660-km discontinuity and what does that imply for mantle composition? (4) what is the strength of small-scale heterogeneity in the mid- to lower mantle and does it vary laterally? (5) what causes the large scatter in earthquake stress drop estimates, i.e., how much is



due to modeling uncertainties versus real differences in earthquake dynamics? (6) does earthquake stress drop vary systematically with tectonic region? (7) how do improved global high-frequency body-wave attenuation models compare to tomographic models and to surface-wave attenuation models? this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Texas at Dallas

Amount: \$579,378.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: IUCRC Proposal Phase I: University of Colorado Boulder: Center for Building Energy Smart Technologies (BEST)

Awardee: University of Colorado at Boulder

Amount: \$578,500.00

Abstract: the building energy smart technologies (best) iucrc brings together universities and industries to transform the building industry through the development and adoption of sustainable and intelligent technologies. best will apply innovative, energy-smart technologies through a wide spectrum of us buildings. best will be located in two sites: the lead site at university of colorado boulder (cub) and the partner site at city college of new york (ccny), taking advantage of the diverse academic, natural and industrial environments these locations provide. the best center will foster smart, sustainable, and efficient development and utilization of energy in the built environment through an integrated systems approach to design, retrofit, construct, and operate sustainable buildings and cities. ultimately, the best center will support the u.s. building industry's efforts to meet increasingly stringent building energy-efficiency regulations, and society's expectations for improved sustainability, resiliency, and security in communities and cities. the best center will

support the goal of achieving net-zero greenhouse gas emissions by 2050. moreover, the center will educate and train a skilled and diverse workforce to address current and future employment needs for the u.s. building industry. the best center will enable the development of new and sustainable building energy technologies through a holistic understanding of the interactions between built and-natural systems. in particular, the center will address design and operation solutions for the built environment associated with extreme weather events, which are becoming more frequent and intense due to a rapidly changing climate. additionally, the center will focus on the emerging challenges in the building sector due to pandemics and health crises such as those caused by covid-19, and increase cybersecurity of the buildings systems and of occupants? privacy. the center?s research scope spans various disciplines specific to building energy systems, including indoor-outdoor energy flows, advanced building envelope systems, demand-response informatics, application of advanced in-situ and remote sensing for monitoring the environment and occupants, and distributed energy efficient and renewable technologies. to cover the rich and wide \*\*diversity\*\* of the building industry needs, five thrust areas are proposed for the center?s research activities: (i) smart buildings materials, (ii) intelligent building mechanical and electrical energy systems, (iii) distributed and renewable energy systems, (iv) city-scale building energy systems and informatics, and (v) smart grid systems integrated with distributed energy and data systems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Sustaining Arctos as a Community of Practice and as a Collection Management Solution for Biodiversity Research & Education

Awardee: University of New Mexico

Amount: \$574,694.00

Abstract: an award is made to three partner institutions ? the museum of vertebrate zoology (univ.

california berkeley), museum of southwestern biology (univ. new mexico albuquerque), and the texas advanced computer center (univ. texas austin) ? to perform critical technical and infrastructure work that will establish a sustainable framework for arctos, a database and collection management system. the arctos community is a group of museum-based professionals representing natural and cultural history collections at over 40 institutions that share in the governance, design, maintenance, and development of arctos. a primary objective of the arctos community is to make high quality data on bio\*\*diversity\*\* and cultural collections openly accessible and richly networked for multidisciplinary research and public understanding. this is accomplished through the arctos online platform, which serves primary species and cultural data to national and international users. these data are used to advance knowledge in a \*\*diversity\*\* of disciplines and serve as an archival record for future generations. additionally, the arctos platform is used as an educational tool where students access raw data to design original inquiries. the arctos community is dedicated to rigorous management of collections and their data, as well as mentoring and training the next generation of curators, collection managers, and scientists. arctos views collections comprehensively and promotes linkages across biological, earth science, art, archival, and ethnographic collections to add value and relevance for education and research. for example, cultural and archival records often contribute temporal, ecological, and behavioral dimensions to bio\*\*diversity\*\* data from identifiable species components or observations. many museums curate more than one type of collection, and arctos provides a comprehensive management solution integrating diverse disciplines. for the last 20 years, arctos has practiced the concept of the ?extended specimen network?. the richly annotated data in arctos creates a web of knowledge with deep comprehensive relationships between cataloged records and all of their derived and associated data, and by using reliable published resources for globally shared information such as taxonomy, people names, and geography. to sustain this community-driven infrastructure and resource, the arctos database platform will complete migration to open-source technologies removing the need for costly software. other benefits include stabilizing web services, query responses and delivery, spatial functionality,

among other core features. the arctos model of community engagement and development is attractive for collections of any size, including small institutions such as field stations that may lack it infrastructure, because of its ease of cloud-based access, community mentorship, and enterprise-level platform at scaled pricing. project activities and results will be accessible on the arctos websites (arctos.database.museum and arctosdb.org). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Geometric Quantum Order: Fractons, Tensor Gauge Theories and Beyond

Awardee: Brown University

Amount: \$574,588.00

Abstract: nontechnical summary this career award supports joint theoretical research and education to advance the theoretical foundations of condensed matter physics. condensed matter physics concerns itself with systems composed of a large number of interacting constituents. materials are a common example as they contain many atoms and many electrons. it is common to think of such complex systems not in terms of the individual constituents, but rather in terms of properties that emerge from their collective behavior. the concept of phases of matter is an important example of a collective property. systems that show the same phase have similar properties. ferromagnets have the collective property that the constituent atoms or electrons align in such a way that the magnetic axis of each one points in the same direction. ferromagnets made of different materials are all ferromagnets. however, a ferromagnet is qualitatively different from an antiferromagnetic phase in which the magnetic axis of one atom points in the direction opposite that of its neighbor. so, systems that belong to the same phase have similar qualitative properties, while systems that belong to different phases have different properties. when quantum mechanics mingles with strong interactions among constituents very strange phases can emerge, such as the topological phases

of the fractional quantum hall effect; the latter occurs when electrons confined to a two-dimension plane by semiconductors are exposed to an intense magnetic field. recently proposed fracton phases of matter are another turning point in this development. these phases have the interesting and distinct property of being hypersensitive to the geometry of the underlying material, for example the way atoms are organized on a lattice, as well as the presence of geometric distortions of the lattice. the pi will undertake a careful study and characterization of these phases, which necessitates the development new concepts and new theoretical tools. new tools will help advance understanding of the physical properties of fracton phases as well as suggest routes for experimental detection of fractions in materials. this is fundamental research; however, fractons could play an important role in developing quantum memory, and suggest new ways to think about quantum computing. finally, it is already becoming clear that some fracton phenomena may have been discovered long ago in superfluids and liquid crystals, without realizing that these are but a page of a much bigger story. the pi will utilize the new techniques developed in the fracton context to gain new insights into the problems of vortices in superconductors, turbulence, and quantum liquid crystals.

the education component of this career project includes training undergraduate and graduate students. students will explore how to use machine learning methods to gain insight into theoretical problems. the pi will participate in global efforts to increase **\*\*diversity\*\*** in physics through mentoring undergraduate students who are members of underrepresented groups leveraging american physical society initiatives. the pi will engage in outreach in local high schools by participating in career days and encouraging students to study science. pi will develop a course aimed at undergraduate and graduate students that will focus on applications of condensed matter physics ideas to deep neural networks.

technical summary this career award supports joint theoretical research and education to advance the theoretical foundations of strongly correlated topological and geometric phases of matter. the project is focused on the physics of systems that support emergent fracton excitations. these excitations possess two remarkable properties: (i) they are topologically non-trivial and (ii) they cannot freely move through space. the constraints on their

motion arise dynamically, while the underlying physical system is translation invariant. more concretely the research concentrated on three major efforts. (i) fracton excitations can emerge in gapless correlated spin liquids. the pi will explore how the existence of these excitations affects observable properties of these systems. (ii) the constrained mobility of fracton excitations can be formally imposed by introducing additional symmetries. the variety of all possible mobility constraints roughly corresponds to all possible symmetries of this kind. the pi will develop a general theory of such symmetries and their manifestation in low energy properties of the physical systems constrained by these symmetries. (iii) a particular form of fracton behavior is already present in well-known systems such as superfluids, liquid crystals and quantum hall states, where vortices, crystalline defects and composite fermions have a subtle version of constrained motion. the pi will investigate this tantalizing connection with the expectation that fracton machinery will provide a fresh look at these systems. the education component of this career project includes training undergraduate and graduate students. students will explore how to use machine learning methods to gain insight into theoretical problems. the pi will participate in global efforts to increase **\*\*diversity\*\*** in physics through mentoring undergraduate students who are members of underrepresented groups leveraging american physical society initiatives. the pi will engage in outreach in local high schools by participating in career days and encouraging students to study science. pi will develop a course aimed at undergraduate and graduate students that will focus on applications of condensed matter physics ideas to deep neural networks. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Virginia Commonwealth University

Amount: \$571,099.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and \*\*diversity\*\* of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Pulmonary Aerodynamic Valves: Distribution & Function

Awardee: University of Utah

Amount: \$566,507.00

Abstract: this project addresses a major, poorly understood question in vertebrate evolution related to the lung's extraordinary structural **diversity**, especially the structures that give rise to one-way airflow. bird lungs have held a special place in this regard, because their design is so radically different from mammalian lungs, and it has been thought that one-way airflow is related to the energetic demands of flight. however, the lungs of other non-flying vertebrate animals, including snakes, turtles, and chameleons, also differ from those of mammals. this research will provide a better understanding of how aerodynamic valves in the lungs of reptiles give rise to one-way airflow, the physiological significance of these patterns of flow, and their distribution across vertebrate animals. it will reveal fundamental, form-function relationships linking lung structures to patterns of airflow in reptiles and amphibians; enhance understanding of the effects of these patterns of airflow on gas exchange, respiratory water loss, and heat loss; and be applied to reconstruction of the respiratory systems of extinct tetrapods. the project also includes significant educational and outreach activities, including science communication training for lab personnel, participation in public-education, distance-learning programs run by utah's hogle zoo, and development of virtual reality infrastructure for research, outreach, and teaching. three primary activities will result from the proposed research. (1) a phyletic survey will be made of patterns of airflow in the lungs of amphibians and reptiles. (2) tests of the following hypotheses for the mechanistic basis of pulmonary aerodynamic valves will be made by measurements and visualizations of patterns of airflow, computational fluid dynamics simulations, and physical models: i) that turtles have a pulmonary tesla valve; ii) that the expiratory valve of archosaurs functions like an internal nozzle, where a coanda surface induces and amplifies flow; iii) that the expiratory valve arises from a caudal guiding dam. (3) balloon catheters will be implanted into the lungs of alligators which will allow unidirectional flow

to be converted to tidal airflow. under these two flow regimes hypotheses for the functional significance of aerodynamic valves will be tested: i) that alligators have counter-current or cross-current gas exchange; ii) that unidirectional flow reduces rates of evaporative water and heat loss, and improves wash-out of lung  $\text{CO}_2$  and wash-in of  $\text{O}_2$ . measurements will be made of  $\text{O}_2$  extraction and  $\text{CO}_2$  removal with each breath, rates of lung washout of  $\text{CO}_2$ , rates of respiratory evaporative water loss and heat loss, and rates of ventilation relative to rates  $\text{O}_2$  consumption and  $\text{CO}_2$  excretion. the proposed research has four strands of educational and outreach broader impacts: 1) recruitment of underrepresented participants into stem; 2) training of lab personnel in science communication, working closely with the natural history museum of utah; 3) outreach to the lay community, including k-12 schools, through distance-learning programs of utah's hogle zoo; 4) development of virtual reality infrastructure for research, outreach, and teaching. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: RCN-UBE: A Network for Facilitating Online Content for Experiential Learning of Tropical Systems

Awardee: Iowa State University

Amount: \$563,619.00

Abstract: life science students must be prepared for solving ?wicked? problems, i.e., complex ones without clear solutions. these problems require higher-level thinking about the connections across scales and disciplines, and within a global context. tropical ecology provides opportunities for studying this kind of complexity, from the interactions of organisms in highly diverse communities to the web of social and economic considerations that guide the processes and conservation of tropical species and ecosystems. despite this, most core undergraduate biology curricula retain a primarily temperate-zone lens and limited exposure to the global **\*\*diversity\*\*** of ecosystems and cultures. at the same time, there is a critical need for online open educational resources (oers) that incorporate real-world examples and are easy for both students and instructors to access and use. this network brings together a diverse community of experts with backgrounds in tropical biology research, active-learning pedagogy, software development, and multimedia content creation. the network activities will support faculty participants in the creation and adaptation of field- and research-based oers. these online modules will be hosted on a responsively designed, open-source and open-access platform, gala. the goals of the online content for experiential learning of tropical systems network are to: internationalize the undergraduate biology curriculum through the creation of oers in tropical ecology; enhance and innovate within platforms such as gala to facilitate the integration of quantitative elements within oers; and broaden participation within the biology community by engaging participants from under-represented groups, hbcus and community colleges. activities will include: initial workshops to create author guidelines and toolkits; 'incubator'

workshops to develop new oers; faculty mentoring networks for adapting existing oers; and engagement with professional societies and other networks to expand and sustain this new network. for each module, design and development of interactive and quantitative elements will be undertaken in collaboration with the developers of the gala platform, the midwest big data hub, and quantitative undergraduate biology education and synthesis. as this new network?s agile process for creating oers is refined, it will provide a novel framework for oer development that can help propel stem education in fields beyond tropical ecology. this project is being funded by the directorate for biological sciences, division of biological infrastructure as part of efforts to address the challenges posed in vision and change in undergraduate biology education: a call to action (<http://visionandchange/finalreport/>). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: CAREER: Multiscale Mechanics of Carbon Nanotube-Polymer Composites

Awardee: Howard University

Amount: \$562,555.00

Abstract: this faculty early career development (career) grant will support research on understanding the fracture mechanisms and predicting the mechanical properties of carbon nanotube-filled polymer composites. these materials have the potential to play a growing role in the prosperity, security, and global competitiveness of the united states and propelling the economic performance of major industrial sectors such as aerospace, manufacturing, biomedical, and civil infrastructure. polymer composites are tunable materials whereby changes to their constituents, processing conditions, and microstructure one can achieve products with distinct functions. understanding the processing-structure-property relations and failure mechanisms of these materials, however, is complicated because they feature a wide range of compositions, phenomena, and interactions across several scales of time, length, complexity, and uncertainty. this research aims to unravel these relations and mechanisms and in turn supplant the traditional trial-and-error approach to the design of polymer composites by an efficient, machine learning-assisted, experiment-informed, multiscale computational approach that will accelerate the discovery of novel polymer composites with improved manufacturability, reliability, and performance, ultimately benefiting the economy and society. the educational and outreach components of this project will contribute to enhancing **\*\*diversity\*\*** in stem multidisciplinary education and include developing courses in advanced materials and forming sustainable collaborations between the pi's research group and industry partners and professional organizations. among the scientific and technological challenges remaining in the field of carbon nanotube-filled polymer composites, one of the least-understood areas is the deformation and failure of these materials and a poor understanding of load transfer in them at the filler-matrix interface. this project will further elucidate the phenomena and mechanisms that underlie the mechanical response of these materials at the nano- and microscales and quantify their processing-structure-property relationships by developing a probabilistic framework comprising laboratory tests, microscopic characterizations, image processing, multiscale modeling and

simulations, and machine learning. the uncertainties involved will be quantified, and a probabilistic multiscale modeling and simulation hierarchy will be developed to study high-fidelity models of polymer composites. machine learning will be used to perform sensitivity analyses and develop probabilistic predictive models for the properties of polymer composites. the study outcome will offer a new route to design heterogeneous, high-performance, and multifunctional composite materials. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: DMREF: Symmetry-Guided Machine Learning for the Discovery of Topological Phononic Materials

Awardee: Massachusetts Institute of Technology

Amount: \$560,000.00

Abstract: non-technical description: fundamental understanding and control of heat conduction processes in materials are important for energy infrastructure, electronic devices, and renewable energy generation systems. this project focuses on a novel property of phonons ? vibrations of

atoms that carry the heat in materials - called "topology". this property may allow new phenomena, such as heat conduction perpendicular to the temperature gradient direction and more efficient transport of heat waves on the material surfaces. to discover topological phonons, the research team will exploit a materials genome approach to search for materials hosting these special heat carriers. once candidates are identified, the research team will synthesize and characterize them, and the results will be used to refine the search algorithm. the research team plans to establish a public database storing the heat conduction properties of a large number of materials. this research will not only advance the fundamental understanding of how topology affects heat conduction in real materials, but also provide new routes to realizing unusual functionalities such as heat conductors that can be switched on and off. this project also supports educational activities to teach basic materials physics concepts to k-12 and undergraduate students through hands-on class projects and short courses. to promote **diversity** in the materials science workforce, the team also provides research opportunities to high school and undergraduate students from underrepresented minority communities.

technical description: while the topology of electronic states has been a central theme in condensed matter physics for the past decade, topological phononic states have received much less attention. unlike their fermionic counterparts, topological states in the entire phonon spectrum can contribute to observable material properties, making topological phononic materials ideal testbeds for emerging new physics in topological bosonic systems, including phonon thermal hall effects, novel topological phonon-electron interactions and the resulting phenomena, such as unusual superconducting states. this project aims to systematically identify materials hosting intrinsic topological phonons in the thermal regime, where the topological phononic states explicitly modify intrinsic material properties, including thermal transport, electron-phonon interactions, and surface phonon modes. the research team will seek to accelerate material discovery by incorporating symmetry-guided machine learning based on euclidean neural networks. machine learning predictions will be verified using first-principles phonon simulation and topological invariance analysis. promising candidate materials will be synthesized as thin films and bulk single

crystals and characterized using inelastic neutron and x-ray scattering, thermal transport, and surface-sensitive spectroscopy and scanning probe measurements. this research will advance fundamental understanding of topological bosonic systems and examine new thermal functionalities enabled by topological phonons. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Ideological Roadblocks to Diversifying STEM: Resistance and Allyship in STEM Diversity and Inclusion Efforts

Awardee: Regents of the University of Michigan - Ann Arbor

Amount: \$559,600.00

Abstract: ideological roadblocks to diversifying stem: resistance and allyship in stem **\*\*diversity\*\*** and inclusion efforts the aim of this project is to break important ground in stem inequality research by better understanding how powerful and privileged groups in stem respond to **\*\*diversity\*\***, equity, and inclusion (dei) efforts in their workplaces and professions. despite the millions of dollars invested each year in dei-related training, recruitment, and retention efforts, stem fields have struggled to diversify demographically and culturally. much research over the last few decades has sought to understand the interactional and institutional-level biases that disadvantage women, people of color, and lgbtq individuals in stem. yet, these biases are not the only ways in which inequality and under-representation are perpetuated. central to stem's stalled diversification are sources of resistance to organizational and institutional changes that seek to advance equity. such resistance can block both the effective implementation of existing dei efforts and the development of new initiatives that would bring deeper structural and cultural transformations. this project seeks to investigate resistance to dei efforts among the population with the greatest structural and cultural power in stem. while many individuals in powerful social groups are personally committed to equity

and inclusion, others may disagree with, and even actively resist, dei efforts in their organizations and professions. the goal of this project is to map the wider landscape of cultural schemas that individuals in powerful social groups use to make sense of dei efforts and to express their resistance to or support for those efforts. using an innovative combination of analysis of existing survey data, interviews with a representative sample of individuals in powerful social groups stem professionals, and a survey experiment, the empirical goals of this project are to (1) investigate resistance to and support for dei efforts relative to their peers, (2) document the roadblock schemas (or shared cultural models) that individuals in powerful social groups may use to frame such resistance to dei efforts, and (3) test interventions that attempt to destabilize adherence to these roadblock schemas and, by extension, resistance to dei efforts. in doing so, this project would offer critical insights to assist academic institutions, workplaces, and professional societies in designing strategies to overcome those roadblocks and promote more effective dei efforts. such an investigation may also contribute to stem inequality, cultural sociology, and sociology of professions literatures by illustrating how cultural norms of professional integrity, which seem on their face to be a degree removed from issues of inclusion or inequality, can serve as powerful tools of resistance to diversification within professions. broadly, understanding the cultural frameworks that powerful social groups use to defend their privilege and resist change is vital for overcoming the stalled diversification of stem and advancing race, gender, and lgbtq equality therein. this project is funded by the ehr core research (ecr) program, which supports work that advances fundamental research on stem learning and learning environments, broadening participation in stem, and stem workforce development. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: AF: Medium: Markov Chain Algorithms for Problems from Computer Science, Statistical Physics and Self-Organizing Particle Systems

Awardee: Arizona State University

Amount: \$551,999.00

Abstract: self-organization can be viewed as a phenomenon whereby unanticipated global configurations and patterns of a collective emerge from fully distributed and simplistic rules performed by each individual, without any global coordination or external intervention.

self-organization and emergent behavior arise naturally across many fields: distributed systems and swarm robotics in computer science, interacting particle systems in physics, population dynamics and flock coordination in biology, autonomous systems in robotics and control theory, and smart materials, to name a few. recently, the synergy between discrete probability, algorithms and statistical physics has provided a new approach for designing self-organizing particle systems by harnessing collective, emergent behavior of physical systems. the laws of physics play an increasingly important role in collective behavior at the nano- and micro-scales, especially since individual agents are far less capable than their macroscopic counterparts. yet, while the principles of statistical physics have motivated many experimental systems, little has been done to make the corresponding underlying distributed algorithms rigorous. this project investigates how to

program collections of agents to perform tasks by modeling the dynamics as self-organizing particle systems performing steps of markov chains through local interactions that can be rigorously analyzed. the limiting distributions of these chains have distinct equilibrium characteristics that can be used to program collective behavior. the principal investigators take a three-pronged approach: first, they introduce and study generalizations of common statistical physics models, such as the potts, ising and hard-core models, to better capture the constraints imposed by micro-scale systems of interacting agents. next, they explore methods to better understand the nonequilibrium dynamics of these systems long before convergence and possibly subject to forces that make the markov chains nonreversible. finally, they explore how collective systems might be programmed through deliberate placement of obstacles and features in the environment, rather than programming the agents themselves, as many of these tiny agents are incapable of any sophisticated (traditional)

computation. as an example of programming the environment, a new version of the schelling segregation model is being studied where people move with higher probabilities if they are unhappy with the local demographics of their neighborhoods, but these preferences can be somewhat mitigated by the placement of desirable urban infrastructures that modify individuals' incentive structures and biases. the project is having impact in promoting and advancing interdisciplinary research across many fields; education, through advanced graduate courses and broad, interdisciplinary talks; **diversity** at the graduate, undergraduate, and faculty levels; outreach to the general public and for k-12 education; and municipal planning, through coordination with regional planning faculty and the city of atlanta. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: i-learn: empowering engineering learners using visualizations in mixed reality and machine learning ecosystems

Awardee: Illinois Institute of Technology

Amount: \$551,436.00

Abstract: in the field of engineering education, significant research on learning with technologies has focused on either the learner's interaction with the technology, on technology-enabled learning material, or on final learning outcomes. research on learning with technologies involving the influence of individual cognitive function (perceptual, attentional, and cognitive skills) is relatively unexplored. there remains a gap in knowledge on how or why learners arrive at different results in the learning process. the i-learn research project bridges that divide by considering the learner's individual characteristics as they execute problem-solving tasks while interacting with the advanced technology-enabled environments ? a machine-learning (ml) and mixed-reality (mx) technology. the i-learn research project's theoretical and empirical methods will provide fundamental knowledge about how learners' cognitive function can be augmented through the advancements of these technologies, closing the gap in understanding the **\*\*diversity\*\*** of individuals' perceptual and cognitive abilities in engineering education. the perspective of tailoring mx with ml technologies to predict individual problem-solving harnesses opportunities to research whether learners' interactions with these technologies leads to improved task performance. i-learn creates mx-based environments with features informed by ml models not merely as interactive features but as a medium of communication for perceptive-action. by focusing on components of learning cognition (e.g., working memory and sustained attention) as well as mental simulation and situational awareness, this project (1) uses ml predictive modelling to explore the effects of individual differences on learners' performance in problem-solving tasks modelling, (2) studies learners' moments of impasse in problem-solving tasks that demand spatial and cognitive ability, and (3)



develops and assesses the effectiveness of an interactive and adaptive mx platform for learning when used by students with different cognitive and attentional abilities. this project will improve the fundamental understanding of how technologies should be designed to enhance technology-enabled learning. it promotes embodied cognition, pioneers individualized learning using ml, and advances insights on the effect of motor activity on operations linked to visuo-spatial abilities. research outcomes will inform the design of adaptive learning technologies and the customization of instruction in engineering education. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: D3SC: Developing Data-Driven, Automated Methodology to Understand and Control Light-Driven Catalytic Processes

Awardee: Carnegie-Mellon University

Amount: \$550,000.00

Abstract: with the support of the chemical catalysis program in the division of chemistry, professor stefan bernhard of carnegie mellon university will study catalytic processes that are driven by light. continued development of a sustainable society requires advances in molecular sciences that will pave the way to the solar-powered, efficient, safe and precise molecular engineering of new functional molecules, materials, and fuels. one of the major obstacles on this path stems from the inherent difficulty of extending current chemical theories to accurately describe the interplay of matter and energy in light-driven chemical transformations. the proposed work utilizes an investigative approach that seeks to accelerate chemical discovery and enhance control of chemical reactions by developing new tools integrating high-throughput experiments, quantum chemistry, and data science. the bernhard lab involves a diverse group of researchers to accomplish these research tasks. stefan bernhard and his research team will be involved in outreach activities for

non-scientists to educate the public on energy issues and instill excitement for science, in general. with the support of the chemical catalysis program in the division of chemistry, professor stefan bernhard of carnegie mellon university will study the complex interplay of reagents and catalysts in light-driven chemical processes. the funded research will create a deeper understanding by using new tools integrating high-throughput experiments, quantum chemistry, and data science. the created artificial intelligence resulting from a merger of chemical theory and chemical data will allow the capture of the effects of complex many-body electronic interactions that elude current algorithms. to gather the data needed to drive this effort, the bernhard team will develop massively parallel, automated chemical reactors capable of sensing and recording the progress on a variety of reaction types in parallel and in real time. increasingly complex photochemical processes ranging from simple energy transfers to light-driven polymerizations will be investigated and their observed reactivity patterns will be modeled, compared and analyzed. the initial phase of the work will focus on photocatalytic reactions catalyzed by iridium complexes. these are expected to provide an excellent trial system due to the ability to easily synthesize structures that span a vast chemical space, but where the structure-activity relationships have been difficult to model and predict. later efforts will increase the chemical and structural **\*\*diversity\*\*** of the photocatalyst by inclusion of a much wider variety of ligand frameworks and involving central ions with a range of electronic structures. quantum chemical calculations on the photocatalysts will be the basis of a feature learning-based approach to find and predict structure property/(re)activity relationships in the studied photochemical systems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Unlocking Reactivity-Based Separations of Olefins using Metal-Organic Frameworks

Awardee: Cornell University

Amount: \$550,000.00

Abstract: chemical separations, which involve partitioning a mixture of compounds into its individual components, are critical to the industrial production of commodities such as plastics. separations account for 15% of energy consumption in the united states alone. the development of new energy-efficient separations could greatly reduce greenhouse gas emissions, improve the sustainability of the chemical industry, and decrease the cost of everyday consumer products. traditionally, separations are carried out based on differences in the physical properties of chemicals, such as their boiling points. here, the investigator will develop sponge-like materials capable of separating chemicals based on their differing reactivities. this will enable industrial separations with much higher selectivities for one component over another and potentially unlock new types of separations. this project will be highly interdisciplinary, involving aspects of chemistry, chemical engineering, and materials science, which will help strengthen communication between these fields. in addition, new scientists from underrepresented communities will be trained, improving the **\*\*diversity\*\*** of the stem workforce. as part of the project, the public, especially underserved students in rural communities, will learn about the importance of chemical separations, sustainability, and green technologies. unsaturated molecules such as olefins are critical building blocks for the global production of polymers. however, polymerization reactions typically require ultrapure streams of olefins to proceed efficiently. currently, mixtures containing olefins (including mixtures of olefins/paraffins or olefin isomers) are inefficiently separated based on small differences in their physical properties. this project seeks to separate mixtures containing olefins based on differences in their reactivities rather than physical properties. specifically, porous crystalline materials known as metal-organic frameworks (mof) will be designed such that they can undergo reversible cycloaddition reactions with olefins. these novel mof systems will allow for separations to be carried out with unparalleled selectivities and for the production of ultrapure olefin product streams in an energy-efficient manner. the materials design strategy is potentially generalizable to

separations involving a range of unsaturated molecules, including carbon dioxide, reflecting the versatility of this approach. the separation efficiency of the strategy will be assessed using gas adsorption analysis and breakthrough measurements. the reactivity of the adsorbents will be characterized using in situ solid-state nuclear magnetic resonance, x-ray diffraction, and infrared spectroscopy. this interdisciplinary research program will forge new connections between chemists, chemical engineers, and materials scientists. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Elucidating the Interfacial Structure of Complex Solvents for Chemical Transformations

Awardee: Case Western Reserve University

Amount: \$549,957.00

Abstract: the availability of high-performing solvents that function as absorbents, co-catalysts, and electrolytes is a critical and unmet need for advanced technologies such as integrated capture and conversion of carbon dioxide. this project will develop functionalized solvents that have high affinity to carbon dioxide as well as facilitate its efficient conversion to other useful products such as fuels. these complex solvents are hydrogen-bonded organic complex (hboc) liquids with high concentrations of salts and often have molecular-scale structure and heterogeneity. the mechanisms of absorption and reactivity of carbon dioxide at the electrode-electrolyte interface are not well understood in these solvents. this project will explore the fundamental mechanisms that underpin absorption, interfacial liquid structure, and reactivity to inform future designs of integrated systems for chemical transformations. the knowledge gained has far-reaching applications in separations, catalysis, sensors, and other electrochemical processes. through these applications, this research addresses the societal challenges of climate change, emission mitigation, waste utilization, and

energy consumption. the educational goal of this career project is to enhance students' learning experience using visuals and to build science literacy through drawing. visual illustrations of the scientific concepts of this project will be created for use as educational materials, which will be disseminated via publications, seminars, and public events. these activities will foster teamwork and strengthen ties with the local community in cleveland through collaboration with the cleveland institute of art. with support from both the interfacial engineering and electrochemical systems programs, this project will characterize the liquid structure of concentrated electrolytes at interfaces with electrified surfaces and quantitatively assess the structural impact on charge distribution, thermodynamics, and reaction mechanisms in separation processes and electrochemical reactions. the solvation structure and reactive state of the carbon dioxide model compound both within and at h<sub>2</sub>o electrolyte-electrode interfaces will be investigated by spectroscopy, neutron and x-ray reflectivity, and electroanalytical techniques. these studies will provide a basis for understanding the structure and dynamics of the behavior of small molecules in complex solvents. more specifically, the following scientific questions will be answered: (1) what is the physical environment of the carbon dioxide solvate complex at the electrode-electrolyte interface? and (2) what is the impact of the interface structure on electron and proton transfer and selectivity of the carbon dioxide reduction mechanism? the results from this study will contribute to the understanding of electrical double layer structures of h<sub>2</sub>o electrolytes, as they cannot be explained by the traditional models suitable for dilute systems. the results will also impact the discussions on the role of the electrolyte in carbon dioxide co-catalysis. the project will apply the stem educational concept of "learning by drawing" and artistic illustration in undergraduate and graduate-level courses and public outreach. learning by drawing is expected to enhance student engagement in engineering courses, improve visual literacy, promote knowledge retention, increase \*\*diversity\*\* among students pursuing stem-related fields, as well foster interdisciplinary communication between art and engineering students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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thermodynamics, and reaction mechanisms in separation processes and electrochemical reactions. the solvation structure and reactive state of the carbon dioxide model compound both within and at h2o electrolyte-electrode interfaces will be investigated by spectroscopy, neutron and x-ray reflectivity, and electroanalytical techniques. these studies will provide a basis for understanding the structure and dynamics of the behavior of small molecules in complex solvents. more specifically, the following scientific questions will be answered: (1) what is the physical environment of the carbon dioxide solvate complex at the electrode-electrolyte interface? and (2) what is the impact of the interface structure on electron and proton transfer and selectivity of the carbon dioxide reduction mechanism? the results from this study will contribute to the understanding of electrical double layer structures of h2o electrolytes, as they cannot be explained by the traditional models suitable for dilute systems. the results will also impact the discussions on the role of the electrolyte in carbon dioxide co-catalysis. the project will apply the stem educational concept of "learning by drawing" and artistic illustration in undergraduate and graduate-level courses and public outreach. learning by drawing is expected to enhance student engagement in engineering courses, improve visual literacy, promote knowledge retention, increase \*\*diversity\*\* among students pursuing stem-related fields, as well foster interdisciplinary communication between art and engineering students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Knowledge-Rich Neural Text Comprehension and Reasoning

Awardee: University of Washington

Amount: \$549,843.00

Abstract: enormous amounts of ever-changing knowledge are available online in diverse textual styles (e.g., news vs. science text) and diverse formats (knowledge bases vs. web pages vs. textual documents). this proposal addresses the question of textual comprehension and reasoning given

this **diversity**: how can artificial intelligence (ai) help applications comprehend and combine evidence from variable, evolving sources of textual knowledge to make complex inferences and draw logical conclusions? recent advances in deep learning algorithms, large-scale datasets, and industry-scale computational resources are spurring progress in many natural language processing (nlp) tasks, including question answering. nevertheless, current models lack the ability to answer complex questions that require them to reason intelligently across diverse sources and explain their decisions. further, these models cannot scale up when task-annotated training data are scarce and computational resources are limited. our results will give rise to the next generation of question answering and fact checking algorithms that offer rich natural language comprehension using multi-hop and interpretable reasoning even when annotated training data is scarce. with a focus on textual comprehension and reasoning, this research will integrate capabilities of symbolic ai approaches into current deep learning algorithms. it will devise hybrid, interpretable algorithms that understand and reason about textual knowledge across varied formats and styles, generalize to emerging domains with scarce training data (are robust), and operate efficiently under resource limitations (are scalable). toward this end, this research will focus on four transformative research initiatives: (1) defining a general-purpose formalism to promote data comprehension through knowledge-rich neural representations, (2) devising an interpretable, multi-hop inference and reasoning engine, (3) developing robust and scalable algorithms to demonstrate generalizable domain and device adaptation, and (4) building applications and datasets in question answering and fact checking tasks that will have lasting general-purpose utility. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: CAREER: Untangling Inter-Area Communication in the Brain Using Multi-Region Neural Networks



Awardee: Icahn School of Medicine at Mount Sinai

Amount: \$549,323.00

Abstract: human and animal behaviors like learning, remembering, and deciding require the interactions of neurons and circuits across regions of the brain. however, despite the importance of these interactions, remarkably little is known about the processes regulating these brain-wide communications. this research builds computer models of the brain based on measurements taken from humans and animals performing behaviors, and uses those models to identify how different brain regions communicate and work together to produce behaviors. this work will identify shared and distinct features of brain-wide communication to guide new experimental studies and enable new computer models to better define brain functions. additionally, this project promotes community engagement, **\*\*diversity\*\***, and inclusion through two complementary programs: "comp-ic book neuroscience," which brings research findings from computational neuroscience into under-served classrooms in new york city through the jargon-free and visually appealing medium of comics; and the student outreach for neuroscience integrated with cs (sonic) program, an annual lab-based summer school to give nyc-area senior college and graduate students hands-on experience with visualizing and modeling brain data. while rapid advances in neuroscience have catalyzed a deeper understanding of individual brain regions and their functions, these regions generally do not operate in isolation. yet, little is known about processes regulating the brain-wide communication underlying many behavioral outputs. to reveal fundamental principles of brain-wide communication, this project will produce (1) a new, scalable, robust, and flexible class of multi-region recurrent-neural network (rnn) models with inter-area communication; and (2) analysis methods to infer the direction and magnitude of interactions within and between areas. multi-region rnns will be constrained with real neural data to uncover mechanisms of the real biological system, for instance, how the cooperative activity of neurons within and across brain regions gives rise to complex behaviors like decision-making. reverse-engineering these models will reveal how multi-area brain circuits use biological plasticity to acquire a new skill. finally, rnn modeling of human

electrophysiology data will help identify inter-area communication processes that are conserved or divergent across multiple species. wider adoption of the new models and tools will transform the understanding of how interacting brain areas function cohesively to orchestrate complex behaviors and inform future experimental paradigms. the research will also promote cross-fertilization between neuroscience and artificial intelligence/machine learning communities, and provide quantitative techniques shared in the broader neuroscience community. furthermore, the project will foster an inclusive, welcoming environment for a diverse new generation of computational neuroscientists. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: NSF-AoF: FET: Small: Ubiquitous in-sensor computing for adaptive intelligent systems

Awardee: University of Massachusetts Amherst

Amount: \$547,998.00

Abstract: miniaturized sensor systems with built-in memory and computing functionalities are the cornerstones of artificial intelligence at the edge. however, in currently deployed systems, sensing and computing occur in separate physical locations, imposing massive data shuttling between the sensor module and the cloud-computing platform. this is unsustainable in terms of energy efficiency, latency, and capacity to process sensor data, and hence has a negative environmental impact with billions of sensors connected in the era of the internet of things (iot). the proposed project intends to go beyond state-of-the-art by system-level integration of sensing, memory, and computing functionalities into one chip, allowing for ubiquitous applications at low energy budget and low latency. furthermore, building such systems on flexible substrates will enable affordable and biodegradable smart-wearables electronics capable of monitoring human health continuously and adaptively. the proposed educational and outreach activities will promote stem careers, encourage **\*\*diversity\*\*** in engineering education and research, and significantly impact securing the future prosperity of the u.s. and the european collaborative partner (finland). the proposed research aims at delivering intelligent and energy-efficient wearable electronics that will become ubiquitous in the era of iot. the specific objectives towards this goal are as follows: 1) to design and fabricate emerging materials and devices for flexible sensors; 2) to integrate ferroelectric sensors and memristor crossbar arrays into a flexible near-sensor computing system with embedded security functionality; and 3) to demonstrate an in-sensor computing platform where emerging devices will be used as both sensing and non-volatile memory elements for in-pixel intelligent processing of images. the proposed research will enable the next-generation smart and flexible wearable electronics to process the acquired information onsite. by integrating the sensor module with the computing engine, the emerging hardware technologies will substantially improve power efficiency and computing throughput. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: BPC-A: LEAP Alliance: Diversifying Future Leadership in the Professoriate

Awardee: University of Illinois at Urbana-Champaign

Amount: \$541,167.00

Abstract: only 5.3% of the faculty at phd-granting universities are from the following underrepresented communities: black or african-american, hispanic, or american indian/alaska native. diversifying the computing professoriate is critical for providing excellent role models, shaping departmental programs and policies, and bringing diverse perspectives into research projects and programs. the leap alliance aims to increase the **\*\*diversity\*\*** of leadership in the computing professoriate by intentionally bringing together four cohorts of universities, each with common strengths and a common agenda. this work builds upon the lessons learned from a first cohort comprised of institutions producing a large percentage of computing faculty and adds three additional cohorts to further strengthen the pipeline to the computing professoriate. the goal of the leap alliance is to address the broadening participation challenge of increasing the **\*\*diversity\*\*** of the future leadership in the computing professoriate at research universities as a way to increase **\*\*diversity\*\*** across the field. key national leadership roles, such as serving on national committees that impact the field of computing, often come from research universities, making these institutions a critical point of focus. the alliance has previously piloted this effort in an initial cohort of 11 research universities who were found to produce over 50% of the faculty at the top 55 research institutions. they will continue to bring together similar institutions in a second cohort, as well as cohorts that focus on institutions graduate a large percentage of computing phds and computing undergraduates, respectively. ultimately, the alliance aims to increase the **\*\*diversity\*\*** of phd graduates from the institutions that are the top producers of computing faculty, increase the exposure of academic careers at the institutions that already have good **\*\*diversity\*\*** in their phd

graduates, and increase the retention of diverse undergraduate students at the institutions who send students to graduate school that go on to be faculty. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CDS&E: Multi-scale Coherent Structure Extraction and Tracking For Modern CFD Data Analysis

Awardee: University of Houston

Amount: \$539,899.00

Abstract: coherent structures are persistent and recognizable patterns that can be found in fluid flows. in turbulent flows, coherent structures are closely related to a diverse range of physical phenomena, and understanding their behavior is crucial for characterizing, predicting and controlling these flows. however, reliable identification and characterization of coherent structures is challenging due to their **\*\*diversity\*\*** and complex inter-relations across different space- and time-scales. this project brings together experts from both the data visualization and fluid mechanics communities to investigate novel solutions to multi-scale coherent structure extraction, separation, tracking, and visualization. it aims at significantly advancing the ability to analyze large datasets of turbulent flows stemming from computational fluid dynamic (cfd) simulations in a wide range of engineering and scientific applications. this project provides opportunities for both undergraduate and graduate students with different and diverse backgrounds to participate in the proposed research. the research outcomes can be integrated into the development of a number of undergraduate and graduate courses taught at the university of houston. the outreach activities enabled by the proposed research help motivate more students to pursue a career in stem related fields. to achieve an efficient and reliable analysis for large-scale turbulent flow data, this project aims to investigate a new multi-scale coherent structure representation that encodes relevant flow

physics, statistics, and uncertainty information, and to develop a robust computation and exploration framework based on this new representation to support data-driven research. to enable this multi-scale analysis, this project applies a number of spatial and temporal domain decomposition strategies to the computational fluid dynamic (cfd) data. multi-field analysis and high-dimensional data projection techniques are adapted to incorporate different physical attributes to the representation. a novel graph representation is leveraged to encode this multifaceted information in a concise and dimension-independent form to enable multi-scale feature extraction and tracking. a matrix representation of this graph is employed to accelerate its processing by utilizing the recent advances in large-scale matrix calculation. a new visual analytic paradigm is devised based on the proposed graph representation to aid the exploration and comprehension of different turbulence structures individually or collectively. the developed techniques implemented as a number of software libraries can be integrated into existing software, e.g., paraview, for domain scientists to use in their daily research. the developed techniques can also be used as pre-processing toolboxes to quantify and extract coherent structures, which can then be visualized by existing software that are not suitable for direct library integration. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Edge CMT: Polygenic traits of heat stress phenome in coral "dark genes" from genome to functional applications

Awardee: University of Miami

Amount: \$537,475.00

Abstract: in this project, the researchers will use genomics, genetics, and cell biology to understand the function of coral genes during heat stress. thermal stress often causes the "bleaching" (whitening) of corals that is harming reefs worldwide and is a threat to marine biodiversity. genes

are the functional unit of dna and how the coral reacts to heat stress is called its phenotype. there are many genes involved in achieving the heat response phenotype and they will be studied in this project. this is important because the function of many of these and other genes and how they influence the phenotype of corals are not understood. in addition, many of the coral stress genes are unknown in other organisms (i.e., they arose in corals), and therefore present the opportunity to discover the function of novel genes. this research is important because it will help in the understanding of how both known and novel genes function, which can aid in the conservation of coral reefs- a resource that is important for national security and economic growth. lastly, this project will fund early career scientists and lead to broader impacts through the training and education of a diverse workforce in science. the overarching goal of this proposal is to determine the mechanistic drivers of the stress response in multicellular organisms, with a focus on the ecologically important corals. to achieve this goal, application of an end-to-end approach that extends from genes to phenotypes, to cell biology, using multi-omics and network methods with both holobiont and single cell data will be applied. this work will elucidate the coral stress phenome in species with differing reproductive strategies and geographical origins to determine the functions of both known and unknown (dark) genes. generating this knowledge base will transform coral biology and more broadly, provide a research platform for testing hypotheses about the resilience of other ecosystems, marine and terrestrial, which is particularly important under accelerating climate change. this project aims to increase the understanding and predictive capability of how key properties of living systems emerge from the interaction of genomes. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Topological dynamics of three-dimensional active fluids

Awardee: Brandeis University



Amount: \$535,193.00

**Abstract:** non-technical abstract spontaneous collective motion can be witnessed at different scales in nature: flocks of birds, migrating ants, and even cells within our own body moving collectively to close a wound. the goal of this research project is to better understand how these collective motions appear by employing simple three-dimensional biomimetic materials. these active materials are composed of proteins that can self-propel by harvesting energy from their environment. two types of 3d liquid crystals will be investigated where the propulsion is driven by either molecular motors or by biofilaments that grow from one end and shrink from the other, recapitulating two fundamental mechanisms employed by living cells to migrate. this research project will address how to relate the forces generated at the microscopic scale to the emergent collective properties in 3d, a critical step towards the predictive design of novel active materials for robotic or bioengineering applications. on the educational side, this project will improve **\*\*diversity\*\*** and retainment of underrepresented minorities at each academic level, from kindergarten through postsecondary education. the principal investigator will leverage the tangible nature of active matter to i) create a bilingual science children's book, ii) monthly science/pizza talks and iii) interactive demonstrations in local schools, and iv) an annual active matter bootcamp for reu students.

**technical abstract** simple biomimetic materials composed of biopolymers have become a paradigm for studying active fluids that spontaneously flow. at the macroscale, these flows often drive the nucleation of motile singularities such as topological defects. investigating such topological dynamics in 3d presents novel conceptual and experimental challenges. in addition, connecting these system-sized topological features to the microscopic driving forces is required to rigorously test hydrodynamic theories of active fluids. this career award aims to elucidate how the magnitude and the symmetry of mesoscopic active stresses drive the emergent topological dynamics of 3d active fluids with orientational order, with a particular focus on 3d active nematics and 3d polar fluids. together, these two complementary research projects provide a comprehensive description of the out-of-equilibrium hydrodynamics of motile topological defects in 3d. they will set the foundations for building

advanced biomimetic materials endowed with life-like properties. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: 21 cm Reionization Science with the MWA

Awardee: Brown University

Amount: \$534,990.00

Abstract: the epoch of reionization (eor) is the period of time in the early universe when it is thought that the first stars and galaxies formed. understanding the physics of galaxy formation and feedback during the eor is one of the key goals of modern cosmology and astrophysics. observations of neutral hydrogen in the early universe have the potential to revolutionize our understanding of these first stars and galaxies. this work will improve data analysis with the munchison widefield array telescope so that researchers can make significantly better detections of such faint signals, making the observations much more useful and providing a tool for researchers engaged in similar projects. in addition, this work will continue and expand the initiative to provide research experiences for non-traditional undergraduates. undergraduate research is an essential component in preparing students both for graduate school and for positions in the broader stem workforce. providing this kind of research experience to non-traditional undergraduate students will enable more of them to go on to graduate school, increasing the **\*\*diversity\*\*** of the broader stem community. this award supports the continued work of a successful eor analysis team. over the past four years innovations by the us imaging power spectrum (ps) team have driven the field forward and have led to the deepest eor ps limits in the world. the investigators will make the next steps needed to reduce the limits by another order of magnitude with munchison widefield array (mwa) data. specifically, this work will make improvements in ps analyses with the mwa that will lower limits on the signal strength by an order of magnitude, making deep cuts into the possible

parameter space for eor models. this research will be invaluable for the entire 21 cm community.

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: MRA: Elucidating Plant and Mycorrhizal Fungal Relationships and Consequences across Space and Time

Awardee: University of Tennessee Knoxville

Amount: \$531,657.00

Abstract: many plants are dependent on belowground fungi to help them obtain nutrients and respond to environmental stress. revealing the patterns and drivers of these interactions is important for understanding forest ecology and improving management practices. plant-fungal associations in the soil can dramatically influence plant growth and terrestrial ecosystem function. this research will take the advantage of several existing datasets, including those collected by national ecological observatory network (neon) and the u.s. forest service (usfs), to understand: 1) nation-wide patterns of plant-fungal associations; 2) key factors that influence these associations; and 3) how plant-fungal interactions influence key ecosystem functions such as carbon cycling. this research project will contribute to the fields of microbial ecology, ecosystem science, and global change biology by formulating and testing new theories about plant-fungal associations. results of the project will inform forest managers, policymakers, and other stakeholders on how to improve ecosystem management of plant and fungal bio\*\*diversity\*\* to promote sustainable ecosystems. the project will contribute to the professional development of diverse students at several stages. the goal of this project is to understand the patterns, drivers, and consequences of the linkages between plant and mycorrhizal fungal \*\*diversity\*\* across spatial and temporal scales. this information will enable better predictive understanding of essential ecosystem functions which they control. the project will use a holistic, scale-dependent framework that forecasts the strength and direction of

arbuscular mycorrhizal (am) and ectomycorrhizal (em) fungal-plant associations, and provides greater insight about the consequences for ecosystem functioning across space and over time. specific objectives of the project include: 1) elucidation of patterns of plant and mycorrhizal fungal **diversity** across scales by extensive dna sequencing and analysis; 2) determination of key abiotic and biotic drivers of observed co-occurrence patterns; and (3) forecasting the effects of plant-mycorrhizal fungal couplings on tree productivity and soil c storage, two key forest ecosystem functions. by linking multiple facets of both above- and belowground **diversity** in a scale-dependent context, the project will produce robust continental-wide distribution maps of am and em fungi for the first time. leveraging data-rich sampling of putative biotic and abiotic drivers of plant and fungal **diversity** by neon and the usfs, the project will also provide broad-scale understanding of when and where these drivers serve to couple or decouple plant and mycorrhizal fungal **diversity**. finally, by linking plant and mycorrhizal fungal **diversity** to the consequences they have for plant productivity and soil c storage and stability, the project will improve understanding of ecosystem resilience to environmental stress. the project will train diverse undergraduate and graduate students, postdoctoral scholars, and will enhance the development of three early-career scientists. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Understanding How Students' Sense of Belonging Develops During Undergraduate Field Experiences: Supports, Barriers, and Implications for Faculty

Awardee: Oregon State University

Amount: \$528,940.00

Abstract: this project aims to serve the national interest by addressing a critical need in the scholarship of stem teaching and learning. specifically, it is designed to advance understanding about how students' sense of belonging develops in undergraduate learning experiences outside of the traditional classroom. the project will focus on residential undergraduate field courses, a pivotal learning experience in stem disciplines such as ecology, geology, and geography. a sense of belonging plays an important role in students' mental health and well-being, academic achievement and motivation, and institution-level retention. it is also pivotal for the persistence of students from communities that are underrepresented in stem disciplines. the overarching goal of the project is to build the capacity of geosciences and biology faculty to support the development of students' sense of belonging. in this way, it can help to improve the inclusivity of courses that are a critical pathway for thousands of undergraduate students in field-based stem disciplines. this project has the potential for broad reach and impact on student engagement and learning in multiple stem disciplines and is likely to have a positive impact on the inclusivity of undergraduate field education.

it may be especially important for students from communities that have been historically excluded from field-based stem disciplines, whose persistence is strongly linked to sense of belonging in the scientific community. the project focuses on advancing understanding about how students' sense of belonging develops in residential field experiences and builds capacity for faculty from geosciences and biology to support the growth of students' sense of belonging. the following objectives will guide the project study: 1) identify factors that contribute to and hinder the development of students' sense of belonging during residential geosciences and biology undergraduate field courses; 2) characterize the design and implementation of geosciences and biology undergraduate field courses, specifically what practices faculty are using and what challenges and needs exist for the development of students' sense of belonging during undergraduate field courses; 3) create an empirically-based framework of how students' sense of belonging develops during residential undergraduate field courses; 4) facilitate a community of practice that uses and contributes to promising practices for the design and assessment of inclusive field courses that support the development of students' sense of belonging; and 5) articulate a suite of promising practices that have the potential to promote the development of students' sense of belonging during a range of formats of undergraduate field courses and for students from different backgrounds. using innovative and robust mixed methods research approaches, this work will contribute to the wider body of evidence-based, student-centered practices in undergraduate stem education. the work has the potential to provide a deep and impactful contribution to the fields of discipline-based education research (particularly in geosciences and biology), higher education, education and social psychology, and **\*\*diversity\*\***, equity, and inclusion. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the engaged student learning track, the program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: BRITE Pivot: Micro-Macro Modeling of Reactive Flow and Rock Weathering Enhanced by Artificial Intelligence

Awardee: Georgia Tech Research Corporation

Amount: \$525,070.00

Abstract: reactive flow is key to geomechanical instabilities that occur over spatiotemporal scales spanning several orders of magnitude. it is particularly challenging to formally link the microstructure changes induced by chemical reactions and pore deformation to measurable physical and mechanical properties, because the microstructural features that govern macroscopic fluid flow differ from those that dominate elastic, plastic and brittle behaviors. this boosting research ideas for transformative and equitable advances in engineering (brite) pivot award will deploy artificial intelligence (ai) strategies to predict the spatiotemporal scales of thermo-hydro-chemo-mechanical (thcm) instabilities and automatically adapt the representation of the microstructure as localizations occur. this adaptive multi-scale modeling approach will help improve the safety and sustainability of long-term underground geological storage facilities and understanding of chemical weathering processes in the bedrock, which play a central role in nutrient supply, landslide hazards, and the global carbon cycle. the integration of computer science, applied mechanics, geotechnical engineering and geomorphology aims to grow convergence research towards the design of new materials and the fundamental understanding of the behavior of solid and soft matter, hence providing new modeling tools to decipher the rules of life and harness the data revolution through deep neural networks that will highlight hidden correlations between topological features and phenomena. the pi will create multi-semester undergraduate research opportunities and international research experiences for students, develop a **\*\*diversity\*\***/equity/inclusion (dei) seminar series and co-design innovative inclusion metrics in engineering. the exploration of ai for computational geomechanics is at its infancy. the researched integration of ai with the



homogenization theory will spearhead impactful advances in applied mechanics, including the modeling of open thermodynamic systems, the development of a new class of adaptive micro-macro models and applications over a wide range of spatiotemporal scales. the research plan will integrate training, research, dissemination and dei activities for the pi and the students involved in the project, and will be organized around the five following scientific objectives: (1) construct a database of virtual experiments of confined reactive flow with a full-field method; (2) train and test a deep convolutional neural network (cnn) to recognize microstructural features that attract high spatiotemporal variations of field variables; (3) enrich eshelby's homogenization theory with inclusion-specific characteristic times; (4) train and test a deep cnn to adapt the homogenization scheme as a function of the microstructure changes and localizations that occur after characteristic times have elapsed; (5) solve coupled thcm boundary-value problems of geomechanics with the adaptive homogenization method. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Self-Assembly of Multicomponent Nanostructures

Awardee: Ohio State University

Amount: \$525,000.00

Abstract: with the support of the macromolecular, supramolecular and nanochemistry program in the nsf division of chemistry, professor jon parquette of ohio state university will develop new strategies to construct multicomponent nanomaterials via the self-assembly of simple building blocks. the capability to build abiological nanomaterials comprised of discrete, self-sorted domains is expected to enable the emergence of novel properties that will drive the development of novel biomaterials, drug delivery modalities, catalysts, and optoelectronic materials. this work will create a platform to also address other problems in human health and society, such as renewable energy, greenhouse

gas conversion, and medicine. this project will be used to enhance public awareness of nanoscience in society and will expose a **\*\*diversity\*\*** of students to scientific research. the pi will achieve these goals by supervising undergraduate and high school students in research, by mentoring undergraduate career clubs, and by participating in science exhibitions at columbus center of science and industry (cosi) as a member the center of applied plant science (caps) at ohio state university. this research aims to gain a better fundamental understanding of the factors that govern "self/non-self" interaction at the nanostructure level and to establish new design principles to construct multicomponent hierarchical architectures by the coassembly of spatially sorted domains of components. this is important because the nanoscale organization of the components of an assembled structure critically impacts the functional attributes of a nanomaterial. the first aim of this work will construct block sequences of two types of supramolecular rings within a self-assembled nanotube via a heterogeneous nucleation-elongation mechanism. the second aim facilitates the interactions between the separate domains by incorporating an intervening polydopamine layer to stabilize one component and mediate further interactions with additional assembled structures. transient nanostructures that only persist in the presence of fuel play critical roles in living cells, such as controlling the mechanical properties of the cytoskeleton. thus, the third aim of this work will focus on the design of transient multicomponent hydrogels that exhibit time-dependent physical/optical characteristics, whose temporal evolution can be directly visualized using confocal light microscopy.

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Title: IntBIO COLLABORATIVE RESEARCH: Integrating trait diversity across hierarchical scales to predict biological resilience in an era of extreme environmental change

Awardee: University of North Carolina Greensboro

Amount: \$524,421.00

Abstract: extreme climate events, such as drought or wildfire, may occur in high frequency and/or in tandem. these extremes are likely to occur more frequently over the coming decades and will likely have more severe effects on natural and human landscapes than when extreme events occur alone. many parts of southern africa suffered the effects of compound extremes in 2015 and 2016 when drought and heavy wildlife use caused substantial declines in vegetative cover and mass wildlife mortality in national parks. many areas are yet to fully recover. ecosystem recovery after compound extremes is critical for maintaining important services that landscapes provide, such as wildlife habitat, food production, and carbon storage. the mechanisms behind recovery after extreme events are not well understood, although there is mounting evidence that the **diversity** of organisms (i.e., **bio**diversity****) within ecosystems may be key. this award will experimentally impose compound extremes in a south african savanna and incorporate measured outcomes into computer models to understand how **diversity** of plant life controls ecosystem recovery after compound extremes. the information and tools created by this project will be important for land managers and policy makers to maximize the recovery potential of public and private lands through the promotion of **bio**diversity****. additionally, this project will provide important training and education opportunities for a diverse assemblage of people (local south african stakeholders, high school, undergraduate and graduate students, and postdoctoral scholars), and will prioritize advancement of **diversity**, equity, and inclusion in the sciences. currently, the importance of **bio**diversity**** for ecosystem recovery (i.e., resilience) is recognized at the community level, but the mechanisms underlying species **diversity** that can extend these concepts to other spatial and hierarchical scales are not

well understood. organismal traits provide a useful framework for understanding these mechanisms because the coordination of physiological, morphological, and anatomical characteristics determine the response of individuals to their environment; this facilitates scaling from organisms to populations, communities, and ecosystems using first principles. this study will first extend bio\*\*diversity\*\*-resilience ideas beyond simple species \*\*diversity\*\* by using methods to examine \*\*diversity\*\* of plant traits (e.g., functional dispersion). second, it will scale bio\*\*diversity\*\*-resilience relationships from individual organisms, through populations and communities, to entire ecosystems. to these ends, this project will experimentally impose extreme drought, extreme grazing, and extreme fire, singly and in combination, in a south african savanna and determine (1) \*\*diversity\*\* of functional traits before, during, and after treatments to link with (2) responses of individuals, populations, communities, and the ecosystem during and after treatments. empirical data will then be used to parameterize and benchmark a mechanistic demographic vegetation model to expand the inference of these effects to longer time frames and a wider range of bio\*\*diversity\*\* scenarios. the three overarching questions this project will address are: (1) how does \*\*diversity\*\* at different hierarchical scales control resilience of biological function after perturbations? (2) how do perturbations affect bio\*\*diversity\*\* at multiple hierarchical scales? (3) how does \*\*diversity\*\* and resilience change with frequency and compound perturbations? this project is jointly funded by emerging frontiers in the directorate for biological sciences and the established program to stimulate competitive research (epscor). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Collaborative Research: CCRI: New: Medium: A Development and Experimental Environment for Privacy-preserving and Secure (DEEPSECURE) Machine Learning

Awardee: SUNY at Buffalo

Amount: \$520,000.00

Abstract: while machine learning (ml) is embraced as an important tool for various science, engineering, medical, finance, and homeland security applications, it is becoming an increasingly attractive target for cybercriminals. deepsecure is a first-of-its-kind development and experimental platform to support secure and privacy-preserving ml research. with its novel modular design

integrated with fully customizable function blocks and sample modules, deepsecure is a game-changing tool to effectively support research in this emerging field by enabling fast design, prototyping, evaluation, and re-innovation of trust-worthy ml applications. it enables a variety of compelling new research projects that focus on ml security and privacy, leading to breakthroughs to protect ml systems and accelerating their development and widening their adoption. it will contribute significantly to the protection of the future cyber and physical world and safeguard human society. deepsecure receives strong community support from over 20 key stakeholders across the country. the project includes significant efforts for fostering and sustaining an ml security and privacy research community, including monthly virtual open forums to provide a regular update to and seek feedback from the community, quarterly advisory board meetings, annual symposiums, and a training workshop series. the project includes specific measures and plans for inspiring the participation of underrepresented groups and infusing **\*\*diversity\*\*** and inclusion in all deepsecure events and activities. the project output includes an open-source and easy-to-use learning platform for curriculum development and workforce training. to support building a sustainable workforce development pipeline, the project team participates in the existing annual gencyber summer camps for k-12 students and a cyber saturday series to introduce cybersecurity and ai career paths and educational resources to k-12 school counselors, teachers, students, and parents. recent development in privacy-preserving and secure ml draws expertise from both ml and security/privacy to tackle the multi-faceted problem. however, the research community is facing fundamental challenges in this emerging area due to its interdisciplinary nature. on the one hand, although deep learning frameworks such as pytorch and tensorflow have been made widely available, a critical hurdle faced by ml researchers is the steep learning curve to effectively use security techniques and libraries to tackle ml security and privacy problems. on the other hand, while the security community has developed highly efficient cryptographic libraries, it remains nontrivial to integrate them into deep learning models to achieve a computation efficiency suited for practical applications. the overarching goal of the project is to close the gap by developing deepsecure, which integrates a



spectrum of essential functions and building blocks that are ready-to-use to flatten the learning curve for researchers coming from both ml and security/privacy communities. at the same time, deepsecure is fully customizable and scalable, enabling deep and fundamental research toward privacy-preserving and secure ml. to meet the overarching goal, specific project objectives include: (1) acquiring a scalable and re-configurable compute environment based on the latest dell, amd, and nvidia technologies to establish the deepsecure hardware infrastructure across the campuses of old dominion university and university of buffalo; (2) developing a new software platform to support deepsecure sde (software development environment) and mec (multi-user experimental chamber). the platform is integrated with pytorch to enable great usability for both beginners and advanced researchers and feature a scalable and customizable modular framework with seamlessly integrated libraries, function blocks, and sample modules; (3) promoting deepsecure across the nation to ensure broad participation, collaboration, and sharing; (4) leveraging deepsecure to foster a long-lasting, self-sustainable ml security and privacy research community that engages all stakeholders in a sustained and ongoing way; and last but not least, (5) educating and training diverse cybersecurity workforce to safeguard the future intelligent cyber systems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: CCRI: New: Medium: A Development and Experimental Environment for Privacy-preserving and Secure (DEEPSECURE) Machine Learning

Awardee: SUNY at Buffalo

Amount: \$520,000.00

Abstract: while machine learning (ml) is embraced as an important tool for various science, engineering, medical, finance, and homeland security applications, it is becoming an increasingly attractive target for cybercriminals. deepsecure is a first-of-its-kind development and experimental

platform to support secure and privacy-preserving ml research. with its novel modular design integrated with fully customizable function blocks and sample modules, deepsecure is a game-changing tool to effectively support research in this emerging field by enabling fast design, prototyping, evaluation, and re-innovation of trust-worthy ml applications. it enables a variety of compelling new research projects that focus on ml security and privacy, leading to breakthroughs to protect ml systems and accelerating their development and widening their adoption. it will contribute significantly to the protection of the future cyber and physical world and safeguard human society. deepsecure receives strong community support from over 20 key stakeholders across the country. the project includes significant efforts for fostering and sustaining an ml security and privacy research community, including monthly virtual open forums to provide a regular update to and seek feedback from the community, quarterly advisory board meetings, annual symposiums, and a training workshop series. the project includes specific measures and plans for inspiring the participation of underrepresented groups and infusing **\*\*diversity\*\*** and inclusion in all deepsecure events and activities. the project output includes an open-source and easy-to-use learning platform for curriculum development and workforce training. to support building a sustainable workforce development pipeline, the project team participates in the existing annual gencyber summer camps for k-12 students and a cyber saturday series to introduce cybersecurity and ai career paths and educational resources to k-12 school counselors, teachers, students, and parents. recent development in privacy-preserving and secure ml draws expertise from both ml and security/privacy to tackle the multi-faceted problem. however, the research community is facing fundamental challenges in this emerging area due to its interdisciplinary nature. on the one hand, although deep learning frameworks such as pytorch and tensorflow have been made widely available, a critical hurdle faced by ml researchers is the steep learning curve to effectively use security techniques and libraries to tackle ml security and privacy problems. on the other hand, while the security community has developed highly efficient cryptographic libraries, it remains nontrivial to integrate them into deep learning models to achieve a computation efficiency suited for practical applications. the

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Matched Words: diversity

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Title: Tuning Teflon-Coated Earth-Abundant Metal Complexes in Oxidative Catalysis

Awardee: Trustees of Boston University

Amount: \$518,135.00

Abstract: with the support of the chemical catalysis program in the division of chemistry, professor linda doerrer of boston university and professor kimberly ann stieglitz of roxbury community college will study the specific conversion of carbon-hydrogen bonds to carbon-oxygen and carbon-carbon

bonds. these oxidation reactions are widespread and critical reactions in modern chemistry. the cheapest and most sustainable oxidant is atmospheric oxygen ( $\text{O}_2$ ) but oxygen also is capable of oxidatively inactivating many catalyst systems. almost all catalysts that utilize  $\text{O}_2$  in these oxidation reactions contain transition metals that enable these reactions to take place. this work will expand on current efforts to prepare new Cu catalysts supported by fluorine-rich "teflon-coated" ligand systems that provide stability to the molecular catalysts. the researchers will prepare new compounds in which clamping ligands hold metal atoms tightly to control reactivity between  $\text{O}_2$  and the substrate. the project will also probe oxidations using other metals besides Cu, particularly with Mn and V, and will extend the research to Fe-containing systems. an important thrust will be the development of catalysts that perform well in water and air to make these hydrocarbon oxidation systems more sustainable and environmentally friendly. the broader impacts of this work will involve undergraduate course development, student training, and a productive collaboration between Boston University and Roxbury Community College. Roxbury Community College delivers instruction to a high percentage of students from underserved minority groups; thus this collaborative effort will be directed at increasing **diversity**, equity, and inclusion in STEM (science, technology, engineering and mathematics) fields.

in these studies, professors Linda Doerr of Boston University and Kimberly Ann Stieglitz of Roxbury Community College will study the oxidation of C-H bonds. this work builds on prior work of the researchers on Cu/ $\text{O}_2$  chemistry that has demonstrated the effectiveness of fluorinated alkoxide ligands to make highly reactive species for oxidizing C-H bonds. the nature and degree of encapsulation of redox inert counter cations, specifically K, on the catalytic activity will be investigated. other counter cations of Li, Na, Rb, and Cs will also be pursued, as will an Fe-based catalysts system which will be accessed via two complementary routes. a Bordwell square approach will be used to generate a proposed  $\{\text{Mn(III)OH}\}$  reagent in situ that will be used to probe its thermodynamic properties. exploration of the scope and optimization of reaction conditions with a benchtop-stable vanadium compound capable of catalytic C-H bond oxidation will be part of a hands-on experimental synthesis and spectroscopy class taught at Roxbury Community College by

the collaborative team. this continued collaboration brings together expertise in transition metal complexes (doerrer) and in organic compound characterization (stieglitz), and will enhance the training of underrepresented minority students for stem careers while exposing them to research at an r1 university. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Excellence in Research: Investigation of Interfacial Chemical and Ion Transport in Solid Inorganic-Polymer Electrolytes

Awardee: Xavier University of Louisiana

Amount: \$513,443.00

Abstract: limited understanding ion transport at the interfaces in electrochemical systems is a major obstacle in the development of safe, reliable advanced lithium batteries with ultra-high energy density and high power-density. such batteries are needed for the widespread electrification of transportation and storage of renewably generated electricity. fundamental understanding of ion transport and control of interfacial reactions between a composite electrolyte and electrodes will enable engineering of new interfaces containing safer, solid polymer-based composite electrolytes. in this project, the researchers will investigate ion transport at the boundaries of the electrolyte/electrodes as well as between the ceramic/polymer matrix. the team will utilize several different characterization tools to understand the properties of the materials. the students involved in this research project will be engaged in cutting-edge research on a topic of importance to addressing the global energy challenge. this project will contribute to improving **\*\*diversity\*\*** in the stem (science, technology, engineering, and mathematics) workforce by recruiting and retaining highly qualified students from underrepresented minority groups and engaging these students in cutting-edge research and development in energy storage technologies. the overall collaboration

between xavier university of louisiana (xula) and the university of notre dame (nd) which includes summer visits of undergraduate xula researchers to the nd research group will enhance the students' research experiences, promote retention of underrepresented minority students in stem fields, and enable research not possible by either group individually. interfacial research is critically needed for designing new solid electrolyte systems with both high bulk ionic conductivity and that is chemically and dimensionally stable against the li anode with cycling. composite polymer electrolytes have flexibility necessary to withstand electrode volume changes with cycling, yet ion transport is limited between the ceramic and polymer in the bulk electrolyte and between the composite and the electrode surface. the interfacial resistances lead to reduced bulk ionic conductivities, reduced safely achievable cycling rates, and poor li anode performance. in this project by researchers at xula and nd, the interfacial chemistry and ion transport within the system including composite polymer electrolytes and li anodes will be investigated as a function of polymer type to allow for the fundamental understanding of each chemistry and polymer dynamics on interfacial properties. these studies will test the hypotheses that nanoscale void formation between the electrolyte and anode, as well as between ceramic and polymer matrix, causes roughness and small contact area for ion transport which increases the interfacial resistance, and a lithium deficient layer at the interface leads to the formation of space-charge which also contributes to interfacial resistance. this project is jointly funded by the established program to stimulate competitive research (epscor), and the broadening participation in engineering program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Texas at Arlington

Amount: \$512,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and \*\*diversity\*\* of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: IntBIO Collaborative Research: An integrative approach for projecting insect responses to a rapidly changing climate

Awardee: University of Alaska Fairbanks Campus

Amount: \$511,073.00

Abstract: projecting species' responses to climate change at continental scales is a current 'grand challenge' of ecological research. insects are sensitive indicators of both climate and land-use change and recent studies indicate widespread declines in many geographic regions. to predict changes across entire ranges, a variety of species distribution models have been developed, but rarely account for regional variability, ecological interactions or a species' potential to adapt to changing conditions. this project spans multiple institutions situated in the united states' southwest, polar north, and temperate eastern regions. a series of physiological experiments will be implemented for five widespread butterfly species with populations sourced from different biomes within each of their ranges. caterpillars will be subjected to a range of conditions mimicking past, current and future climates. their development rate, survivorship, immune response, and genetic

structure and gene expression (which genes are actively coding for proteins) will be measured and used to build models that predict distributional shifts. data collected by community (?citizen?) scientists will be used to validate the models. this project requires substantial cross-disciplinary collaboration, and a central goal is to recruit diverse trainees at the graduate and undergraduate levels and train them in the ?science of team science?. project trainees will develop independent research ideas that align with and expand the project?s scope and travel between and work at collaborating institutions as an inter-lab exchange to learn new techniques and be exposed to different research philosophies. finally, the project has significant management implications for insect bio\*\*diversity\*\* conservation. projecting responses to climate change at continent scales is a current ?grand challenge? of ecological research. insects are the most diverse and ecologically important terrestrial animal taxon and are strongly affected by climate change. to predict changes, species distribution models (sdms) have been widely implemented across many taxa. sdms, however, rarely account for ecological interactions, plasticity or evolutionary adaptive potential owing to the extensive physiological and ecological data required to parameterize such models. the biology of lepidoptera, particularly butterflies, is extremely well observed, thus it is logistically feasible to build upon past knowledge and collect additional data that enables mechanisms to be more seamlessly integrated into sdms. multiple populations for each species will be sourced from different biomes across its range. caterpillars will be reared in common gardens under a range of temperature conditions mimicking past, current and future climates. their development rate, survivorship, immune response, genetic structure and gene expression will be measured and used to build models that predict future distributions. distribution data collected by community (?citizen?) scientists will be used to validate and improve models and allow robust estimates of uncertainty. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: CAREER: Models and Algorithms for Strategic Conservation Planning

Awardee: Arizona State University

Amount: \$511,057.00

Abstract: this faculty early career development program (career) award will contribute to the national health, prosperity, and welfare by improving decision-making in conservation planning through new theory, models, algorithms, and visual analytics tools for landscape and conservation ecology. bio\*\*diversity\*\* has been declining at rapid rates during the last several decades due to habitat loss, landscape deterioration, environmental change, and human-related activities that directly and indirectly affect natural habitats. in addition to its economic and cultural value, bio\*\*diversity\*\* plays an important role in keeping an environment?s ecosystem in balance. disrupting such processes can reduce the provision of natural resources such as food and water, which in turn yields a direct threat to human health. protecting natural areas is fundamental to preserving bio\*\*diversity\*\* and to

mitigate the effects of ongoing environmental change. this award will contribute quantitative methods to support informed decisions on conservation design and effective land use to support species sustainability. these methods integrate realistic ecological features, specific spatial properties of the selected reserves (e.g., connectivity), population dynamics within the spatial assets, and the impact of current and future threats. the educational plan will improve the skills and **diversity** of future generations of engineers via technical training and engagement in transdisciplinary research. the outreach activities aim to increase the students' awareness of current bio**diversity** and conservation challenges. this award supports fundamental research on the design of portfolios of land or marine patches to support species sustainability. these design problems result in very large mixed-integer linear programs whose solutions require innovative formulations and new large-scale optimization methods. the new models and specialized algorithms will allow decision-makers to solve a variety of realistic large-scale corridor and reserve design problems that include patch-specific conservation decisions under spatial, operational, ecological, and biological requirements. these models will feature realistic objectives faced by practitioners, such as maximization of the protected area or the number of species covered and minimization of the conservation cost. the design models will embed stochastic processes to capture the species' spatiotemporal movement across the landscape and to assess the effectiveness of conservation plans, including extinction risks, mortality, and ecosystem disturbances. new bi-level and stochastic optimization models and algorithms will support the design of robust conservation areas, i.e., areas that provide acceptable levels of ecological benefits even under future extreme and adverse events affecting the landscape. a visual analytics tool will integrate the developed tools, facilitating the discussion of optimal conservation plans with practitioners, advocates, and experts. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: Varieties of Crises, Elite Responses, and Executive Approval

Awardee: Georgia State University Research Foundation, Inc.

Amount: \$510,490.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2. this project examines four major types of crises -- economic, security, natural disaster, and public health crises ? and how they influence public support for political leaders in contemporary democracies. this is important to understand because leader approval is a key barometer of policymaker accountability and democratic stability, both of which can be undermined by crises. this project analyzes the interplay of four factors which vary systematically across these different types of crises and how, in turn, these shape public evaluations of political executives: (1) the ability of citizens to assign responsibility for policy decisions and outcomes; (2) the degree of expert consensus on effective policy response; (3) how much a given crisis in one area generates acute challenges or crises in other areas; and (4) the extent to which an effective response depends on citizens acting collectively. several data sets including (quarterly) measures of executive approval

and crises; the tone and salience of leader messaging about the crises; the media's treatment of leader messaging; and (monthly) leader approval for a smaller number of countries for which such data is available; and survey-based experiments in three countries are collected and made publicly available. the award supports education and **\*\*diversity\*\*** by building the research capacity of a student project lab at georgia state university, a minority serving institution, in coordination with pis at four other universities who will also engage graduate and undergraduate students in this work.

puzzling divergences across countries in public reactions to leader responses to the covid-19 public health crisis have revealed major gaps in our understanding of how crisis events translate into public assessments of leaders. to resolve these puzzles, this project advances a unifying theoretical framework that identifies four major types of crises: economic, security, natural disaster, and public health. it then locates these crises on four key dimensions which should condition public support of top officials: the institutional and political context and other factors that impact attribution of responsibility, degree of expert consensus and incentives for politicians to follow expert recommendations, the likelihood and nature of spill-over to other crisis types, and the degree to which citizen action is required for an effective response. the project collects data to test theoretically-motivated hypotheses using: 1) a macro time-series cross-national data set to study the effects of crisis type on public approval for political executives for 48 countries, 2) a high-frequency time-series data set appropriate to test how approval dynamics reflect leader responses, as well as messaging choices and media effects for 18 countries for which this data is available, and 3) conjoint experiments in france, italy, and mexico, countries with different political and institutional settings, to assess the validity of the links between crisis types and dimensions as well as to validate proposed individual-level mechanisms. this project is supported by the accountable institutions and behavior program and the sbe build and broaden program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Instrument Development: Creating a Tunable, Broad bandwidth 2D IR Microscope for Quantitative Imaging of Chemical Dynamics Near Reactive Surfaces

Awardee: Colorado State University

Amount: \$510,200.00

Abstract: with the support of the chemical measurement and imaging (cmi) program in the division of chemistry, amber krummel of colorado state university will study the structures and motions of molecules near electrode surfaces. a major goal is to produce molecular snapshots during the formation and growth of the solid electrolyte interphase (sei) in a model electrochemical cell. the electrolytes and electrodes used in this project will be chosen to closely model organic battery electrolytes and half-cells contributing to emerging energy storage technologies. dr. krummel and her group will be building new capabilities into an emerging imaging technique? 2-dimensional infrared (2d-ir) microscopy. 2d-ir microscopy holds the promise of visualizing the "molecular dance" taking place near electrode surfaces, due to its ability to provide chemical information at ultrafast time scales and its sensitivity to different types of molecular structures. the efforts supported by this funding will produce new chemical imaging tools crucial to many disciplines of science and technology, such as electrochemical processes associated with clean energy technologies, materials science, biotechnology, and geology. the results of the imaging experiments are expected to provide insights into the fundamental characteristics of sei, which is key for understanding device performance issues encountered in energy storage technologies. further broadening impacts of the project are dr. krummel is helping to train the next generation of spectroscopists and microscopists in the areas of physical chemistry, laser physics, and materials chemistry. the primary goal of building a tunable, broad bandwidth 2d-ir microscope will require integration of knowledge in optical physics, imaging, and ultrafast nonlinear optical spectroscopy tools. finally, through hands-on mentoring, the researchers in the krummel group will learn the art of communicating their innovations to broad audiences and principles of community through direct training in **\*\*diversity\*\***,

equity, inclusion, and social justice issues within their communities. developing an imaging modality capable of reporting chemical dynamics at ultrashort timescales and then connecting the observed dynamics to macroscopic observables is extremely attractive. two-dimensional infrared (2d-ir) spectroscopy is a proven tool for capturing information on chemical structures and dynamics at femtosecond timescales and longer, which limits its recording chemical information about reactions that are extremely fast and key to many crucial chemical processes. this project is expected to significantly reduce the acquisition time of 2d ir spectra, thus making it possible to develop new 2d-ir imaging tools to directly measure molecular interactions across multiple length scales. the scientific inquiry outlined in this project aims to create a new nonlinear optical microscopy tool capable of mapping chemical interactions. the chemical interactions that will be mapped are expected to contain quantitative details of dynamic behaviors in electrolytes near electrode surfaces. the research team will initiate in situ imaging of molecular structures and dynamics during solid electrolyte interphase formation for the first time. these experiments have to potential to increase knowledge of fundamental driving forces present during sei formation at electrode surfaces, providing crucial control parameters of the sei, as well as demonstrating the utility of 2d-ir imaging across a range of scientific disciplines. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: Edge CMT: Polygenic traits of heat stress phenome in coral "dark genes" from genome to functional applications

Awardee: Rutgers University New Brunswick

Amount: \$509,125.00

Abstract: in this project, the researchers will use genomics, genetics, and cell biology to understand the function of coral genes during heat stress. thermal stress often causes the "bleaching" (whitening) of corals that is harming reefs worldwide and is a threat to marine biodiversity. genes are the functional unit of dna and how the coral reacts to heat stress is called its phenotype. there are many genes involved in achieving the heat response phenotype and they will be studied in this project. this is important because the function of many of these and other genes and how they influence the phenotype of corals are not understood. in addition, many of the coral stress genes are unknown in other organisms (i.e., they arose in corals), and therefore present the opportunity to discover the function of novel genes. this research is important because it will help in the

understanding of how both known and novel genes function, which can aid in the conservation of coral reefs- a resource that is important for national security and economic growth. lastly, this project will fund early career scientists and lead to broader impacts through the training and education of a diverse workforce in science. the overarching goal of this proposal is to determine the mechanistic drivers of the stress response in multicellular organisms, with a focus on the ecologically important corals. to achieve this goal, application of an end-to-end approach that extends from genes to phenotypes, to cell biology, using multi-omics and network methods with both holobiont and single cell data will be applied. this work will elucidate the coral stress phenome in species with differing reproductive strategies and geographical origins to determine the functions of both known and unknown (dark) genes. generating this knowledge base will transform coral biology and more broadly, provide a research platform for testing hypotheses about the resilience of other ecosystems, marine and terrestrial, which is particularly important under accelerating climate change. this project aims to increase the understanding and predictive capability of how key properties of living systems emerge from the interaction of genomes. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: WINTRE-MIX: Winter Precipitation Type Research Multi-scale Experiment

Awardee: University of Wyoming

Amount: \$507,753.00

Abstract: during near-freezing weather conditions, a **\*\*diversity\*\*** of surface precipitation types are possible, including: rain, drizzle, freezing rain, freezing drizzle, wet snow, ice pellets, and snow. such near freezing precipitation affects wide swaths of the united states and canada, impacting aviation, road transportation, power generation and distribution, winter recreation, ecology, and hydrology.

this award is for a field experiment, named the winter precipitation type research multi-scale experiment (wintre-mix) with the overarching goal of improving understanding of how a variety of processes influence the variability and predictability of the type and amount of precipitation that falls during winter weather events. the project has direct societal impact through the potential for improved forecasting of these events. additionally, the project will have significant student involvement, public outreach events, and citizen science participation. the wintre-mix campaign will be conducted in southern quebec, canada and northern ny and vt in the united states. the canadian national research council convair-580 research aircraft and the university of illinois mobile radars will be deployed along with a host of surface-based instrumentation in february and march of 2022 to make observations that can be used to determine the thermodynamic, dynamic, and microphysical processes that interact to determine near-freezing precipitation type. more specifically, the project has three overarching scientific questions that will be addressed using observations, analysis, and modeling: 1) how do mesoscale dynamics modulate near-freezing precipitation, 2) how do microscale processes modulate near-freezing precipitation, and 3) how do multi-scale processes combine to determine the predictability of near-freezing precipitation? this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: CAREER: Development and Application of First-Principles Dielectric Embedding Many-Body Perturbation Theory for Heterogeneous Interfaces

Awardee: Wayne State University

Amount: \$507,453.00

Abstract: nontechnical summary      this career award supports research and education in computational and theoretical condensed matter and materials physics. the research part of this

project focuses on the development and application of new computational tools to study the electronic properties of heterogeneous interfaces formed between molecules and solid substrates. such interfaces find broad applications in energy conversion materials, such as photovoltaics that convert solar energy into electric current and photocatalytic materials that harvest solar light to drive chemical reactions. to understand and control these complex processes at a fundamental level, it is essential to accurately describe the electronic structure based on quantum mechanical simulations of the materials. given the large system size and the accuracy needed to quantitatively understand the energy conversion mechanisms at heterogeneous interfaces, most conventional simulation methods are unfortunately either inefficient or inaccurate. the objective of the research part of this project is to develop a suite of new computational schemes that are both accurate and efficient in the characterization of the electronic structure at heterogeneous molecule-substrate interfaces. these methods will significantly expand the scope of materials and interfaces that can be routinely modeled as compared to the current state of the art. the basic idea is to divide the interface into its smaller constituents or building blocks and then treat each component with high-level theory while considering it embedded in the environment of the others. using this embedding approach, the team will quantitatively investigate how the electronic structure of each component of the interface is affected by the others, and how the electronic structure of the entire interface is different from those of the individual constituents. the team will apply the new computational approach to a few emerging systems of experimental significance, especially interfaces involving multiple light absorbers and interfaces featuring electronic and optical properties which differ considerably when measured in different directions. the research will lead to new insights into energy conversion mechanisms and the rational design of new energy materials. the research activity is closely integrated with the education and outreach parts of this project. the pi will organize a summer camp annually for local high school students in the southeastern michigan area, promoting the awareness of the importance of computation and its power in scientific research. the summer camp also addresses the **\*\*diversity\*\*** challenge in science, technology, engineering, and mathematics in the metropolitan

detroit area. additionally, the pi will provide summer intern positions in his research group for local high school students and teachers, broadening the impact of the pi's undertaking in educating the next generation of scientists beyond training graduate students. furthermore, the pi will continue the development of a computational chemistry course at wayne state university for both undergraduate and graduate students. the pi will continuously add course content based on his research expertise in materials chemistry and customize the topics to meet the research needs of the enrolled students. moreover, the pi plans to organize mini-workshops on the basic use of mathematical software in the chemistry department at wayne state university for both undergraduate and graduate students, offered twice a year, as an endeavor to mitigate the students' common math anxiety in the learning of science courses.

technical summary      this career award supports research and education in computational and theoretical condensed matter and materials physics. the research part of this project focuses on the development and application of new computational methods to study the quasiparticle electronic structure and optical excitations at heterogeneous interfaces formed between molecules and solid substrates. such interfaces are ubiquitous in nanoscale energy conversion applications, such as photovoltaics and photocatalysis. although many-body perturbation theory such as the gw-bse formalism (g is the green's function, w is the screened coulomb interaction, and bse stands for bethe-salpeter equation) provides a rigorous theoretical framework, first-principles calculations of large molecule-substrate interfaces are computationally expensive. lack of efficient yet reliable computational schemes for large heterogeneous interfaces hinders fundamental understanding of the molecule-substrate interactions and interfacial charge dynamics.

the research part of this project aims to develop a suite of new tools, termed as "dielectric embedding gw-bse", to make such calculations practically affordable for large interfaces without sacrificing accuracy. the essential idea is to confine explicit gw-bse calculations within each component of the interface while treating the effect of the others as a dielectric environment. this project will leverage the newly developed methods to study a few systems of experimental significance, including: (1) interfaces formed between monolayer transition-metal dichalcogenides

(tm<sub>2</sub>S<sub>2</sub>) and (metallo)phthalocyanines, where the gaps and excitons of both components as well as the valley pseudospin of the tmd substrates within the interface will be studied; (2) interfaces involving black phosphorus, where the anisotropy of the dielectric screening at such interfaces will be scrutinized; and (3) charge-transfer systems modulated by interfaces, such as molecular donor-acceptor pairs adsorbed on metal or semiconductor substrates and large organic adsorbates on bilayer tm<sub>2</sub>S<sub>2</sub> featuring inter-layer charge-transfer excitons. the research activity is closely integrated with the education and outreach parts of this project. the pi will organize a summer camp annually for local high school students in the southeastern michigan area, promoting the awareness of the importance of computation and its power in scientific research. the summer camp also addresses the **\*\*diversity\*\*** challenge in science, technology, engineering, and mathematics in the metropolitan detroit area. additionally, the pi will provide summer intern positions in his research group for local high school students and teachers, broadening the impact of the pi's undertaking in educating the next generation of scientists beyond training graduate students. furthermore, the pi will continue the development of a computational chemistry course at wayne state university for both undergraduate and graduate students. the pi will continuously add course content based on his research expertise in materials chemistry and customize the topics to meet the research needs of the enrolled students. moreover, the pi plans to organize mini-workshops on mathematica and wolframalpha in the chemistry department at wayne state university for both undergraduate and graduate students, offered twice a year, as an endeavor to mitigate the students' common math anxiety in the learning of science courses. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Development and Application of First-Principles Dielectric Embedding Many-Body Perturbation Theory for Heterogeneous Interfaces



Awardee: Wayne State University

Amount: \$507,453.00

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Matched Words: diversity

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Title: EF: Collaborative Research: MTM 2: Marine Invertebrate Microbiome Assembly, Diversification, and Coevolution

Awardee: University of Alabama Tuscaloosa

Amount: \$505,300.00

Abstract: microbes associated with marine invertebrates are of broad interest for establishing the rules of life for host-microbe associations. although some marine invertebrates host only one or two types of microbes, others host thousands of different kinds of microbes. the project goal is to understand how and why particular microbes are hosted by invertebrates; whether the **diversity** of these microorganisms is related to the **diversity** of their hosts; and how these associations change over evolutionary time. the investigators are training graduate, undergraduate, and high school students how to assess microbiome **diversity**; how to use novel software to search, categorize, and compile data from dna sequence archives; and how to identify and classify marine invertebrates. they are integrating graduate students and undergraduate students in the development of a high-school-based program to mentor students in the assessment of marine invertebrate **bio-diversity**, training the next generation of scientists in invertebrate biology, host-microbe ecology, and evolutionary data analyses. in addition, research scientists are being trained to use novel data mining and compilation software to address unexplored questions in host-microbe evolution. this project is investigating three ecological and evolutionary processes that structure the **bio-diversity** of microbiomes: assembly, diversification, and coevolution. while previous studies have focused on the host-specificity of microbiomes, the project shifts the perspective from host evolution to microbial evolution. the project is developing models of host-symbiont interactions that function across multiple spatial, temporal, and taxonomic scales. by incorporating theories from evolutionary ecology and metacommunity ecology, the investigators are assessing the relative importance of environmental filtering, host-associated selection pressures,

spatial connectivity, microbial competition, cospeciation, and host switching on the assembly of microbiomes. through the use of phylogenetic comparative methods, the project is testing whether different clades of symbionts and clades of hosts respond to these forces differently. the investigators are examining how microbiomes both impact and respond to the process of host speciation in sympatry and allopatry. to accomplish these goals, novel software and evolutionary models are being developed to support large-scale analyses of microbial diversification and colonization of eukaryotic hosts. these models are being experimentally tested by using a replicated series of settlement structures to examine the assembly of sessile marine invertebrate communities and the assembly of their associated microbiomes. in addition, marine sponges are being used as model organisms to contrast allopatric and sympatric microbiome divergence over evolutionary time. these investigations are enhancing our broader understanding of the roles of microbiomes in sustaining bio\*\*diversity\*\*. this project is funded by the understanding the rules of life: microbiome theory and mechanisms program, administered as part of nsf's ten big ideas through the division of emerging frontiers in the directorate for biological sciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Belmont Forum Collaborative Research: Abandonment and rebound: Societal views on landscape- and land-use change and their impacts on water and soils (ABRESO)

Awardee: University of New Hampshire

Amount: \$504,124.00

Abstract: this award provides support to u.s. researchers participating in a project competitively selected by a 9-country initiative on global change research through the belmont forum. the belmont forum is a consortium of research funding organizations representing over 55 countries focused on support for transdisciplinary approaches to global environmental change challenges and

opportunities. it aims to accelerate delivery of the international research most urgently needed to remove critical barriers to sustainability by aligning and mobilizing international resources. each partner country provides funding for their researchers within a consortium to alleviate the need for funds to cross international borders. this approach facilitates effective leveraging of national resources to support excellent research on topics of global relevance best tackled through a multinational approach, recognizing that global challenges need global solutions. this award provides support for the u.s. researchers to cooperate in consortia that consist of partners from at least three of the participating countries. the research teams will work to identify sustainable pathways to help alleviate the increasing and unprecedented pressure on the natural resources that interact to provide sustainable life support systems and essential benefits to societies such as food production and water quality and quantity. the impacts of changes in land management and urbanization will be evaluated to develop sustainable soils and groundwater management options that will help create and maintain sustainable terrestrial ecosystems. the project seeks to develop a global transdisciplinary platform for understanding the impacts of land abandonment on sustainability of soil and water resources. land abandonment and subsequent land use or land cover change can have profound implications for water resources, as the changing fabric of the critical zone dictates changes in infiltration, runoff, and the delivery of sediment and nitrogen to groundwater and surface waters. the project team will describe social and natural forcing functions that drive land abandonment and subsequent land use change; and quantify impacts on water quality due to this abandonment. the team will also identify gaps in understanding of the impacts and those perceived by stakeholders so that land use change can be better understood and modeled. the team will use this information to develop a modeling framework to assess sustainability of various land use and land abandonment scenarios in the context of the intergovernmental science-policy platform on bio\*\*diversity\*\* and ecosystem services. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: CAREER: New Platforms for Topology, Correlation, and Superconductivity in Quantum Materials

Awardee: University of Florida

Amount: \$504,022.00

Abstract: nontechnical summary this career award supports theoretical research and education on the interplay between strongly correlated quantum materials and topological phases of matter. strongly correlated quantum materials are solids in which the electrons behave collectively rather than an individual particles, while topological phases exhibit behavior that is insensitive to noise, defects, and impurities. over the past decades, driven by these two topics, condensed-matter physics has witnessed great progress, with examples ranging from high-temperature superconductors to topological insulators and topological superconductors. these advances not only deepened our understanding of the quantum physics of many-body systems but also hold enormous potential for revolutionary applications, from commercial mri machines and lossless power transmission to quantum computers that are no longer a futuristic concept. while historically



the two areas of research have, in large part, developed separately, in recently years it has become increasingly clear that their synergy reveals even richer novel phenomena and greater potential for applications. one prominent example is the so-called moire flat-band materials, including the recently discovered magic-angle twisted bilayer graphene superconductor. when two layers of graphene are twisted relative to each other and the electron density varied, the system exhibits a variety of topological phases and unconventional superconducting phases. while potential applications abound, the fundamental mechanism for forming these phases is still under intensive investigation. these developments present an exciting opportunity for breakthroughs at the intersection of topology and correlation effects. the pi will pursue the research goal in multiple directions. the pi will develop the ideas needed for a new topological quantum-computing platform based on the notion of higher-order topological phases, which seem featureless in the bulk and on the edge but host nontrivial states on the corners. the pi will uncover various kinds of topological superconducting phases in topological semimetals, which form an ideal playground for examining topology and interaction effects. to properly address the role of strong correlations, the pi will develop new theoretical and numerical approaches for quantum many-body systems that are not captured by perturbation theory and apply these approaches to topological systems, including moire flat bands. the closely related research topics addressed in this project will advance the forefronts of topological phases and their applications. an integral component of this project is an education plan at high-school, undergraduate and graduate levels, with a specific emphasis on enhancing inclusion and **\*\*diversity\*\*** in academia and the stem workforce. the pi will participate in existing programs at the university of florida to reach out to high school students through lectures and direct mentorship on summer research projects. the pi will host a series of seminars in the physics department that focuses on career development within and outside academia. via adapting and developing graduate-level courses, the pi will fill a gap in the training of junior condensed-matter physicists by bridging traditional topics and modern aspects such as topological phases. by integrating outreach and education into the research plan, this work will provide young citizens of

diverse backgrounds with unique learning and research experiences at the forefront of quantum physics and its potential applications, ensuring the success of the fundamental "quantum leap" identified by nsf as one of the "10 big ideas for future investment".      technical summary      this project focuses on the intersection between topological phases of matter, in particular topological superconductivity, and strongly correlated systems. in the first part of the project, the pi will establish a new classifying framework for higher-order topological phases based on characterization of topological defects in topological insulators and topological ordered states. the pi will demonstrate the potential application of higher-order topological superconductivity as a new platform for braiding non-abelian anyons. the second part focuses on demonstrating interacting topological semimetals as natural hosts of novel topological phases, including higher-order topological superconductivity and ultra-nodal topological superconductors with bogoliubov fermi surfaces. the final part is devoted to a close examination of theoretical models that admit topological superconducting instabilities. these models involve low-energy fermions in the vicinity of a quantum-critical point interacting with soft bosonic modes, which induce unconventional superconducting instabilities. to further understand the strong correlation and rich phases in these models, the pi will adopt and develop quantum monte carlo methods and a sachdev-ye-kitaev-like model that is exactly solvable in a large-n limit. in broader terms, these results will connect two thriving fields of condensed matter physics: unconventional superconductivity and topological phases of matter. combining tools and ideas from both rapidly developing fields will tremendously deepen our understanding of quantum many-body physics.      the project also has three main educational components targeting students at different career stages. in collaboration with the university of florida's center for precollegiate education and training, the pi will actively engage motivated high-school students through lectures on the basics of quantum computing and through individual research projects. with an emphasis on enhancing inclusion and **\*\*diversity\*\*** in academia and the stem workforce, the education plan includes a series of seminars focused on career development for physics majors and physics graduate students. through a long-term plan of

special-topic and regular graduate courses, the pi will develop a new pedagogical framework for quantum many-body physics that naturally incorporates perturbative, non-perturbative, and topological aspects of these systems, which better suits modern research activities in condensed-matter physics. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Impact of Pesticide and Antibiotic Cocktails on Nitrogen Removal Processes in Treatment Wetlands

Awardee: University of Kentucky Research Foundation

Amount: \$501,479.00

Abstract: nitrate is the most commonly observed chemical contaminant of ground and surface water in the world. this prevalence leads to nitrate being the major cause for drinking water impairment. common use pesticides and antibiotics have also become ubiquitous in waterways worldwide, particularly in agricultural settings. while these chemicals are important for agricultural productivity, their release to the environment has resulted in significant impacts to agroecosystem food webs and human health, including bee colony disruptions, human reproductive and development disruption, and the spread of antibiotic resistance. treatment wetland systems have the potential to be a cost-effective alternative to prevent the release of these chemicals and other emerging contaminants to the environment. however, there is a lack of understanding whether treatment wetlands can remove both nitrate and contaminant mixtures that exist in runoff; a critical knowledge gap that prevents more widespread adoption of this technology. the goal of this project is to develop science-based guidance for the use of treatment wetlands to remove contaminant mixtures and nitrate to improve water quality. this goal will be achieved by evaluating the influence of specific contaminants on wetland treatment processes using state-of-the-science tracers and automated

sensing technology. successful completion of this project may lead to cost-effective treatment alternatives for contaminants to protect human and ecological health in low income, rural communities. these results will be used to develop innovative community water quality education programs both locally and remotely. additional engagement of community members will advance scientific literacy and **\*\*diversity\*\*** through hands-on engineering experiences for underrepresented groups in stem. these groups are often among those most impacted by degraded water quality and, as a result, have the greatest potential ability to benefit from these efforts. the twin goals of this career project are to improve understanding of how antibiotics and pesticides impact nitrate removal in wetlands while engaging communities through an innovative citizen science and education platform to advance science literacy and stem workforce development. the following specific objectives are designed to achieve these goals: i) identify water quality parameters that impact nutrient removal efficacy through the use of  $^{15}\text{N}$  isotopic enrichment studies in land-based and floating treatment wetland systems; ii) create a toolkit for identifying ideal placement and sizing of wetlands using three-dimensional multiparameter in-situ sensor technologies; iii) train future practitioners through mentorship and the development of pre-k and high school curricula to deliver hands-on ecological systems education; and iv) provide citizen science opportunities and water quality training virtually and at field locations to engage affected rural communities. field and laboratory scale experimental approaches will bridge gaps between observation and kinetic modeling from microcosm and mesocosm experiments with field-scale monitoring and modeling. successful completion of this research will advance knowledge by elucidating mechanisms controlling nitrogen removal and transformation in two distinct wetland treatment systems. knowledge will also be advanced through understanding how contaminants of emerging concern impact microbially mediated denitrification in wetlands. further benefits result from improved protection of downstream water quality and reservoir resilience by evaluating the influence of specific contaminants of emerging concern on wetland ecosystem services. these results have potential to benefit society by accelerating the development of treatment wetland design and

management based on science-based observation to enhance treatment options for water in agricultural and other settings. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Information-Theoretic Approach to Turbulence: Causality, Modeling & Control

Awardee: Massachusetts Institute of Technology

Amount: \$500,000.00

Abstract: many flows of engineering interest are dominated by the presence of turbulence, which is the chaotic and multiscale motion of fluids. to date, real-world turbulence limits our ability to fully understand, model, and control complex systems. the lack of a rigorous framework to evaluate cause-and-effect interactions in turbulence is a cross-cutting concept at the core of discovery. the goal of the present proposal is to advance the field of turbulence research by reformulating the problems of causality, modeling, and control using information theory or the science of message communication. in this new framework, turbulence is envisioned as a sequence of bits, and its dynamics is characterized by the transfer of bits among flow variables. the theoretical foundations of this project will provide a new perspective to tackle problems in turbulence research ranging from aircraft aerodynamics to geophysical and planetary flows. the project will also leverage transformative programs to promote **\*\*diversity\*\*** and inclusion in engineering, including the participation in annual summer research programs and undergraduate research opportunities to engage women and underrepresented minorities. the goal of this project is to formulate the problems of causality, modeling, and control for turbulent flows using information theory. the central quantity of the formulation is the shannon entropy, which measures the amount of information in the states of the system. within this framework, causality in a turbulent flow can be quantified by the information flux among the variables of interest. reduced-order modeling is posed as a problem on

the conservation of information, in which models aim at preserving the maximum amount of information from the original system. similarly, control theory can be cast in information-theoretic terms by envisioning the tandem sensor-actuator as a device reducing the unknown information of the state to be controlled. this new formulation will be exploited to advance three outstanding problems in turbulent flows: (i) causality of the energy transfer in the turbulent cascade, (ii) subgrid-scale modeling for large-eddy simulation, and (iii) suppression of turbulent separation bubbles with active flow control. the cases of study range from canonical flat plate turbulence to complex flows such as realistic aircraft configurations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SHF: Small: Transforming Computer Architecture Evaluation with Statistical Model Checking

Awardee: Duke University

Amount: \$500,000.00

Abstract: this project is developing a statistically rigorous framework for the experimental evaluation of computer processors. the evaluation of a new processor design involves many experiments, in which the processor is simulated in different hardware configurations and with different software running on it. the current state of the art is to perform some number of these experiments and present the results, but this methodology provides no statistical guarantees; there is no bound on the probability that subsequent experiments would show very different results. this project is adapting and enhancing a rigorous statistical technique, called statistical model checking (smc), that is used in other fields that have required stronger guarantees, like cyber-physical systems (e.g., implanted medical devices). with the newly enhanced smc that this project is developing, it is possible to not only provide statistical guarantees, but it is also possible to evaluate system properties that are not analyzable with current methodologies (e.g., security hyper-properties that

depend on the differences between multiple experiments). enhancements to smc are necessary to accommodate computer architecture research and to enable, for the first time, rigorous analysis of important issues, like the impact of very rare events and the processor's behavior in worst-case scenarios. the project's infrastructure will be made publicly available, so computer architects in academia and industry can benefit from it, with the ultimate result being better processor designs in which architects and society can be more confident. this project involves undergraduate research assistants through duke's data+ and code+ programs, two well-established university-wide summer outreach programs with exceptional **diversity**. the project's research is also incorporated into a new cross-listed (ece and compsci) class in experimental evaluation of computer systems. the pi and co-pi will develop and present a tutorial on smc for computer architects at a major computer architecture conference. the project's results and framework will be transferred to industry via the extensive industry contacts of the pi and co-pi. this project pioneers the use of statistical model checking (smc) in computer architecture, thus enabling architects to reason about their experimental results with statistical rigor. this project provides architects with a novel framework for performing experimental evaluations. part of the development of the framework involves the development of expressive properties and hyper-properties that allow architects to evaluate conditions and situations they do not currently consider. this project uses smc to mitigate the longstanding problem of how to evaluate the impact of rare events, through a new event injection methodology. this project also uses smc and machine learning to provide the first statistically rigorous scheme for identifying the worst-case situation when using a mechanism (e.g., power management, computational sprinting). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Preparing the Next Generation of Environmental Scientists through Research-based Coursework and Community Internships

Awardee: University of Puerto Rico-Rio Piedras

Amount: \$500,000.00

Abstract: there is a critical need for a more robust environmental workforce in puerto rico that mirrors similar demands across the united states in multiple sectors, including energy generation, food cultivation, and environmental protection. additionally, a larger cohort of well-prepared professionals could positively impact the island's future ability to respond to unexpected environmental catastrophes including increased frequency and intensity of hurricanes, flooding, coastal erosion, coral reef mortality, and reduced bio\*\*diversity\*\*. to address this opportunity, this project - with support from the improving undergraduate stem education: hispanic-serving institutions (hsi program) - aims to provide experiences that will engage undergraduate students in the study of environmental science and lead to an expansion of this critical workforce. in particular, the project targets students during their first two years as undergraduates, which are known to be crucial in fostering positive student perceptions towards the discipline and successful academic outcomes. incoming freshman will participate in a summer research project that will provide hands-on experiences to build excitement and contribute to a more thorough understanding of future careers. throughout their course of study, students will engage in four content-rich courses with substantial field work components and will have opportunities to participate in community-facing internships. the proposed courses and experiences will be embedded in the regular environmental science undergraduate curriculum, thereby enriching the current degree requirements while providing innovative academic strategies for students through practical experiences created with the purpose of improving student retention. the proposed project has three main objectives. first is to create annual el verde field station (evfs) summer research experiences to attract 30 incoming freshmen. second is to design an environmental analysis training curriculum to improve technical skills. and third is to develop a paid internship program to bring environmental science undergraduates and local employers together. a longitudinal, quasi-experimental study will be employed to evaluate the hypothesis that the treatment sequence in the program will contribute to improving environmental



science student retention, enhancing content knowledge, and expanding students' technical skills. quantitative and qualitative approaches will provide evidence-based data to determine if there is an individual and/or additive effect of the project components on participant students' attitudes and persistence in environmental science undergraduate studies. expected products include student-generated environmental science research videos demonstrating techniques and documenting their experiences in the program, conference presentations, journal publications, and meetings and workshops at university of puerto rico-rio piedras with high school teachers and counselors to share project outcomes. furthermore, curricula, educational resources, and research instruments will be available for sharing with teachers and researchers. the hsi program aims to enhance undergraduate stem education, broaden participation in stem, and build capacity at hsis. achieving these aims, given the diverse nature and context of the hsis, requires innovative approaches that incentivize institutional and community transformation and promote fundamental research (i) on engaged student learning, (ii) about what it takes to diversify and increase participation in stem effectively, and (iii) that improves our understanding of how to build institutional capacity at hsis. projects supported by the hsi program will also draw from these approaches to generate new knowledge on how to achieve these aims. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CNS Core: Small: Offline Inference for Ultra-Efficient Memory Management

Awardee: University of California-Los Angeles

Amount: \$500,000.00

Abstract: machine learning (ml) has made its way into systems of various kinds, helping them make informed decisions at critical points. a typical approach to ml-for-systems is to perform inference online by querying a model with runtime data. online inference incurs non-trivial overheads,

imposing a tight restriction on model size and complexity. in fact, systems that involve ml in their decision making often use very simple models (e.g., linear models) with inferior accuracy. this project develops a transformative approach to ml-for-systems - instead of doing online inference, this project advocates to train models that can predict runtime properties directly from program source code. as such, inference can be done offline and their results can be encoded and efficiently looked up during execution. given that inference no longer contributes to run time, the proposed approach removes the above-discussed restrictions, enabling systems to employ state-of-the-art model architectures. this project further applies offline inference to memory management tasks that are critical to cloud applications. modern society relies on services provided by large-scale systems. improving the throughput and efficiency of such systems improves the service-level efficiency and scalability that human can experience in their lives. replacing complicated and heuristics-driven decision making in today's memory management systems with learning has a potential to dramatically reduce the cost of allocation and deallocation, which is a significant component in an application's execution. traditionally, inference is performed online, restricting what models to use and how high the accuracy can reach. this project develops techniques that make ml a more appealing approach by removing these restrictions. the techniques proposed span runtime system and ml. this interdisciplinary nature produces research that has impact in both areas. the project also makes efforts in education and **\*\*diversity\*\*** by incorporating research into courses and recruiting researchers from underrepresented groups. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CCF: Small: Real-Number Function Encoding Driven Error Resilient Signal Processing and Control: Application to Nonlinear Systems from Adaptive Filters to DNNs

Awardee: Georgia Tech Research Corporation

Amount: \$500,000.00

Abstract: technology scaling, device integration and high circuit speeds have increased the risk of errors in digital processors running computing and control applications. such errors can jeopardize the operational safety of autonomous systems employing embedded processors in the field, causing severe loss of performance, accidents, or damage to life and property. to put this in perspective, applications such as self-driving cars and drones demand tera-ops of computation throughput and yet must perform with exacting levels of reliability and safety. the latter reliability and safety demands must be met with minimal degrees of hardware and software redundancy without negatively impacting dependability, power consumption, payload, form factor and cost considerations that are critical for commercial success. to alleviate relevant safety threats, this project aims to deploy low-cost and efficient methods for detecting and mitigating the effects of monitored errors in real time and in the field as effectively and rapidly as possible. this will enable a paradigm shift in the way failure-tolerance technologies are applied to autonomous systems while maintaining their reliability, affordability and cost. the project integrates research with education involving development of educational infrastructure for teaching and laboratory work, incorporation of **\*\*diversity\*\*** in student participation, exchanges with industry, technology transfer and engagement with undergraduate and high-school students, all with the goal of producing highly qualified trained engineers for the workplace of the future. today, implementing failure tolerance for nonlinear signal-processing and control algorithms is dependent on some form of computation duplication. the algorithm-based fault-tolerance techniques of the past were designed mostly for linear computations and are not directly applicable to error control in nonlinear computations of modern autonomous systems. to resolve this, the project is built around the concept of algorithmic checks that encode nonlinear computations with linearized or nonlinear checking mechanisms. the checks are created using analytical methods for weakly nonlinear systems or by machine-learning algorithms for generic nonlinear systems and enable real-time error detection in switched capacitor circuits, nonlinear digital filters, adaptive state-estimation filters, nonlinear control algorithms and

deep neural networks. error correction is performed via state restoration in which the system state after error detection is restored to a prior fault-free system state or by using probabilistic error-compensation techniques. the core techniques can be applied to different aspects of the core computations performed in embedded computing infrastructure for autonomous systems, namely perception, intelligence, decision-making and control to make them error-resilient and trustworthy. the underlying science is enabling the design of entirely new classes of self-checking reliable autonomous systems that are beyond the scope of the current state of the art. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CNS Core: Small: Principled Methodologies and Systems Support for Automated Cost-Effective Service Blending in the Emerging Public Cloud

Awardee: Pennsylvania State Univ University Park

Amount: \$500,000.00

Abstract: a growing number of individuals and organizations rely on public cloud providers for their information technology (it) needs. many of these cloud users are budget-constrained and, therefore, interested in ways to reduce their cloud bills while still meeting their applications' performance needs. cloud providers offer myriad service types (spanning infrastructure-, platform-, and software-as-a-service and **\*\*diversity\*\*** within each of these) and blending these can offer significant cost savings to users over prevalent techniques that tend to be limited to a small number of service types. however, getting such blending right is non-trivial and may itself pose significant effort and cost. this project aims to help users overcome such hurdles by significantly automating the process of cost-effectively blending and sizing cloud services. in particular, this automation will be realized via a cloud cost optimizing compiler called coco. a framework for application code annotation will allow users to convey blending-related hints based on their domain expertise. coco will require

fundamentally novel optimization techniques and heuristics to transform user code into its cloud-ready form which will be cost-effective while meeting performance requirements. finally, a runtime system for continual adaptation to dynamic workload changes will also be developed. all of these ideas will be prototyped on state of the art public cloud platforms and open-sourced. this project has the potential to significantly simplify the task of migrating user applications to the public cloud with attendant cost savings. perhaps more importantly, the transformed code is expected to incur lower recurring cloud bills owing to careful blending and sizing of cloud service types that adapts to dynamic conditions. these innovations are likely to be especially useful to small/medium-sized users for whom cloud migration can pose significant technical and cost hurdles. the educational and outreach components of the project will create awareness of such cost savings offered by service blending and, in combination with our open-source prototypes, will help spur further innovations on related themes within the cloud computing research community. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: FET: Medium: Neuroplane: Scalable Deep Learning through Gate-tunable MoS2 Crossbars

Awardee: Northwestern University

Amount: \$500,000.00

Abstract: the increasing complexity of deep-learning systems has pushed conventional computing technologies to their limits. while the memristor is one of the prevailing technologies for deep-learning acceleration, it is only suited for classical learning layers where two operands, namely weights and inputs, are processed at a time. meanwhile, to improve the computational efficiency of deep learning for emerging applications, a variety of non-traditional layers, requiring concurrent higher-order processing of many operands, are becoming popular. for example, hypernetworks

improve their predictive robustness by simultaneously processing weights and inputs against the application context. two-electrode memristor grids cannot natively support such operations of emerging layers. addressing the unmet need, this research will develop neuroplane -- a novel deep-learning accelerator of gated memtransistor crossbars. exploiting crossbars' gate controllability, multiple operands can be processed within the same crossbar unit in neuroplane. many advanced inference architectures that can generalize beyond a typical passive crossbar will thus be possible. overall, the ultra-low-power, higher-order processing of neuroplane will harness high robustness and efficiency of emerging deep-learning layers within area/power-constrained devices such as mobile, sensor, and embedded systems. the investigators will develop fabrication methods for nanometer node gate-tunable dual-gated crossbars of mos2 memtransistors. a self-aligned fabrication method with defect passivation and process variability compensation will be created. exploiting the gate-tunability of mos2 memtransistors, a new generation of crossbar platforms with many runtime control knobs will be developed, rendering the design a high elasticity and agile computing space. for example, computing methods will be created for the gated crossbars to utilize crossbar elements for product-sum digitization, thereby preventing the critical overheads in current crossbar technologies. similarly, control-flow methods will be developed for gated crossbars to adapt their inference paths depending on the input characteristics by dynamically deactivating input/output neurons to conserve processing energy. a coherent collection of software and hardware-based correction techniques is proposed to minimize the impact of process variability. unlike the current schemes, by following the train-once-deploy-anywhere tenet, the proposed crossbar correction methods can scale to millions of deployments without considerable overhead. an annual workshop will be conducted at local high schools with substantial ethnic and gender **\*\*diversity\*\*** to mentor underrepresented students. undergraduate research projects will be sponsored using paid summer internships and university-level programs such as summer undergraduate fellowship. an inter-university senior-design mentoring program will be created for students among participating institutions. this award reflects nsf's statutory mission and has been

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Matched Words: diversity

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Title: CAREER: Modernizing Risk Assessment Through Systematic Integration of Probabilistic Risk Assessment (PRA) and Prognostics and Health Management (PHM)

Awardee: University of Maryland, College Park

Amount: \$500,000.00

Abstract: safe, reliable, affordable energy is intricately connected to broad advances in health, science, prosperity, and our national defense. engineering risk assessment is an essential tool used in designing the regulations, codes, and standards that enhance energy system safety and resilience without imposing unreasonable regulatory burden. advancing the science behind



risk-informed regulation is essential as systems become more complex and new challenges emerge. this faculty early career development (career) project investigates how principles from two domains of reliability engineering can be systematically integrated to advance this science. this research that probabilistic risk assessment (pra) and prognostics and health management (phm) have complementary characteristics that can offset their individual weaknesses. the research will establish and validate a conceptual framework along with mathematical and computational methods to systematically integrate pra and phm methods, data, and models. direct engagement with interdisciplinary stakeholders from nuclear power plant and hydrogen transportation infrastructure applications will facilitate both validation and adoption of the new methods. the results will provide new knowledge about the range of data and models that can be used in regulatory design and decision making. integrated educational initiatives include design of the first public museum exhibit on energy system risk assessment, enhanced reliability engineering coursework, and **\*\*diversity\*\*** and inclusion initiatives for women and underrepresented minorities in engineering. the overarching goal of this project is to establish a strong foundation of integrated research and educational activities centered on energy system risk assessment. the research focuses on transforming risk-informed regulation for energy systems through systematic integration of concepts, data and methods drawn from pra and phm and rigorous validation using both energy system case studies and expert stakeholder engagement. the educational activities enhance k-12 and public education through a new museum exhibit on energy system risk assessment that will be displayed in the nation's only nuclear history and science museum and that will also be made available to a broad network of affiliated museums. graduate coursework in reliability engineering will be enhanced through development of new active learning exercises based on this research. the research draws upon engineering techniques of pra, which provides a comprehensive quantitative approach for synthesizing data, scenarios, and probability models to assess risk under uncertainty for complex engineering systems; and phm, which provides powerful algorithms for using sensor data and failure models to understand and predict health of components. to date, there has been little work at the

intersection of pra and phm. unlike previous approaches which seek to make pra more dynamic or to extend phm to more complicated components within their current architectures, this research seeks to deconstruct pra and phm and engineer a new approach which leverages the benefits of both approaches. the research starts by defining the conceptual framework and then defining mathematical and computational structures. the candidate structures will be compared and validated using energy system case studies and stakeholder-based validation. nuclear power plants and hydrogen fueling stations are used as testbeds to ensure that the results are generalizable beyond a single energy system or regulatory process. the research has broader societal impact by creating new knowledge and methods that will impact the design of regulations for nuclear power plants, hydrogen infrastructure, pipelines, and other energy systems and critical infrastructures. the integrated educational activities broaden k-12, graduate student, and public understanding of the science behind energy system safety. broader participation of women and underrepresented minorities in engineering will be encouraged via the enhancement of graduate student recruitment and mentoring activities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: (Radio)Fluorination and Other Nucleophilic Functionalizations Enabled by Photocatalytic Radical-Polar Crossover

Awardee: University of California-Los Angeles

Amount: \$500,000.00

Abstract: with the support of the chemical synthesis (syn) program in the division of chemistry, professor abigail doyle of university of california, los angeles is developing new chemical reactions that will enable the synthesis of organofluorine compounds; namely those that contain a c-f bond. such bond constructions are in high demand as c-f bonds are found in next-generation medicines,

agrochemicals, and biomedical imaging agents. the chemical reactions under development here use a catalyst that can harness the energy in visible light to generate a high-energy reactive intermediate, a carbocation, that is most often only accessible under harsh (thermal or strongly acidic or lewis-acidic) conditions. because the strategy being pursued by professor doyle and her students accesses this intermediate under the mild conditions associated with visible light irradiation, reactions are being developed that generate chemical structures that were previously challenging to access, starting from abundant and inexpensive reagents. the researchers will use a variety of tools to help them understand how the reactions work at the molecular level such that this knowledge can be used to discover new processes and design improved reactions. students conducting these research activities will have the opportunity to develop a broad skill set, both scientific in nature and with respect to communication, mentorship, leadership, and also with respect to embracing and building **\*\*diversity\*\***, equity, inclusion and belonging, that will help them become leaders in their independent careers. broader impacts of this work also include the development of activities directed at recruitment and retention of students from underrepresented groups to science, technology, engineering, and mathematics (stem). for example, the program includes the development of undergraduate teaching material to highlight scientific contributions from researchers of diverse backgrounds, experiences and perspectives and the design of workshops for entering graduate students on topics such as citation bias, conflict management, and micro-aggression.

carbocations are reactive intermediates in a broad range of synthetic transformations because they undergo reaction with abundant and stable nucleophiles like water, alcohols, halides, amines, and olefins. nevertheless, the generation of carbocation intermediates typically requires harsh reaction conditions and requires use of pre-oxidized precursors such as alkyl halides. these limitations preclude applications in more complex settings, such as in the synthesis of bioactive compounds or radiolabelling, and access to desirable products. this program seeks to address these challenges by using a photocatalyst and light to convert abundant and stable  $c(sp^3)OH$ ,  $RNH_2$  and  $RH$  precursors to radicals and then to carbocations (a so-called radical-polar

crossover). a focus of these efforts will be to use fluoride to trap the carbocation intermediates in order to generate organofluorine products that are useful in the pharmaceutical and agrochemical industries. mechanistic studies will accompany these synthetic efforts and the most efficient strategies will also be adapted for the synthesis of 18-fluorine-radiolabelled small molecules for use in positron emission tomography (pet), an important diagnostic tool for detecting disease. this research will provide a rigorous and multi-disciplinary training environment for a diverse group of graduate and undergraduate students and postdoctoral fellows. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Side-Chain Driven Assembly of Polymer Semiconductors

Awardee: Georgia Tech Research Corporation

Amount: \$500,000.00

Abstract: with the support of the macromolecular, supramolecular and nanochemistry program in the division of chemistry, prof. natalie stingelin and dr. anna m. österholm of georgia institute of technology are studying fundamental processes that underlie the assembly of polymer semiconductors. the local arrangements of these long chain macromolecules dictate important photophysical, electronic and electrochemical processes in this broad class of materials. all of these processes are important in a range of optoelectronic device platforms, such as led (light-emitted) screens, wearable electronics, and even bioelectronics. in this research, semiconducting polymers will be prepared in which the main polymer backbone is decorated with side-chains of different lengths, densities, and polarity. optoelectronic properties will then be investigated to gain further understanding on how they depend on side-chain arrangement and subsequent backbone ordering. as opposed to conventional synthetic approaches, this research will use electricity and blending with surfactants to manipulate and control side-chain assembly. relevant physical processes associated with polymer dynamics will be investigated using a plethora of sophisticated experimental tools. they include linear and vibrational spectroscopies, thermal analysis, and electrochemical measurements that allow for rapid evaluation of polymer assembly motifs. this project will create a highly multidisciplinary and diverse research and education environment for students where they will be exposed to academic and industrial perspectives, national laboratories, as well as national and international collaborators. the research team will also partner with the georgia tech's center for organic photonics and electronics, the georgia tech polymer network, and groups such as women in



materials science and engineering (wimse) and women in chemistry (wic) to develop a set of **\*\*diversity\*\***-supported programs focusing on preparing underrepresented minorities for faculty positions. this research aims to provide fundamental insights of the physics underlying the assembly of polymer semiconductors, focusing on answering the question of what role side-chain design plays in dictating backbone order/disorder. particular emphasis is placed on the use of electrochemical and physicochemical approaches to control the side-chain interactions and subsequent backbone order in various polydioxothiophenes to deliver an assembly framework that exploits the sidechain arrangement for dictating backbone ordering. side-chain motifs that promote supramolecular assembly in neat polymer semiconductor systems into solid-state structures with little backbone distortion will first be identified with a strong emphasis on chemical structure, side-chain branching point location, and side-chain density. electrochemical doping will then be utilized to investigate changes in polymer assemblies and how they influence both redox and charge transport properties. lastly, small molecule additives will be blended with a polymer semiconductor to examine their effect on backbone conformation. this research will address fundamental questions in the field of conjugated polymers through extrinsic approaches rather than the synthetic ones. if successful, the proposed work will have a major impact on the semiconducting polymer field, particularly optoelectronic device platforms, such as organic light-emitting diodes, organic photovoltaics, organic field-effect transistors, as well as emerging technologies for bioelectronics and neuromorphic sensing. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Side-Chain Driven Assembly of Polymer Semiconductors

Awardee: Georgia Tech Research Corporation

Amount: \$500,000.00

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this research aims to provide fundamental insights of the physics underlying the assembly of polymer semiconductors, focusing on answering the question of what role side-chain design plays in dictating backbone order/disorder. particular emphasis is placed on the use of electrochemical and physicochemical approaches to control the side-chain interactions and subsequent backbone order in various polydioxithiophenes to deliver an assembly framework that

exploits the sidechain arrangement for dictating backbone ordering. side-chain motifs that promote supramolecular assembly in neat polymer semiconductor systems into solid-state structures with little backbone distortion will first be identified with a strong emphasis on chemical structure, side-chain branching point location, and side-chain density. electrochemical doping will then be utilized to investigate changes in polymer assemblies and how they influence both redox and charge transport properties. lastly, small molecule additives will be blended with a polymer semiconductor to examine their effect on backbone conformation. this research will address fundamental questions in the field of conjugated polymers through extrinsic approaches rather than the synthetic ones. if successful, the proposed work will have a major impact on the semiconducting polymer field, particularly optoelectronic device platforms, such as organic light-emitting diodes, organic photovoltaics, organic field-effect transistors, as well as emerging technologies for bioelectronics and neuromorphic sensing. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Giant Polymer Brushes: How Fluid-Like Hyaluronan Brushes Minimize Biofilm Adhesion

Awardee: Georgia Tech Research Corporation

Amount: \$500,000.00

Abstract: non-technical abstract it is surprising how much can be accomplished by changing the properties of a surface. when made hydrophobic, a surface repels water and can, for example, protect paper or wood from moisture intrusion and damage. when made reactive to a specific gas or biomolecule, it can become an ultra-sensitive detector, for example a biosensor for coronavirus particles. one very successful way to control surface properties, so as to create designer materials like those described above, is to anchor polymers to the surface at such a high density that they align and stretch away from the surface because of crowding by their neighbors. this configuration is

known as a polymer brush. polymer brushes have been used in a stunning variety of practical applications. this grant has a twofold scientific purpose. the first purpose is to leverage nature's molecular machines to produce polymer brushes by growing molecules directly from the surface. amazingly, this new technology enables the production of polymer brush layers nearly one hundred times thicker than the those achievable with conventional techniques. this presents exciting new properties for the strategic design of materials. the second purpose is to address an important problem that plagues mankind: the formation of biofilms ? that is communities of recalcitrant bacteria entrenched and protected in a mucous-like goo of their own making. polymer brushes are a popular strategy to delay biofilm attachment but ultimately, they still fail. motivated by promising preliminary results, the project explores in this grant whether the giant molecular-machine generated brush and its corresponding fluid-like interface can lead to a surface that the bacteria are unable to tether to ? a new strategy only recently introduced in other contexts. to ensure that any bacteria which still manage to adhere are quickly eliminated, the researchers will embed antimicrobials within the large volume of the brush. together, these measures will result in the maturation of an exciting new polymer brush technology addressing the age-old problem of bacterial infection and contamination of man-made materials. in outreach and education, the curtis lab will publish a series of short playful cartoon videos about the science, biomaterials, and applications of this interdisciplinary project. the videos will be shared on a you tube channel and disseminated widely. topics will include anti-microbial materials, biofilms, polymer brushes, and molecular machines for making polymers.

technical abstract polymer brushes are an important tool for engineering interfaces in a variety of applications such as drug delivery, implants, catalysis, and anti-microbial materials. this grant will focus on pinpointing the origin and extent of the anti-fouling properties of a non-traditional, ultra-thick polymer brush recently established in the curtis lab. fabricated by surfaces coated with hyaluronan synthase, the enzyme-derived brushes are the thickest ever created by almost two orders of magnitude. preliminary results demonstrate that these hyaluronan brushes repel bacteria and prevent biofilm adhesion for up to a week, performing an order of magnitude better than hyaluronan

films, which are recognized as having superior anti-fouling properties. the curtis lab will test the hypothesis that the superior performance of these brushes arises from their fluid-like interface, similar to other recent very successful materials introduced for anti-biofilm applications. in addition, they will optimize the anti-fouling performance of the brushes with systematic studies of its dependence on brush grafting density and molecular weight. lastly, to maximize the anti-biofilm properties of the brush, they will immobilize biocides throughout the material to create a multi-functional biointerface with optimal anti-microbial performance. more broadly, this research will contribute to the continued development of a new class of polymer brush, which is expected to find broader applications in materials science. in outreach and education, the curtis lab will publish a series of short playful cartoon videos about the science, biomaterials, and applications of this project. the videos will be shared on a you tube channel and disseminated widely. topics will include anti-fouling materials, biofilms, polymer brushes, etc. additionally, dr. curtis will continue her efforts to increase **\*\*diversity\*\*** in stem by using the period of this grant to establish contacts and build lasting relationships with faculty, advisors, and students at historically black colleges and universities. these activities have the primary goals of (1) building effective relationships to help improve recruitment and retention of minority students and (2) learning through conversations how to enhance the climate at georgia tech to make it more welcoming and supportive for students of color. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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focus on pinpointing the origin and extent of the anti-fouling properties of a non-traditional, ultra-thick polymer brush recently established in the curtis lab. fabricated by surfaces coated with hyaluronan synthase, the enzyme-derived brushes are the thickest ever created by almost two orders of magnitude. preliminary results demonstrate that these hyaluronan brushes repel bacteria and prevent biofilm adhesion for up to a week, performing an order of magnitude better than hyaluronan films, which are recognized as having superior anti-fouling properties. the curtis lab will test the hypothesis that the superior performance of theses brushes arises from their fluid-like interface, similar to other recent very successful materials introduced for anti-biofilm applications. in addition, they will optimize the anti-fouling performance of the brushes with systematic studies of its dependence on brush grafting density and molecular weight. lastly, to maximize the anti-biofilm properties of the brush, they will immobilize biocides throughout the material to create a multi-functional biointerface with optimal anti-microbial performance. more broadly, this research will contribute to the continued development of a new class of polymer brush, which is expected to find broader applications in materials science. in outreach and education, the curtis lab will publish a series of short playful cartoon videos about the science, biomaterials, and applications of this project. the videos will be shared on a you tube channel and disseminated widely. topics will include anti-fouling materials, biofilms, polymer brushes, etc. additionally, dr. curtis will continue her efforts to increase **\*\*diversity\*\*** in stem by using the period of this grant to establish contacts and build lasting relationships with faculty, advisors, and students at historically black colleges and universities. these activities have the primary goals of (1) building effective relationships to help improve recruitment and retention of minority students and (2) learning through conversations how to enhance the climate at georgia tech to make it more welcoming and supportive for students of color. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Fundamental Studies on Spider Egg Case Silk Biomaterials and their Mimics

Awardee: Arizona State University

Amount: \$500,000.00

Abstract: non-technical summary    silk is a fascinating, naturally occurring biomaterial that has had a large impact on human civilization. although silkworm silk is the most investigated biomaterial, in part because of wide availability, the **\*\*diversity\*\*** of spider silks available can lead to new generations of hitherto unexplored biomaterials. spiders produce many different forms of silk including ones used to construct egg cases. spider egg case silk proteins and biopolymer fibers have scarcely been studied, compared to spider dragline silk (commonly used to as the scaffolding of spider webs) and silkworm silk. yet, its mechanical properties (i.e., toughness) and conserved and repetitive gene sequence have been studied and shown to be significantly different from other spider silks. the molecular structure- and mechanical-function relationship in spider egg case silks and biomaterial composites with nanoparticles will allow for the development of new bionanomaterials with predictably tunable optical, mechanical and thermal properties. this biomaterials research brings together aspects of biochemistry, biomaterials and bioengineering, which requires a diverse scientific team, including physicists, chemists, biochemists and bioengineers from arizona state university (asu) and collaborations with argonne national laboratory (anl). this multi-institutional and multi-disciplinary research will expose graduate, undergraduate and high school students to modern transdisciplinary research and modern communication and teamwork tools for building and maintaining research across multiple labs and institutes.

technical summary    spiders produce different forms of silk proteins or spidroins, of which, tubuliform and aciniform silk is used to construct egg cases. the mechanical properties (i.e., toughness) and conserved and repetitive gene sequence are known for many spider's egg case silk proteins and shown to be significantly different from other proteins used to make the more commonly studied dragline spider silks. the proposed research team plans to explore the structure-function relationship in spider egg case silks, spider silk polypeptides derived from spider



egg case silk protein motifs, and biomaterial nanocomposites of egg case silks with nanoparticles. using recently developed methods for obtaining appreciable quantities of isotopically enriched spider egg case silks, molecular structure and dynamics will be investigated using advanced magnetic resonance techniques. besides natural spider silks, significant effort will be placed on peptide mimics derived from spider egg case proteins repetitive motifs, allowing structure-function studies, self-assembly and potentially in the long-term overcoming the bioproduction bottleneck for practical application. using both spider silk polypeptides and processed spider egg case silk, nanoparticle-silk composite biomaterials with tunable properties will be designed and generated for specific biomaterials applications. the biocompatibility of the spider silk polypeptides, their mimics and nanocomposites will be studied comprehensively in vitro and in vivo. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF-BSF: Designing semiconductor-based membranes for photoelectrochemical modulation of cardiac systems

Awardee: University of Chicago

Amount: \$500,000.00

Abstract: non-technical summary finding biomaterials to replace the wires in heart pacemakers remains a challenge for society. many biomaterial approaches have been developed for pacing heart tissue without leads; the wires that connect to the tissue. existing alternative strategies have not been successful in clinical settings. in this collaborative project between nsf and the u.s.-israel binational science foundation (bsf), drs. tian and dvir propose to develop a new class of silicon (si) and silicon carbide (sic)-based nanostructured membranes for optically controlled stimulation of cardiac tissues. the semiconductor-based membranes are flexible and biocompatible, and are capable of bypassing many of the current limitations faced by traditional cardiac pacing tools. the

team will use the pulsed light illumination of the si and sic membranes to trigger the excitation of heart cells under physiological conditions. this research will provide new data that are critical for understanding and developing biomaterials-based tools to meet the needs of future cardiac therapy. the educational goals include providing learning opportunities for students in a highly interdisciplinary area. dr. tian will build on existing model programs at the university of chicago to increase **\*\*diversity\*\*** in science and engineering by offering summer research opportunities to high-school and undergraduate students. other educational activities include an international student exchange program to provide us students with unforgettable awareness and lifelong appreciation of the science and engineering research in israel. the research and education results will be disseminated broadly through peer-reviewed publications, seminars, conference presentations, and websites.

technical summary      many biomaterial approaches for leadless cardiac pacing capabilities, including those based on infrared photothermal effect, electromagnetic induction, and ultrasound-mediated energy transfer, have failed to translate clinically. therefore, new biomaterial tools and biointerfaces are still highly desired for understanding the treatment of arrhythmias and conduction disorders. drs. tian and dvir propose to develop a new class of silicon (si) and silicon carbide (sic)-based nanostructured membranes for optically controlled, non-genetic modulation of cardiac tissues. the semiconductor-based membranes are flexible and biocompatible, and are capable of bypassing many of the current limitations faced by traditional modulatory devices. when activated by pulsed light illumination, the si and sic nanostructures can trigger membrane depolarization of cardiomyocytes under physiological conditions, causing the interfaced cardiomyocytes to fire action potentials. this research will provide new data that are critical for the fundamental understanding and development of biomaterials-based tools to enable future leadless cardiac resynchronization therapy. the research activities will provide learning opportunities for students in a highly interdisciplinary area. the proposed study will also provide a unique knowledge and skill set that can open new endeavors in the semiconductor or detector industry. dr. tian will build on existing model programs at the university of chicago to increase **\*\*diversity\*\*** in science and

engineering by offering summer research opportunities to high-school and undergraduate students. through an international summer exchange program, the team will provide the us students the experience to establish unforgettable awareness and lifelong appreciation of the science and engineering research in israel. the research and education results will be disseminated broadly through peer-reviewed publications, seminars, conference presentations, and websites. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Designing Inclusive Computational Thinking Metrics to Broaden Participation in Computer Science

Awardee: Northeastern University

Amount: \$499,999.00

Abstract: broadening participation in computer science requires helping students understand how they can use computer science in ways that they see as valuable. this includes students? learning by designing their own games. the experience of game design has proven effective at helping them learn about algorithms, computational thinking, and programming in meaningful ways. tools such as scratch programming enable students to engage in such game design learning. however, interpreting and assessing students? understanding of computer science in these environments is challenging. automated approaches to assessing the products students create may have biases or may not account for diverse approaches to game design. automated assessments have the potential to provide feedback on their work to students in real time and help them learn about computer science effectively. this project seeks to understand how to create methods for automatically analyzing students? computational thinking that are equitable, inclusive, and diverse.

the work addresses three critical needs in computer science education: (1) improving computational thinking metrics to support automated assessment of computational thinking; (2)

providing students with real-time feedback that helps them monitor their progress in computational thinking and programming to build confidence in their skills; and (3) creating context-sensitive assessment and feedback tools that promote inclusivity and encourage students to learn about computer science, computational thinking, and programming. the key research question in this project is: how do we address inclusivity and **diversity** in existing metrics-based automated computational thinking assessments to help broaden participation in computer science? the project will use assessment data gathered from eighth-grade students using scratch who created games connected to science concepts. the analysis of students' products will document how students' computational thinking development, design practices, and programming routines are assessed currently. subsequent work will create metrics that are more inclusive and equitable. the project will use machine learning techniques to analyze data (e.g., to identify patterns in the students' products). the project will also use measures of self-efficacy in computer science to understand students' product design. in later phases of the project, a participatory design process will be used to redesign the metrics to enhance inclusivity in the assessment of computational thinking via game design in scratch. this project is funded through the cs for all: research and rpps program this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Computational Thinking Funds of Knowledge: A Culturally-Relevant Assessment for Early Elementary Students

Awardee: University of Massachusetts Amherst

Amount: \$499,999.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). it is developing equitable computational thinking (ct) assessments for historically marginalized black and hispanic students in the early grades. children and their families engage in ct

in their everyday lives, with such experiences serving as potentially powerful learning and assessment opportunities. the everyday knowledge of black and hispanic families and communities, in particular, must be interwoven with instructional and assessment opportunities, as too often they are not reflected in standard instruction and assessment. given the lack of **\*\*diversity\*\*** in computer science, uncovering the rich ct resources of black and hispanic families through research will aid in the development of culturally sustaining assessments tools (csat) for ct. this will help educators leverage what students know in order to find ways to support these underrepresented students. this knowledge will subsequently provide a foundation for development of more equitable ct assessment materials. this approach is transformative, in that it puts family and community knowledge at the heart of assessment development. it addresses concerns related to the problem of cultural bias in standardized measures of achievement. while focusing on the lived experiences of black and hispanic families in springfield, massachusetts, the team anticipates that the csat for ct will be useful for black and hispanic families in mid-sized cities similar to springfield, and will, therefore, have a broad national impact.

computational thinking funds of knowledge (ctfok) is a research project focused on the development of csat for ct for students from kindergarten to second grade. it seeks to broaden participation in computer science (cs) by explicitly focusing on the rich resources of black and hispanic families as regards their ctfok enacted through activities of daily living and by creating valid assessments that reflect that knowledge and cultural context. through classroom observations, family interviews, and teacher interviews, research in this project will focus on: identifying family and community ctfok with which children enter school; the effectiveness of the csat for measuring ct; young students? conceptual understanding of ct (grades k-2); teachers? experience on the project, especially as reflected in knowledge of and valuing of strengths-based approaches to working with black and hispanic families and students, and in integrating cs/ct concepts into these teachers? instructional practices. traditional assessments have been shown to embed cultural bias, thus perpetuating disadvantage for children of color. therefore, it is vitally important that the cs educational research community develop assessment methods that are equitable. the work is

transformative on two levels: first it centers family and community knowledge as foundational to children's prior and future knowledge; and second, it uses this information to create equitable assessment materials. this work will have a broad impact in providing the results of research to the cased community at large. this project is supported through the cs for all: research and rpps program.

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Excellence in Research: Collaborative Research: Computational Modeling and Experimental Investigation on Multivalent Interaction at Nano-Bio Interface for 2D Materials

Awardee: Clark Atlanta University

Amount: \$499,999.00

Abstract: part 1: non-technical summary nano-materials are extremely small sized materials. nano-materials become biomaterials when they directly or indirectly interact with living things, and also when they are used as biosensors, bioimaging or therapeutic agents. understanding the interactions occurring at the interface of such nano-materials and biological molecules is very important for several potential applications. the current project will develop novel, two-dimensional (2d) nano-materials and examine their physical and chemical interactions with biomolecules. this will be accomplished by coupling computational simulations and experimental investigations. the expected outcome is that novel nano-platforms will be developed, and they will have capability to be explored for numerous promising applications in industry. successful completion of this project will offer many fascinating physicochemical properties that will generate exciting opportunities for future two-dimensional nanomaterials-based biosensing, bioimaging, and therapeutic applications. the project will provide excellent research and education opportunities for underrepresented minority undergraduate and graduate students from clark atlanta university and jackson state university. the current project will increase the skilled workforce in the important fields of computation and

emerging novel material design, with an emphasis on enhancing and promoting **diversity** from underrepresented groups.      part 2:      technical summary      the project will provide a better understanding of the nano-bio interface at the cellular and molecular levels, which is extremely important to guide the rational design of 2d material for biomedical devices. the proposed research will address essential new questions on how the heterogeneous nature of the biological system influences the dynamics of nano-bio interactions. the research and educational activities of this project include: (i) development, computational exploration, and characterization of chemically functionalized 2d materials of graphene oxide and phosphorene; (ii) elucidation of the multivalent interactions at nano-bio interfaces between 2d materials with dna/rna, proteins, and peptides; (iii) understanding how corona formation on 2d nano-material changes the biological fate, using cell viability and cellular uptake experiment; (iv) performing computational modeling to understand the interactions of 2d materials with biomolecules; and (v) engaging minority students in advanced research on emerging nano-bio technologies. the current project will provide opportunities for underrepresented minority participants to become next generation materials scientists through innovative research and education in emerging 2d material-based biotechnology research areas. the successful execution of this project may lead to the development of safe nano-materials for bio-nano technologies.      this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: FIRED UP: An immersive early field experience program to build community, support inclusivity, and foster large-scale research ideas

Awardee: University of Colorado at Boulder

Amount: \$499,997.00

Abstract: this national science foundation innovations in graduate education (ige) award to the university of colorado boulder will test the efficacy of a first-year graduate student program designed

to promote the inclusion of students from diverse identities as well as provide discipline-specific training in field methods. currently, ecology and evolutionary biology graduate programs in the us lag behind other biological disciplines in the representation of peer students (persons excluded due to ethnicity and race). this project aims to address this issue by piloting a program that aims to increase peer recruitment, create a cohort community, improve the sense of belonging among students, increase early access to expert field methods training, and expand training to address ecological questions relevant to global environmental change. challenging issues related to environmental change, such as bio\*\*diversity\*\* loss and climate change, require a diverse workforce of highly trained biologists who can collaborate across disciplines and produce solution-oriented scientific approaches. while our program is tailored to the disciplines of ecology and evolution, the basic elements of the program could be adapted to many stem disciplines and broaden the impact of this approach. the pis of this project will work to increase peer graduate student recruitment efforts through connection with multiple conferences and networks that promote student \*\*diversity\*\*. the design of the graduate education model draws on theories of human motivation and personality (self-determination theory and sources of self-efficacy) to target psychological needs that, when satisfied, foster well-being and success in graduate school: autonomy, competence, and relatedness. by providing an early immersive field experience for a cohort of students the summer before they begin graduate school, our program will work to remove the barriers that fieldwork poses to peer students interested in ecology while providing critical early-training and cohort building to increase retention and students' success. the project will take advantage of the well-established niwot ridge long-term ecological research (nwt lter) program and the mountain research station at cu boulder. evaluation of the program will focus on understanding how programmatic components support students in developing competence in the field and analytical methods, autonomy and independence as researchers, and a sense of belonging within the field. the project aims to publish and disseminate the approaches used to be accessible for a variety of stem fields in addition to the discipline-specific results in ecological science. the innovations in graduate education (ige)



program is focused on research in graduate education. the goals of ige are to pilot, test and validate innovative approaches to graduate education and to generate the knowledge required to move these approaches into the broader community. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: III:Small: Interpretable Deep Generative Models for Drug Development

Awardee: Ohio State University

Amount: \$499,995.00

Abstract: drug discovery is time-consuming and costly: it takes approximately 10-15 years and between \$500 million to \$2 billion to fully develop a new drug. molecule optimization is a critical step in drug discovery to improve desired properties of drug candidates through chemical modification. for example, in lead (molecules showing both activity and selectivity towards a given target) optimization, the chemical structures of the lead molecules can be altered to improve their selectivity and specificity. conventionally, this process is facilitated based on knowledge, intuition and experience of medicinal chemists, and is done via fragment-based screening or synthesis. such an approach is not scalable. the objective of this project is to develop a new class of artificial intelligence (ai) methods and tools to conduct in silico molecule generation. specifically, this project will focus on the following important aspects in ai-based in silico molecule optimization: 1) major scaffold retention, 2) molecule **\*\*diversity\*\***, 3) molecule synthesizability; 4) multi-property optimization; and 5) interpretability. the central hypothesis underlying the proposed research is that the increasing amount of publicly available molecule data, including molecule properties, synthesis pathways and drug-likeness, contains a wealth of information that, if properly analyzed and utilized, can provide key insights in revealing, characterizing and automating the computational molecule generation and optimization process. developing a new class of ai methods for in silico drug

molecule optimization will require the development of novel ai models and methods for in silico molecule optimization. examining designs based on new deep generative models, deep graph convolutional networks, conditional sampling approaches and reinforcement learning methods that learn from pairs of molecular graphs, and accordingly generate new molecular graphs with improved biochemical and biophysical properties, is necessary. the proposed research will also provide a holistic framework to explore prospective molecules that are sufficiently different from one another; and will investigate molecular graph search approaches and bayesian optimization methods to guide search in the latent embedding (representation) space. for multi-property optimization, the proposed research will provide a pipeline structure and new reinforcement learning approaches. to understand and facilitate interpretable generative models, the proposed research will develop a set of novel methods including network dissection, perturbation-based attribution methods, self-explaining methods and disentanglement. this project will have substantial societal and educational impacts, and will enhance **\*\*diversity\*\*** in stem through education and research dissemination. the broader scientific contributions of the will be the development of innovative ai methodologies and tools that will aid drug development. these technical innovations will not only address the key computational challenges in generative models for molecules, but also potentially generalize to other problems (e.g. cheminformatics, materials design) in which generation of structural data is highly needed and interpretation of such generation process is critical. the proposed research can potentially reduce the investment costs during drug discovery, increase its successful rate significantly, and ultimately aid in the improvement of the us health care quality. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RCN-UBE: Biologists and Graph Interpretation: Professional development for an online curriculum to foster data literacy and value diverse identities

Awardee: SUNY College at Geneseo

Amount: \$499,978.00

Abstract: like other stem disciplines, biology undergraduate students from historically excluded groups graduate at lower rates than their counterparts. to increase student persistence in biology, classrooms should promote student confidence and foster students' sense of belonging. specific strategies towards these goals include improving representation of diverse scientists in the curriculum and incorporating data interpretation skills, which are increasingly critical for student success in biology. however, faculty often lack the experience and resources to create curricula on their own that both highlight counter stereotypical scientists while also addressing complex data literacy skills. in this project, a research coordination network of faculty participants will work collaboratively to create, revise, and disseminate the "biologists and graph interpretation" curricular materials. modules within the curriculum will teach students data literacy skills through an activity that highlights the work of a counter stereotypical scientist. each module will also contain a video interview with that scientist and offer students a moment to reflect on diverse representation in biology. curricular materials produced by network participants will cover both introductory and advanced topics, will include extensive instructor guidelines for classroom implementation, and will be available as open access resources on the quantitative undergraduate biology education and synthesis hub. to further facilitate dissemination of the curriculum, network participants will also lead workshops that guide faculty through the process of finding and incorporating a module into their course. the database of biologists and graph interpretation modules will provide an accessible alternative to textbook resources that historically have not highlighted the work of counter stereotypical scientists. this project will create multiple faculty development opportunities within a supportive network as faculty generate, disseminate, and train others to use "biologists and graph interpretation" curricular materials. to achieve this goal, online faculty mentoring networks will first create, pilot, revise, and publish curricular materials on the quantitative undergraduate biology education and synthesis hub (qubeshub). next, workshops will train new faculty participants in the

implementation of the curriculum. participants will have the opportunity to take leadership roles in future iterations of faculty mentoring networks and workshops. throughout, participants can engage with and support one another via network-wide online activities and discussion boards. partnerships established between this network and other initiatives will facilitate continued growth of this supportive faculty community. the efficacy of the network's professional development will be assessed by monitoring faculty gains, while the impact of the curriculum will be assessed by measuring student outcomes. the **\*\*diversity\*\*** of scientists featured in the curriculum will also be quantified relative to standard textbooks. with more diverse representation and deliberate integration of data literacy skills in biology courses, all students are expected to have a greater sense of belonging as well as an increased confidence in the biology classroom. this project is funded by the directorate for biological sciences, division of biological infrastructure as part of efforts to address the challenges posed in vision and change in undergraduate biology education: a call to action (<http://visionandchange/finalreport/>). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Dimensions US-China-South Africa: Establishing genetic, phylogenetic and functional mechanisms that shape microbiome diversity of polar and alpine soils

Awardee: University of Delaware

Amount: \$499,973.00

Abstract: microorganisms are the foundations of ecosystems and drive the biology and chemistry in soils, e.g. the conversion of soil organic matter into the greenhouse gases carbon dioxide and methane, as well as nitrogen and phosphorous compounds that can be used by plants. soil microbial community **\*\*diversity\*\*** maintains ecosystem stability and sustainability. understanding the ecology of these microorganisms is one of the most compelling scientific challenges. this project will

focus on the microbial ecology of soil ecosystems in the arctic, antarctic, and tibetan plateau. these ?tri-polar? soils are chosen for study as they are disproportionately impacted by climate change and predicted to show increased microbial activity and enhanced turnover of soil organic matter in the future. while microbes excel at adapting to environmental change, the functional implications of microbial community transitions remain to be characterized. laboratory- and field-based approaches will identify microorganisms that are successful in these ?tri-polar? soil ecosystems and why, i.e., which bacterial species/strains are successful and what functional traits make them successful. understanding how soil ecosystems respond in these polar regions is critical for evaluating the controls of biogeochemical cycling and clarifying microbial feedbacks in a changing world. this project will assemble an international team and recruit young scholars to reflect a blend of expertise in microbiology, ecology and environmental sciences. research will be integrated with educational activities by involving samples and data into hands-on classroom training at the k-12, undergraduate, and graduate levels. this project will delineate mechanisms that lead to diverse soil microbial communities that are hallmarks of stable and sustainable soils. we lack predictive understanding of mechanisms that regulate and maintain microbial bio\*\*diversity\*\* and how this relates to biogeochemically relevant microbial functions. integrative approaches are needed to identify the principles that shape and maintain this bio\*\*diversity\*\*. this project combines genetic, phylogenetic, and functional dimensions of bio\*\*diversity\*\* to probe factors that shape the ?morass of \*\*diversity\*\*? of soil systems. the overarching hypothesis is that resource partitioning, selective predation, and temporal separation of activity each contribute to the success of particular bacterial strains/species in polar and alpine systems. the international research team will focus on testing these hypotheses in soils across arctic, antarctic and tibetan plateau habitats with the acidobacteria as a model microbial phylum for study. laboratory- and field-based approaches will be linked to describe the genetic, phylogenetic and functional \*\*diversity\*\* the acidobacteria, one of the most ubiquitous but elusive bacterial phyla found in terrestrial ecosystems around the globe. the study will identify their ecosystem functions in soils, their interactions with other microbes, their adaptations to

environmental stress such as climate change, and will assess their in situ dynamics and activity. integration of these data will address which organisms compete for resources, avoid predation, and ultimately, occupy fundamentally distinct niches in these ecosystems. elucidating these equalizing/stabilizing mechanisms can begin to explain the tremendous bacterial **\*\*diversity\*\*** observed in soil microbiomes. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: III: Medium: Collaborative Research: MUDL: Multidimensional Uncertainty-Aware Deep Learning Framework

Awardee: University of Texas at Dallas

Amount: \$499,955.00

Abstract: people encounter serious hurdles in finding effective decision-making solutions to real world problems because of uncertainty from a lack of information, conflicting information, and/or unsure observations. critical safety concerns have been consistently highlighted because how to interpret this uncertainty has not been carefully investigated. if the uncertainty is misinterpreted, this can result in unnecessary risk. for example, a self-driving autonomous car can misdetect a human in the road. an artificial intelligence-based medical assistant may misdiagnose cancer as a benign tumor. further, a phishing email can be detected as a normal email. the consequences of all these misdetections or misclassifications caused by different types of uncertainty adds risk and potential adverse events. artificial intelligence (ai) researchers have actively explored how to solve various decision-making problems under uncertainty. however, no prior research has looked into how different approaches of studying uncertainty in ai can leverage each other. this project studies how to measure different causes of uncertainty and use them to solve diverse decision-making problems more effectively. this project can help develop trustworthy ai algorithms that can be used in many

real world decision-making problems. in addition, this project is highly transdisciplinary so that it can encourage broader, newer, and more diverse approaches. to magnify the impact of this project in research and education, this project leverages multicultural, **\*\*diversity\*\***, and stem programs for students with diverse backgrounds and under-represented populations. this project also includes seminar talks, workshops, short courses, and/or research projects for high school and community college students.

this project aims to develop a suite of deep learning (dl) techniques by considering multiple types of uncertainties caused by different root causes and employ them to maximize the effectiveness of decision-making in the presence of highly intelligent, adversarial attacks. this project makes a synergistic but transformative research effort to study: (1) how different types of uncertainties can be quantified based on belief theory; (2) how the estimates of different types of uncertainties can be considered in dl-based approaches; and (3) how multiple types of uncertainties influence the effectiveness and efficiency of decision-making in high-dimensional, complex problems. this project advances the state-of-the-art research by performing the following: (1) proposing a scalable, robust unified dl-based framework to effectively infer predictive multidimensional uncertainty caused by heterogeneous root causes in adversarial environments. (2) dealing with multidimensional uncertainty based on neural networks. (3) enhancing both decision effectiveness and efficiency by considering multidimensional uncertainty-aware designs. (4) testing proposed approaches to ensure their robustness in the presence of intelligent adversarial attackers with advanced deception tactics based on both simulation models and visualization tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RCN: Feedbacks between geological, climatological, and biological dynamics associated with the formation of the Galápagos Islands: The Island Systems Integration Consortium (ISIC)

Awardee: Regents of the University of Idaho

Amount: \$499,866.00

Abstract: the dynamic and changing nature of our planet has long been recognized by researchers in fields such as geology, climatology, and biology. geological and climatological forces influence the formation and maintenance of biological **\*\*diversity\*\***, and evidence from these disciplines is often used to understand these biological patterns. yet, how signatures of current and past bio**\*\*diversity\*\*** patterns may inform geological and climatological models has often been overlooked. this project establishes the island systems integration consortium research coordination network (isic-rcn), a consortium of geologists, climatologists, and biologists focused on determining the potential for each field to inform the others in novel, previously unexplored ways. to do so, the researchers will focus on the galapagos archipelago, an oceanic island system for which ample data have been assembled and that is ripe for such cross-disciplinary analyses. the isic-rcn participants will: (1) form a long-lasting community of researchers whose discipline-focused skills will spawn new interdisciplinary ideas and research directions; (2) quantify the current state of the knowledge about the geological, climatological, and biological understanding of these islands and of ocean islands around the world; and (3) move that understanding forward by addressing outstanding questions in new ways. finally, the isic-rcn will extend its interdisciplinary framework to wider audiences in both the scientific and public spheres by maximizing the **\*\*diversity\*\*** of participants, conducting hands-on training in science communication, providing opportunities and tools to organize galapagos outreach activities, and creation of a website to share galapagos research, isic-rcn scientific advances, outreach activities, and a student-led interactive learning app. the isic-rcn will use the galapagos archipelago as a model to leverage the power of cross-disciplinary research to address fundamental questions too challenging or impossible to address through single disciplinary approaches. activities will align along three primary axes: (1) fostering a unique interdisciplinary community around island systems, using the galapagos archipelago as a focal point, (2) creating new research directions through cross-disciplinary collaboration, and (3) facilitating training and educational activities for



scientists and the general public. to develop and maintain this novel scientific community, the isic-rcn will conduct a series of virtual and in-person meetings, facilitate data sharing and dissemination of scientific knowledge through a web-portal, and support the formation of working groups focused on specific cross-disciplinary scientific questions. products of the isic-rcn include a new community focused on innovative research approaches, new collaborations, white papers on the state of the field and promising avenues of interdisciplinary research, and scientific publications.

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: CyberTraining: Implementation: Small: Building Future Research Workforce in Trustworthy Artificial Intelligence (AI)

Awardee: Georgia State University Research Foundation, Inc.

Amount: \$499,245.00

Abstract: the goal of the project is to train current and future research workforce members in trustworthy artificial intelligence (ai) by developing instructional materials that expose students to various challenges of trustworthy ai systems. the project is focused on the vital national need for well-trained and highly knowledgeable researchers in trustworthy ai who are capable of solving real world problems in complex ai systems and help enable secure and safe adoption of ai systems. the project will have direct and long-term impact in both the public and private sectors by training the research workforce to address trustworthy ai challenges. georgia state university is a minority-serving institution (msi), and the project will form a coordination network consisting of research universities, 4-year colleges, historically black colleges and universities (hbcus), hispanic-serving institutions (hsis), and women's colleges in metro atlanta and the broader region. the collaboration will significantly increase the collective impact of the project, benefit numerous students from underrepresented groups and help increase the **\*\*diversity\*\*** of the research workforce. the project team will develop interactive instructional materials including a set of hands-on labs that employ state-of-the-art trustworthy ai techniques to address the various challenges of ai systems. the instructional materials to be developed include modules on adversarial machine learning, evasion attacks and defenses, data poisoning attacks and defenses, privacy attacks and defenses, testing and verification, and fairness, accountability, transparency, and ethics (fate). the project employs learning science principles, specifically the active learning and inquiry-based learning strategies that result in deeper understanding by students and provide formative feedback to instructors. the instructional materials are based on real-world systems and are designed to systematically cover fundamental principles in trustworthy ai and practical skills. the project also will provide guidelines to help instructors integrate the modules into their curriculum. the hands-on labs will be built based on only open-source software and tools that are free to use for educational purposes and will be distributed via free cloud platforms. the project evaluation includes formative and summative evaluations that use both quantitative and qualitative approaches and will be conducted by an experienced external evaluator with help from the project team. the project will

disseminate the developed materials through training workshops for the educational and research communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Redefining the footprint of deep ocean methane seepage for benthic ecosystems

Awardee: University of California-San Diego Scripps Inst of Oceanography

Amount: \$498,985.00

Abstract: this research examines the role of deep-sea organisms in determining the fate and footprint of methane, a potent greenhouse gas, on pacific continental margins. the investigators are evaluating the deep ocean methanosphere defined by the microbial communities that consume methane and the animals that directly feed on or form symbioses with methane-consuming microbes. they are also investigating animal communities that gain energy indirectly from methane, as well as those that take advantage of carbonate rocks, the physical manifestation of methane consumption in seafloor sediments. the study of methane seeps in the deep waters of both alaska (4400-5500 meters) and southern california (450-1040 meters) is enabling comparisons of the methanosphere under different food-limitation and oxygen regimes. by applying diverse chemical, isotopic, microscopy, and genetic-based analyses to seep microbes and fauna, this study is advancing understanding of the contribution of methane to deep-sea bio\*\*diversity\*\* and ecosystem function, information that can inform management and conservation actions in us waters. in addition to training for graduate and undergraduate students at their home institutions, the investigators are collaborating with the alaska native science and engineering program (ansep). they are recruiting alaskan undergraduates to participate in the research, contributing to ansep?s online resources that promote interaction between scientists and middle and high school students, and participating in ansep?s annual residential career exploration in marine science programs to engage middle school

students in learning about deep-sea ecosystems and the variety of career pathways available in marine related fields. microbial production and consumption of methane is dynamic and widespread along continental margins, and some animals within deep-sea methane seeps rely on the oxidation and sequestration of methane for nutrition. at the same time, understanding of methane-dependent processes and symbioses in the deep-sea environment is still rudimentary. the goals of this study are to 1) examine the **diversity** of animals involved in methane-based symbioses and heterotrophic consumption of methane-oxidizing microbes and how these symbioses extend the periphery of seeps, contributing to non-seep, continental slope food webs; and 2) determine whether carbonates on the seep periphery sustain active methanotrophic microbial assemblages, providing a localized food source or chemical fuel for thiotrophic symbioses, via anaerobic oxidation of methane, or free-living, sulfide-oxidizing bacteria consumed by animals. the investigators are addressing these goals by surveying, sampling, and characterizing microbes, water, sediments, carbonates and animals at a deep seep site on the aleutian margin and a shallow site off southern california. shipboard experiments and laboratory analyses are using molecular, isotopic, geochemical, and radiotracer tools to understand transfer of methane-sourced carbon from aerobic methanotrophs under multiple oxygen levels, pressures, and photosynthetic food inputs. this approach offers a wide lens by which to examine the methane seep footprint, allow reinterpretation of past observations, and identify new scientific areas for future study. improved characterization of the deep continental margin methanosphere informs climate science, bio**diversity** conservation, and resource management. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CICI: UCSS: Helix++: Securing Open Science Platforms

Awardee: University of Virginia Main Campus

Amount: \$498,021.00

Abstract: the helix++ project's goal is to use recently developed, promising cybersecurity research results to secure open-science platforms. securing these open-science platforms is vital because compromise of research infrastructure can have severe consequences, including the delay of critical research, corruption of research results, theft of intellectual property, and exposure of personally identifiable information. beyond providing researchers customized, secure packages of widely used open software, the helix++ project will provide insights and directions for future research and strategies for protecting critical cyber infrastructure. using two existing operational open-science platforms at the university of virginia, the project will investigate the interaction of technical and policy issues which are fundamental to infrastructure protection. the open-source helix++ project improves the security posture of open science platforms by applying cutting-edge cybersecurity techniques to diversify and harden software automatically. a distinguishing feature of helix++ is that it does not require source code or build artifacts. it operates directly on software in binary form—even stripped executables and libraries. this feature is key as rebuilding applications from source is a time-consuming and often frustrating process. helix++ enables the rapid generation and deployment of secure containers and virtual machines, wherein various applications and libraries are transformed to incorporate the helix++ protections. diversification breaks the software monoculture and makes attacks harder to execute as information needed for a successful attack will have changed unpredictably. diversification also forces attackers to customize an attack for each target instead of attackers crafting an exploit that works reliably on all similarly configured targets. hardening directly targets key attack classes. the combination of **diversity** and hardening provides defense-in-depth, as well as a moving target defense. helix++ is evaluated on two open science platforms to demonstrate its efficacy and usability. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: MIM: The impact of the fungal microbiome in metal tolerance and soil biogeochemical transformations

Awardee: University of New Mexico

Amount: \$497,969.00

Abstract: some metals are essential nutrients for life, while some are non-essential or even harmful to living organisms. fungi and bacteria are microorganisms that often live in a close association and play a key role in transforming and detoxifying metals in the environment. in spite of this importance, there is relatively little understanding of how the interactions between bacteria and fungi influence the transformation and/or detoxification of metals. the goal of this project is to address this knowledge gap by identifying how fungal-bacterial interactions affect metal transformation. this will be achieved through a novel multidisciplinary research approach employing advanced, state-of-the-science analytical techniques. knowledge gained through this project will allow the engineered control of metal transformations for a wide range of applications in environmental cleanup, biorefining, production of nanoparticles, and other beneficial applications. successful completion of this research has strong potential to benefit society through improvements in environmental remediation and industrial manufacturing. this project will improve the nation's stem workforce by providing a unique training opportunity for student researchers that bridges diverse fields such as environmental engineering, microbiology, geochemistry, bioinformatics, and art. remediation of metal contamination is a major environmental challenge because, unlike many organic pollutants, metal species cannot be degraded and can only be extracted or biotransformed to less toxic forms. while past approaches to biotransform metals have focused primarily on single microorganisms, host-microbiome interactions have shown potential to biotransform surrounding environments and improve host resiliency. however, the mechanisms for metal biotransformation by microbial host-microbiome systems are largely unknown. the overall goal of this project is to elucidate the rules of life that govern fungal microbiomes. this goal will be achieved through a

specific focus on fungal microbiomes, which include a fungal host, endosymbionts (endobacteria), and symbionts (exobacteria that live extracellularly) as a model host-microbiome system. the specific research objectives of this project designed to achieve the goal are to: understand the effects of metals and metalloids on the **\*\*diversity\*\*** and transmission of fungal microbiomes (facultative and obligatory); and determine the role of fungal microbiomes in metal tolerance by mediating the uptake, transformation, and sorption of metal ions, nanoparticles, or other metal species. a deeply integrated multidisciplinary approach will be used to investigate physiological, genetic/genomic, and metabolic processes that govern the structure and function of fungal microbiomes in the presence of metals. this will be achieved using novel state-of-the-science isotope probing, advanced microscopy, spectroscopy, and integrated genomics, transcriptomics, and metallomics to elucidate how the microbiome influences the metabolic activity of the host towards metal ions. successful completion of this research has strong potential to identify new genes and/or pathways for metal tolerance and biotransformation, as well as expand our mechanistic understanding of the structure and function of fungal microbiomes in nature. this knowledge has strong potential to benefit society by facilitating applications in remediation, water treatment, electronics manufacturing, antimicrobial production, medicine, and related fields. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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genetic/genomic, and metabolic processes that govern the structure and function of fungal microbiomes in the presence of metals. this will be achieved using novel state-of-the-science isotope probing, advanced microscopy, spectroscopy, and integrated genomics, transcriptomics, and metallomics to elucidate how the microbiome influences the metabolic activity of the host towards metal ions. successful completion of this research has strong potential to identify new genes and/or pathways for metal tolerance and biotransformation, as well as expand our mechanistic understanding of the structure and function of fungal microbiomes in nature. this knowledge has strong potential to benefit society by facilitating applications in remediation, water treatment, electronics manufacturing, antimicrobial production, medicine, and related fields. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RCN-UBE: The River Field Studies Network: Connecting rivers, people, & science through immersive field-based education

Awardee: Virginia Commonwealth University

Amount: \$497,139.00

Abstract: rivers perform a broad set of functions essential to human societies and the landscapes rivers flow through. the relationship between humans and rivers are often impaired, which threatens both rivers and people. restoring these relationships will require a diverse workforce of interdisciplinary problem solvers. field studies are essential to creating this workforce because they connect students to learning objectives, peers, instructors, and society through immersive active learning in real world environments. they help overcome achievement gaps, propel inclusion, catalyze career interest, and create informed and engaged citizens. however, to achieve these benefits, field instructors must overcome a unique and growing set of challenges. in addition to knowledge of their stem discipline, field studies instructors require a sophisticated grasp of

specialized pedagogy and assessment, fundraising, negotiating institutional bureaucracy, issues of **diversity**, equity, and inclusion, and multiple dimensions of risk management. mastering these is more than many self-taught instructors will be able to manage on their own. without a network for support and guidance, instructors will burn out, risk-averse institutions will shy away, and field studies will continue to decline. the river field studies network is a response to the paired crises of rivers and field studies. at this moment of critical vulnerability, we must restore and expand the capacity to bring students and rivers into contact through active learning. the river field studies network aims to advance stem education and support healthy rivers by connecting rivers, people, and science through immersive field education. to accomplish this, the network will, create a dual-track professional-development structure, including a network for mentorship and curricular exchange as well as a more intensive field-based certificate program; develop an online library of open-source lessons and other content for instructors, featuring innovative modules designed to enable student collaboration across institutions and regions; recruit intentionally to overcome barriers to **diversity** of all kinds, and train participants in pedagogical methods that foster inclusivity; tackle the pressing need for informed risk management in field-based education through in-person instruction and expert tutorial videos; reach out to a wider community by building the premier public-facing website for river field studies and creating structures to facilitate student exchange; and incorporate assessment at every level to evaluate and continually refine our programming. these are the essential elements needed to form a sustainable community of practice in river-based education that shares expertise, imparts specialized skills, and cultivates the next generations of leaders, ultimately closing the gaps in institutional capacity that currently threaten the future of the field. this project is funded by the directorate for biological sciences, division of biological infrastructure, as part of their efforts to address the challenges posed in vision and change in undergraduate biology education: a call to action (<http://visionandchange/finalreport/>). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Nonequilibrium Molecular Dynamics: Dynamical Consistency Across Scales

Awardee: Johns Hopkins University

Amount: \$497,000.00

Abstract: with support from the chemical theory, models and computational methods (ctmc) program in the division of chemistry, professor rigoberto hernandez of johns hopkins university and his team will work to advance the rules describing molecular science at multiple scales. a fundamental challenge to the use of simulation and theory to predict and design chemistry is the requirement that such systems must be specified at atomic resolution, at the scale in which the system functions (generally as large as beaker or a chemical refinery), and everything in between. the coarse-graining of electrons, allowing for the propagation of all-atom molecular dynamics has already proved to be critical in revealing the properties of molecules and assemblies with nearly up to a billion atoms. professor hernandez will develop coarse-grained representations and the equations of motion needed to accurately describe molecular-specified solutions and materials through the middle scales in length and time for systems ranging from a billion to a septillion atoms. dr. hernandez will also advance science generally through his leadership and mentoring of students, staff, chemistry faculties and broader audiences through approaches increasing **\*\*diversity\*\***, equity and inclusion within the chemical enterprise. rigoberto hernandez of johns hopkins university will work to advance understanding and tools for propagating chemical systems that are structurally and dynamically consistent in the sense that observables and their non-equilibrium behavior can be accurately and precisely described at every scale. specifically, the major objectives of his work are to: (i) characterize far-from-equilibrium dynamics of molecular to mesoscale systems driven by macroscale disturbances using reduced-dimensional models; (ii) develop the theory to predict the intrinsic pathways for nonequilibrium pathways in processes involving many particles heterogeneously which is preserved across multiple space and time scales, and (iii) advance the

stochastic hard core (shc) model for complex solvents, benchmark the proposed algorithms for structural and dynamical consistency, and develop a new framework for approximately identifying the pathways in heterogeneous chemical systems exhibiting a hierarchy of interactions at multiple time and length scales. dr. hernandez has also been involved and will continue to be involved in efforts to (i) broaden the use of theoretical and computational tools in chemical dynamics beyond its developers, (ii) increase learning and appreciation of chemistry in the education of undergraduate students and graduate students both inside and outside of the classroom, (iii) engage the general public, and (iv) help diversify the faculty in research-active chemistry departments through his direction of the open chemistry collaborative in **diversity** equity (oxide) and the academic leadership training (alt) workshops. his research findings will be disseminated widely through peer-reviewed publications, and postings on everywherechem, and through scientific and public lectures. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: The Merian Survey. Characterizing Dark Matter and Feedback in Star Forming Dwarf Galaxies

Awardee: University of California-Santa Cruz

Amount: \$496,989.00

Abstract: while most of the mass in the universe is unseen, the smallest galaxies in the universe (the so-called dwarf galaxies) pose significant challenges to this ?dark matter? model. in order to further test our best dark matter models, a large observational survey of dwarf galaxies is needed. this project focuses on the meriam survey, which will observe 100,000 dwarf galaxies with known distances. furthermore, each of the dwarf galaxies in this survey has constraints on their dark matter content from other methods. the new data will provide their stellar structure and colors. these results can all be taken together to test our ideas of dark matter in the universe. the team will place priority

on recruiting a diverse group of students who will carry out the data mining that will be required in the era of the vera rubin observatory. established programs at both princeton and uc santa cruz recruit historically underserved students for summer research and then continuing cohort support. these students will be trained in "big-data" and modern science analysis with merian. extensive studies of dwarf galaxies have revealed a considerable scatter in many of their fundamental properties. in particular, galaxies with stellar mass of  $10^8 - 10^9$  msun present a **\*\*diversity\*\*** of star formation rates and rotation-curve shapes which are in tension with theoretical models. reliably characterizing the dark matter distribution and baryonic processes in these galaxies, such as feedback, is key to in order to establish a complete picture of dark matter on small scales. the merian survey will obtain a volume-limited census of dwarf galaxies in this mass range at  $z=0.058-0.1$ . using two custom made filters, merian will provide redshifts to a complete sample of 100,000 star forming dwarf galaxies (two orders of magnitude larger than sdss+gama) over an area of 870 deg<sup>2</sup>. combined with deep+high spatial resolution imaging from the hyper-suprime camera, this program will result in high s/n weak lensing profile measurements for dwarf galaxies, probing their dark matter halos out to their virial radii. also, hyper-suprime camera imaging will be used to measure dwarf sizes and shapes. the next generation of scientists must be trained to deal with the deluge of vera rubin observatory data coming in the next decade. programs at both princeton and uc santa cruz recruit historically underserved students for summer research and then continuing cohort support. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Genome editing approaches to unravel microRNA roles in stochastic multistable networks

Awardee: University of Texas at Dallas

Amount: \$493,291.00

Abstract: one of the fundamental questions in biology is to understand the roles of the gene regulatory networks driving cellular decisions; cellular decisions drive everything from an organism's development to a cell's fate as healthy or diseased. microRNAs (miRNAs) are small RNA molecules that bind to the mRNA of target genes, acting as regulators of gene expression. Previous studies have demonstrated the critical roles of miRNAs in a variety of biological processes such as cell growth and cell differentiation. However, what is still not well understood concerns possible synergistic effects from multiple miRNA molecules targeting different binding sites of the same mRNA and concerns how miRNA interactions operate within a complex gene regulatory network. To address these issues, an interdisciplinary platform that combines genome editing, live-cell imaging, and mathematical modeling will be developed in this project. The broader impacts of the project from the University of Texas at Dallas side will include support for the International Genetically Engineered Machine (iGEM) team and developing custom educational modules for local schools (Plano ISD) and summer camps, organizing public educational events at the interface of the biological and physical sciences, and the recruitment of underrepresented minorities. From the Northeastern University side, the group will take advantage of the investigators' participation in the NSF Center for Theoretical Biological Physics ongoing **\*\*diversity\*\*** efforts to recruit undergraduates from under-represented to work on this project, and spearhead an effort to create a modeling and computational track for undergraduate bioengineering majors. Finally, both groups will be directly involved in reaching out to local biomedical groups to create more appreciation for the types of rapid progress that can be made by combining advanced tools such as CRISPR with state-of-the-art computational methodology including both mechanistic studies and machine learning approaches. Lying at the heart of intricate relationships that determine the epithelial-mesenchymal transition (EMT) and mesenchymal-epithelial transition (MET) phenotypes is a core regulatory unit that consists of transcription factors and microRNAs. The project will focus on miRNAs targeting the master transcription factor (TF) families of EMTs, Snail and Zeb during the cellular decision process of EMT in multiple cell lines. The team will first perform CRISPR-based screens and custom genome and base editing modifications on miRNA

binding sites that are located at the 3'-utr of the transcription factor families snail and zeb. the effects of binding site modifications in emt and isolated respective clones will be evaluated. second, the team will prepare and optimize an rna imaging platform in live cells and measure time-series data and population distributions for mirna, mrna and protein levels of corresponding genes. using this data, the team will develop stochastic kinetic models of mirna regulation and infer the combinatorial effects of multiple mirna species binding to multiple sites of the same mrna. third, the team will integrate the kinetic models for each mirna interaction into full transcription factor-mirna network models for different cell lines. the models will be refined by calibrating model predictions with experimental observations on the distributions of gene expression and the distribution of cells in various emt states. this project brings together investigators who have extensive experience in genome editing/systems biology (bleris), epithelial?mesenchymal networks (levine), and systems biology/mathematics (lu). this award reflects nsfs statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Role of electric fields and a dynamic local environment in protein-RNA molecular recognition

Awardee: University of Utah

Amount: \$492,516.00

Abstract: ribonucleic acids (rna) are biopolymers with substantial amounts of negative electrical charge, and the surfaces of proteins that bind them often contain amino acid residues with electrical charge that can help attract, direct, and bind their targets. importantly, these are large and flexible molecules so fluctuations in their structure and local environment play a significant role in their function. this project seeks to understand how the process of molecular recognition between rna and proteins is influenced by their electrostatic interactions and by the dynamic environment in which binding occurs by developing a multimodal instrumentation that combines a variety of spectroscopic



techniques. this research will train students in a multidisciplinary skillset at the interface of physical chemistry and biophysics, with broader impacts that include the development of transferrable methods for quantitative characterization of biomolecular interactions. in this project, scalable and quantitative experiment kits for remote learning will be designed and implemented with the goal of expanding hands-on, experience-based education beyond typical teaching laboratory settings.

interactions between proteins and rna show significant **\*\*diversity\*\*** ? proteins can recognize their rna targets in ways that are specific to their sequence, to their structure, to both, or to neither. to uncover the molecular-scale mechanisms that tune substrate recruitment, complex stability, and cooperative target recognition by multiple protein domains, this project integrates electrochemical and spectroscopic tools to measure the dynamic signatures of protein-rna binding, their conformational fluctuations, and their response to non-equilibrium perturbations ? all under the effects of a controlled electrostatic environment. rna substrates will be localized at an electrode surface to tune their electrostatic interactions with proteins in solution, and the resulting protein-rna complexes will be probed with a multimodal instrument that combines electrochemistry with mid-infrared plasmonics, ultrafast multi-channel fluorescence, and pump-probe spectroscopies. the outcomes of this research will reveal the way electrostatic interactions and fast dynamics of biomolecular structure and solvation affect the thermodynamics and kinetics of formation, stability, and dissociation of protein-rna complexes. this project is supported by the molecular biophysics cluster of the division of molecular and cellular biosciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Predicting impacts of coastal species redistribution in a changing climate

Awardee: University of California-Irvine

Amount: \$492,382.00

Abstract: this project will improve our ability to anticipate the impacts of shifts in the geographic range of coastal species in a changing climate. although range shifts may be necessary for some species to avoid extinction as the climate warms, the arrival of new ones to an ecosystem can also lead to population declines and loss of bio\*\*diversity\*\*. the investigator is developing approaches to predict the impacts of range shifts along pacific shorelines using techniques that have been previously validated for risk assessments for invasive species. the research objectives of this study are integrated with educational activities: engagement of undergraduate and graduate students in data collection and analysis and implementation of a hierarchical mentoring program to serve english language learners within the investigator's minority serving institution. the investigator is also partnering with outreach organizations in the u.s. and mexico to educate k-12 students and multiple stakeholder groups about climate-driven range shifts and tools for predicting outcomes of redistribution, which can assist practitioners in creating management plans and policies. this study is developing a framework for understanding the impacts of marine species redistribution with a focus on poleward-moving carnivorous whelk species in rocky shorelines from northern california to baja, mexico. project goals are to 1) quantify the impacts of shifting species on populations and communities in the expanded range; 2) assess whether impacts of shifting species differ between their native and expanded ranges; and 3) predict future impacts under climate warming. the investigator is addressing fundamental questions in community ecology about the degree to which species interactions are density- and context-dependent. she is combining observational and experimental approaches with a broader data synthesis effort to test whether the impacts of species redistribution can be predicted by key indicators of invasion impacts: abundance, trophic level, and impacts in the native range. empirical data combined with paired demographic and distribution modeling will be used to project future impacts across the expanded ranges of these coastal marine species. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Leveraging Microfluidics for High-Throughput in Vitro Investigations of Transcriptional Regulation

Awardee: Stanford University

Amount: \$490,977.00

Abstract: all biological processes depend on the precise regulation of when genes are transcribed and how many rna transcripts are produced. this regulation is driven primarily by transcription factor (tf) proteins that bind specific dna sequences in the genome and then recruit additional "effector" proteins to either activate or repress gene transcription. while scientists have "cracked" the dna code specifying the sequences of rna and protein molecules produced from protein-coding dna, it remains unclear how the tf/dna "regulatory" code that governs the strength and timing of gene expression. it is not known how closely related tfs with apparently similar dna binding preferences recognize different sites in the genome to regulate distinct transcriptional programs. there is little known about the web of interactions between tfs and the "effector" proteins required to activate transcription. this project will utilize new microfluidic technologies that enable accurate measurement of 1000s of protein/dna and protein/protein binding interactions simultaneously and at low cost. this project will apply these technologies to better understand how tfs find and bind their dna targets, how bound tfs recruit "effector" proteins, and the degree to which the "regulatory code" relies on thermodynamics. the pi will expand a hands-on microfluidics device laboratory to provide inquiry-based summer research experiences to community college students, increasing training opportunities for student populations traditionally underrepresented in stem. regulated gene expression is central to biology, sculpting the transformation from embryo to animal and enabling cells to respond dynamically to environmental changes. at a molecular level, this regulation is accomplished primarily by transcription factor (tf) proteins that bind dna regulatory elements and then recruit additional protein cofactors to either activate or repress transcription. biological \*\*diversity\*\* is simply too vast for us to ever measure tf binding and transcription in all organisms

and all tissues under all conditions of interest. this project will provide in vitro measurements that quantify thermodynamic and kinetic constants of reconstituted macromolecular interactions at unprecedented scale by using multiple novel microfluidic platforms capable of measuring affinities and kinetics for up to one million protein/dna or protein/protein interactions in parallel that were developed in the pi's laboratory. in this project, these in vitro technologies will be used to develop quantitative and predictive models of how tfs find and bind their genomic targets and how bound tfs recruit cofactors to regulate gene expression. using cutting-edge in silico tools, these measurements will then be integrated with existing in vivo data sets to develop quantitative models that, in turn, will be directly tested in vivo by quantifying tf and cofactor binding and gene expression for sequence variants. this project is funded by the molecular biophysics and genetic mechanisms clusters in the division of molecular and cellular biosciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF-BSF: Elucidating Interactions between Multiple Optical Cycling Centers in Hypermetallic Polyatomic Molecules

Awardee: Smithsonian Institution Astrophysical Observatory

Amount: \$490,503.00

Abstract: laser-cooled molecules are a powerful tool for exploring the frontiers of quantum science and ultracold physics, provided their energy can be cooled in all degrees of freedom to temperatures very close to absolute zero. although certain classes of molecules can be cooled with precisely engineered laser-light, particularly those containing a single heavy atom, extending efficient laser cooling to molecules more generally has proven challenging. this project aims to understand the general design principles that affect the performance of exotic, new classes of laser-coolable molecules containing multiple heavy atoms. through a collaborative national science foundation - us

israel binational science foundation experimental program, the investigators will explore how light from radio to visible wavelengths interacts with such molecules. this effort will broaden the **\*\*diversity\*\*** of cold molecule applications spanning quantum computing and simulation to tabletop searches for new physics. such cutting-edge yet fundamental measurements are well suited to educating and training students in stem fields, and such mentorship is a core project aim. all demonstrations of direct laser-cooling to date have used molecules containing a single heavy-atom photon-cycling center. more complex species containing multiple optical centers have the potential to greatly increase the versatility of laser-cooled molecules, but have not been thoroughly explored experimentally. this program comprises a systematic spectroscopic study of substituted hydrocarbons, including acetylene chains and benzene rings, containing multiple alkaline earth or alkaline-earth-like atoms. by combining broadband optical and microwave data, the investigators will directly probe how the intricacies of electronic structure and chemical bonding influence the molecular properties relevant to laser-cooling applications, as well as the molecular physics of these exotic, biradical species in general. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Oklahoma State University

Amount: \$490,084.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides

three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: New Anions to Understand Recognition Chemistry and Drive Hierarchical Assembly with Cyanostars

Awardee: Indiana University

Amount: \$490,000.00

Abstract: with support of the macromolecular, supramolecular, and nanochemistry program in the division of chemistry, professor amar flood of indiana university will undertake a project to understand how to design molecular compounds to capture negatively charged ions (anions) and use them to synthesize more complex chemical compounds. the significance of studying anions stems from their many global impact areas spanning from the use of nitrate and phosphate as fertilizer, which impact food production and water quality, through to organic phosphates that are the workhorse anions in lithium ion batteries. the significance of anion-directed synthesis is inspired by nature's use of bottom-up self-assembly and has the potential to impact the future of nano-manufacturing. the planned activity will benefit society by training graduate, undergraduate and postdoctoral coworkers in research, communication and collaboration both nationally and internationally. inclusive practices will be developed that foster a culture that embraces **\*\*diversity\*\*** and equity in stem (science, technology, engineering and mathematics). this project also has the potential to broaden understanding of anion-based chemistry for the public and undergraduate communities with videos and laboratory experiments. outputs from this research are expected to offer benefits to researchers in other areas of chemistry, and to industries that need to manipulate

anions. in this project on anion recognition and anion-driven hierarchical assembly, professor amar flood and his team will synthesize a series of anions to control their modes of self-assembly, study their anion recognition by cyanostar macrocycles, and examine their mechanisms and cooperativities of self-assembly. the project has three aims. aim 1 seeks to determine how the sterics, electronics and charge of substituents on anions composed of trifluoroborates control formation of cyanostar complexes by using synthesis, titration data and crystal structures. aim 2 aims to establish the correlation between the structures of substituted phosphates and their mechanisms of threading inside cyanostar macrocycles and to make threaded polymers with beads-on-a-string structures. aim 3 seeks to expand the role of anions in hierarchical self-assembly synthesis by understanding how anions and cyanostar structures need to be programmed to produce specific architectures that include network gels, cyclic polymers, and spherical cages. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: AF: Medium: A Unified Framework for Geometric and Topological Signature-Based Shape Comparison

Awardee: Tulane University

Amount: \$489,744.00

Abstract: a fundamental aspect for data analysis is the ability to compare data sets, in order to measure (dis)similarity and quantify patterns present in the data. however, data is often too large and complex to analyze in its entirety, and therefore different techniques are used to summarize the data in order to work with smaller, more manageable representations of it. this project studies the data-comparison problem through the lens of mathematics, using geometric and topological signatures to represent these shapes concisely. this project will consider a variety of different kinds of shape data which live in some larger geometric or topological space (e.g., gis trajectories, point

sets, meshes, 3d scans, or graphs), and consider classes of algebraic, geometric, and graphical signatures which can be used to represent these shapes concisely. the project draws primarily upon the nascent yet rapidly developing area of topological data analysis, where tools from topology like homology or homotopy are combined with geometric measures to create robust analysis tools for analyzing the shape of data. graduate and undergraduate students will be tightly integrated into the project, and special efforts will be made to involve students from underrepresented groups. additional efforts by the research team include planning a workshop focused on women in this field, as well as broadening **\*\*diversity\*\*** and inclusion efforts in their own universities. the project focuses on shapes that have some common underlying annotation framework on top of the signature, which is usually additional structural or geometric information from the original embedding. the research consists of two major components. in the first, the investigators are initiating a principled study of algorithms and approaches to develop a unified framework which leverages multiple signatures for shape comparison. the goal of this phase is to provide theoretical results as well as empirical evaluations on a variety of data sets and signatures. the second major component of the project studies inverse problems, which aim to reconstruct shapes from a combination of signatures. such problems are notoriously difficult for geometric or topological signatures, as they are necessarily lossy and remove certain types of information. during the course of the project, the investigators are also developing a shape signatures toolkit that enables computation of a range of signatures and distances, adding to the software both existing notions of distance and new ones developed over the course of the project. this project is jointly funded by the algorithmic foundations core program and by the established program to stimulate competitive research (epscor). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Testing the reduction of aerobic habitat as a common kill mechanism for major mass extinction events

Awardee: Syracuse University

Amount: \$488,302.00

Abstract: the project will study the response of marine animal ecosystems to environmental change using three mass extinction events from the geological record as study systems. specifically, the project will test the hypothesis that a large proportion of extinction during these events can be explained by the stresses that elevated temperatures and reduced oxygen availability place on animal respiration. geochemical data will be used to constrain computer simulations of changing ocean conditions during these mass extinction events. results from laboratory studies on animal respiration will then be paired with fossil data to assess whether differences in extinction intensity in space and across taxonomic groups can be explained by spatial variation in environmental change or differences among taxonomic groups in their ability to withstand environmental change. the project will provide interdisciplinary training to a group of graduate students and post-docs. it will further impact stem education through the creation of a website that will allow access to model results so that students can visualize and explore model output to understand cause-effect relationships between continental configuration, ocean conditions, and biological **diversity**. the investigators will also offer short-courses on earth system modeling and data interpretation at major conferences that will be recorded for asynchronous use. the project will also involve the development of a podcast series addressing how we reconstruct the ancient earth system and use these reconstructions to better understand the present and predict the future. in this project, the hypothesis will be tested that the loss of habitat through constraints on aerobic respiration under climate change and ocean deoxygenation can explain the magnitude, taxonomic selectivity, and latitude variation in intensity for the late devonian (frasnian-famnenian), end-permian, and end-triassic mass extinction events. paleoredox and paleoclimate proxy data and geochemical indicators of diagenetic alteration will be used for both global average and local conditions before

and after each major event combined with predictions from earth system models and occurrence data from the fossil record of marine animals to separate aspects of extinction than can be explained by physiological stress from those that require other explanations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: Collaborative Research: Testing Hypotheses about Rates of Diversification & Controls on Diversification related to the Opportunities for Speciation vs Fate of Incipient Divergences

Awardee: Mississippi State University

Amount: \$487,275.00

Abstract: all of combined planetary bio\*\*diversity\*\* owes its existence to the formation of new species. it is the newly formed boundaries separating one group of individuals from others that maintain the distinct and unique characteristics of individuals in each species. new species can form quickly or slowly. depending upon this pace of species formation (i.e., the rate of diversification), the numbers of species within a group will differ. however, the diversification rate itself is not sufficient to understand why species \*\*diversity\*\* varies because there are multiple potential explanations for any estimated diversification rate. this research project will focus on statistically distinguishing among these different explanations in order to understand why species \*\*diversity\*\* differs across

space, time, and among different groups of organisms. specifically, by applying newly developed statistical models of species formation to genomic sequences from individuals collected across multiple populations within each of several hundred species, the research will distinguish between various potential controls on diversification. these alternative controls have never previously been tested within a single study. as such, the research will provide unprecedented insights into how the frequency of formation and persistence of isolated populations (and hence, the opportunities for new species to form) affects diversification rates. the targeted study group (north american melanoplinae grasshoppers) includes representatives that span the climatic, geographic, and ecological conditions theorized to affect species formation, which will provide robust tests of how bio\*\*diversity\*\* is shaped. by illustrating the utility of population-level sampling within species in tests of species formation, the project will set a new benchmark for other researchers to consider for their own bio\*\*diversity\*\* studies. such research is important to avoid misinterpretations about why bio\*\*diversity\*\* differs across geographic regions, or among habitats, or among groups of organisms that co-occur. the research will also highlight the importance of museum collections for genomic-era bio\*\*diversity\*\* studies, while enhancing this publicly accessible community resource through the addition of newly collected and curated specimens, including their dna, ecological and geographic information. a complementary program of public and educational outreach activities built around the core research objective of why diversification might be promoted (or inhibited) across different landscapes or organismal groups will reach a diverse audience.       \*\*diversity\*\* differences

observed across taxonomic groups reflect different rates of diversification. however, there are two fundamentally different controls on diversification dynamics (meaning there are different explanations for any given diversification rate): the evolution of reproductive isolation that affects the fate of incipient divergences versus the frequency with which isolated populations form and persist affecting the opportunities for speciation. because diversification studies are typically carried out on phylogenetic estimates of species lineages, it has not been possible to test hypotheses about the opportunities for speciation. this research addresses this knowledge gap. through combined

theoretical and empirical studies and the generation of large-scale genomic data, the research will apply newly developed analytical methods to test hypotheses about diversification rates (based on phylogenetic estimates of species lineages) vs. the controls on diversification dynamics (based on phylogenetic estimates of species and population lineages). by testing for linkages between different controls on diversification dynamics with factors potentially affecting the formation of new species (e.g., fragmented habitats, topographically complex landscapes, or periods of climatic change, and species-specific traits), the work will address why these conditions might promote or inhibit the formation of new species. this will be the first study to establish potential linkages between the various controls on **diversity** dynamics (e.g., topographic complexity, geologic and climatic events, and selectively driven divergence). leveraging the researchers' extensive specimen collections with advances in collecting large-scale genomic data across hundreds of thousands of individuals and state-of-the-art analytics, the empirical dataset will contain almost complete taxonomic coverage of over 600 closely related grasshopper species (355 of which are from a single genus) that radiated recently (i.e., within the pleistocene and pliocene) in north america and mexico. by combining the skillsets of researchers with taxonomic expertise and genomic and quantitative analytics, the research team will promote broad training and mentoring of graduate students, while also offering public and educational outreach activities developed by researchers with different backgrounds to reach diverse audiences and underserved communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Microdiversity drives ecosystem function: SAR11 bacteria as models for oceanic nitrogen loss

Awardee: Montana State University

Amount: \$486,782.00

Abstract: this project studies how low oxygen availability influences the bio\*\*diversity\*\* and ecological role of sar11 bacteria, one of the most abundant microbial groups in the ocean. the work involves oceanographic sampling across a range of oxygen and nutrient levels in the eastern tropical north pacific ocean. using a combination of genomic, microbiological, and biogeochemical methods, the study identifies the mechanisms by which sar11 strains diversify into separate niches and species and contribute biochemically to the ecosystem, likely through removing nitrogen from seawater. the project equips the next generation of researchers and educators, notably those from underrepresented minority groups, to use oceanographic, genomic, and microbiological concepts to meet contemporary scientific challenges. this goal is met through a combination of bioinformatic workshops that target undergraduate students from the university system of puerto rico, middle school teacher-training workshops, and middle or high school teacher internships in the investigator?s labs. this multifaceted research and educational agenda fills a gap in our understanding of marine biological \*\*diversity\*\*, identifies the contribution of sar11 bacteria to nutrient and carbon cycles in low oxygen oceans, and provides lessons and analytical tools to study microbial processes in other ecosystems. this project has two aims. aim 1 employs comparative metagenomic and single-cell genomic analyses to identify metabolic properties that distinguish sar11 clades from low oxygen regions and processes of selection or gene flow operating across the clades. aim 2 combines microbial transcriptomics, incubation experiments with isotope tracers, and culturing to delimit the oxygen and nutrient conditions that define the niche space of each sar11 clade and to correlate sar11 gene transcription with community biochemical outcomes, including nitrogen loss through denitrification. the results of these aims and the informatic methods used to probe microbial micro\*\*diversity\*\* are disseminated through genomics-focused undergraduate workshops, and new teacher-training educational modules, including lab-based modules focused on the importance of microorganisms under environmental change in the oceans. data, manuscripts, and informatics workflows from this project are made publicly available. the results are critical for resolving the processes that create and sustain microbial \*\*diversity\*\* in the oceans and informing

biogeochemical models that predict how **diversity** influences ecosystem processes. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: New Mexico State University

Amount: \$486,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **diversity** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MCA-ECON: The Impacts of Supply and Demand on Ideas, Innovation, and Diversity in Economics

Awardee: University of Colorado at Boulder

Amount: \$485,862.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). researchers play a critical role in the production of new ideas, yet relatively little is

known about how the composition of researchers affects research output. this project will address this question directly and explicitly tie the evolution of ideas to demographic shifts in the representation of historically underrepresented minority (urm) groups and women in economics. as such, it connects closely with efforts to broaden participation toward greater inclusion of historically marginalized groups at universities, colleges, and professional organizations across the nation. this project will link the most comprehensive data sets on the supply of, and demand for, ph.d. economists by year and field within economics. this unprecedented coverage will enable researchers to track the evolution of ideas and innovation in economics and the role that labor supply and demand factors have played in that process. close examination of these data will lead to a better understanding of the relationship between the demographic composition of researchers and ideas, with a focus on estimating the impact of increasing **\*\*diversity\*\*** on the depth and breadth of research innovation and ideas. this project will also yield insights from the variation in the representation of women and urm groups across fields over time to provide actionable evidence on increasing **\*\*diversity\*\*** more broadly in the profession. finally, this mid-career advancement (mca) project will support moving the pi's area of expertise into the field of innovation while opening new avenues of inquiry into the link between **\*\*diversity\*\*** and innovation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Amount: \$485,862.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). researchers play a critical role in the production of new ideas, yet relatively little is



known about how the composition of researchers affects research output. this project will address this question directly and explicitly tie the evolution of ideas to demographic shifts in the representation of historically underrepresented minority (urm) groups and women in economics. as such, it connects closely with efforts to broaden participation toward greater inclusion of historically marginalized groups at universities, colleges, and professional organizations across the nation. this project will link the most comprehensive data sets on the supply of, and demand for, ph.d. economists by year and field within economics. this unprecedented coverage will enable researchers to track the evolution of ideas and innovation in economics and the role that labor supply and demand factors have played in that process. close examination of these data will lead to a better understanding of the relationship between the demographic composition of researchers and ideas, with a focus on estimating the impact of increasing **\*\*diversity\*\*** on the depth and breadth of research innovation and ideas. this project will also yield insights from the variation in the representation of women and urm groups across fields over time to provide actionable evidence on increasing **\*\*diversity\*\*** more broadly in the profession. finally, this mid-career advancement (mca) project will support moving the pi's area of expertise into the field of innovation while opening new avenues of inquiry into the link between **\*\*diversity\*\*** and innovation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CSBR: An inordinate fondness for beetles - expanding access to the Triplehorn collection of Coleoptera, phase 2

Awardee: Ohio State University

Amount: \$484,967.00

Abstract: the specimens held in natural history collections are the documentation of the world's bio**\*\*diversity\*\***, including what the species are, where they live, their life history, and their

relationships with other organisms. the specimens and the information associated with them are a timeline that records the changes in flora and fauna that have resulted from growing human populations, changing land use patterns, habitat alterations, species extinctions, and the introduction of invasive species. these specimen records are invaluable and irreplaceable, but they are also irrelevant unless they are both secure and accessible. to be secure, specimens must be protected from environmental hazards such as heat, humidity, light, and pests. accessibility encompasses equally the physical availability the materials for researchers to study through visits and loans as well as free and open access to the data associated with the specimens using information technologies. the process of photographing, copying and uploading data itself requires the ability of workers to remove and handle specimens. recording of data and quality control can be a prolonged and expensive process. however, it is also a valuable opportunity to engage with the general public in the documentation of their own biological heritage. this not only contributes to a better understanding of the inner workings of natural history collections, but how and why scientists explore the natural world. this project will provide the physical and virtual access needed to the hundreds of thousands of beetle specimens housed in the triplehorn insect collection at the ohio state university. beetles are the most species-rich group of plants or animals in the world, and they include many species that are serious pests of food and forests as well as beneficial species that keep pests at low population levels. the researchers in the collection will rehouse the specimens in new, secure cabinets, drawers and unit trays. the work will be coordinated with transcription of the data on the labels attached to each specimen. these data will then go through a quality assurance check before being stored in the collection's electronic database. this information resource is open to the general public, and its contents are automatically shared with idigbio, the national clearinghouse for bio\*\*diversity\*\* information, and the global bio\*\*diversity\*\* information facility, the worldwide counterpart. the data associated with the collection of tiger beetles will be the focus of a citizen science collaboration. the specimens and labels will be photographed and uploaded to notes from nature, and with the help of lay collaborators, the data will be transcribed and then uploaded

into the collection database. this work will then ensure the maintenance and availability of specimens and their data for future research, resources that are the results of more than a century of collecting effort. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: CAREER: Identifying the Role of Tandem Repeats in Great Ape Adaptation through Undergraduate Team Research Using a Novel Statistical Framework

Awardee: San Francisco State University

Amount: \$483,199.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). this project will substantially expand our ability to study rapid trait evolution. rapid trait

evolution results in dramatic differences between closely related species, such as chimpanzees and humans. the way genes are used (gene expression) has been implicated in such differences, but the genetic basis for altered gene expression is poorly understood. until recently, because of limits in dna sequencing techniques, a major source of genetic variation (tandem repeats) has been difficult to study. while sequencing technology has advanced so that we can produce these data, we still lack a way to analyze it. this project will create a new analysis tool and will demonstrate its use by studying great ape evolution, addressing longstanding biological problems such brain evolution. further, this project will support the professional development of undergraduate and masters student scientists, mostly persons excluded due to ethnicity, race, and gender, improving the **\*\*diversity\*\***, rigor, and relevance of science in the long term. specifically, this project will complete the following objectives: (1) create treva, a statistical tool that uses tandem repeat (tr) variation data between and within species to test evolutionary hypotheses, in particular to identify trs under balancing or directional selection; (2) apply treva to empirical data to determine how tr variation underlies adaptation in great apes; (3) identify genes impacted by trs under selection and determine the downstream biological processes and traits under selection. this project will integrate education into research using three mechanisms. (1) the research will primarily be carried out by san francisco state university (sfsu) undergraduates and master's students. (2) the project will create the computational research introductory summer program where sfsu masters students will be supported to mentor teams of novice sfsu undergraduates to learn computer science skills and apply them to original research projects. (3) students performing the research will create video abstracts describing their work, which will be used in science classes nationally to engage students with diverse scientists. this project is co-funded by the biological anthropology program in the division of behavioral and cognitive sciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Quantum Transport in Self-Assembled Hybrid Superlattices

Awardee: Florida State University

Amount: \$483,006.00

Abstract: new phenomena emerge when two semiconductors are brought together in a periodic structure. such semiconducting superlattices have properties not observed in bulk semiconductor crystals. their unique properties have led to novel devices such as tunable optical filters, infrared photodetectors, and quantum cascade lasers. superlattices are expensive to make, requiring ultrahigh vacuum and meticulous layer by layer assembly. the project aims to discover a new type of superlattice based on hybrid perovskites, materials with both organic and inorganic components. hybrid perovskites can be solution processed, allowing for spontaneous assembly into layered nanostructures. their chemical **diversity** can revolutionize superlattice research with a vastly expanded range of materials with varied properties. this research will enable future superlattice devices that are scalable and cost-effective. this project will also provide interdisciplinary training to undergraduate and graduate students, providing them with critical-thinking and problem-solving skills needed for careers in stem and industry. semiconducting superlattices are quantum heterostructures important to condensed matter physics and with applications in advanced electronic technologies. the constituents of the superlattices to date have been limited to inorganic semiconductors, such as GaAs and AlGaAs. this project will investigate quantum transport in a new class of semiconducting superlattices based on Ruddlesden-Popper halide perovskites. the project will employ theoretical and experimental studies in an iterative manner so as to accelerate materials discovery. first principle density functional theory (DFT) calculations will be used to predict materials structures and the optical and electronic properties will be modeled by combining tight-binding models with the DFT calculations. superlattice structures will be prepared by solution processing and self-assembly, allowing for facile tuning of the electronic structure by varying constituents. the design strategy, using semiconducting organic ligands, will create new possibilities for band

engineering. electrooptical measurements will be used to identify signatures of semiconducting superlattices such as electronic minibands. complementary electrical characterization will be used to search for evidence of quantum transport, using optical excitation to generate charge carriers without unintended effects arising from doping. the project will elucidate the properties of 2d perovskite superlattices, differentiate their behaviors from conventional inorganic superlattices, and determine if their optical and electronic properties can be tailored in a controllable manner. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: QUANTUM MATERIALS IN SQUARE-NET BASED COMPOUNDS

Awardee: Princeton University

Amount: \$482,515.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). non-technical summary so-called "quantum-materials" are materials that do not follow the laws of classical physics. examples are superconductors, complex magnets, or topological materials. topological materials are a class of quantum matter that show promise to enable future technologies such as new devices for data storage or quantum computing. not much is yet understood, however, about the materials chemistry of topological matter. with this career award, professor leslie schoop at princeton university aims to understand how the discipline of solid-state chemistry can impact the understanding of topological matter. towards this goal, the team will focus on a particular class of crystalline compounds: those in which atoms arrange in a square-net fashion. in these materials, electronic properties can be understood on the basis of the chemical bonds in the square lattice. understanding the nature of the chemical bonds then allows the intentional modification of these bonds and how this effects physical properties, such as electronic and magnetic properties. ultimately, prof. schoop's team will create a recipe for

discovering quantum properties in materials with square nets. this proposal also includes outreach to community colleges by providing support for students from new jersey-based community colleges to spend a summer in the schoop lab to learn more about quantum materials synthesis. the pi will visit these community colleges to give lectures targeted to a general audience to provide basic insights to the complex and exciting field of quantum materials. technical summary with this career award, professor leslie schoop at princeton university aims to establish predictive power for the development of new quantum materials based on a class of compounds with a common structural motif - a square net. in this class of materials, a topological electronic structure can be linked to the type of chemical bonding within the square net. this delocalized bonding has been classified as hypervalent and is in direct competition to a charge density wave-type lattice distortion. the aim here is to understand the effect of such distortions on the topological band structure. charge density waves in topological materials have recently gained attention because they provide a pathway for the creation of multiple new correlated topological phases that still have yet to be discovered. this project addresses the current challenges from a chemical angle. the second aim is to use the structural distortions as a tool to create materials with complex magnetism. magnetism has the potential to add electron-electron correlation to a topological material. such correlated topological materials are believed to result in the discovery of yet unknown physics, which could lead to new quantum devices. the goal will be reached by synthesizing and structurally characterizing multiple square-net materials, as well as by varying their composition. the structural data will be used to derive chemical rules for structural distortions. finally, the magnetic and electronic properties of the synthesized compounds will be investigated. the broader impacts consists of student education; a commitment to **diversity**; service to the community; and the potential for advancing technology. the pi will provide opportunities to new jersey community college students to work in her lab while reaching out to these campuses with public lectures to help underrepresented minority students understand different possible stem career paths. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the



foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Dynamics of Seasonal Forecast Uncertainty: Cross-Basin Ocean-Atmosphere Interactions

Awardee: University of California-San Diego Scripps Inst of Oceanography

Amount: \$482,252.00

Abstract: every few years the pacific ocean warms dramatically in a narrow strip along the equator extending roughly from the south american coast to the dateline. this warming is called an el nino event, and el ninos and their cold la nina opposites are referred to collectively as el nino/southern oscillation (enso) events. while enso events are broadly similar there are important differences, in particular they differ in whether the sea surface temperature (sst) change is greatest in the eastern or central pacific. they also differ in their magnitude, and el nino events are often stronger than la nina events. the consequences of enso are felt worldwide, from changes in the indian monsoon to the severity of winters in canada, and these impacts vary according to the pattern and magnitude of the event. the dynamical mechanisms that cause **\*\*diversity\*\*** in behavior among enso events and their global impacts are thus an important practical problem as well as a topic of scientific interest.

this project examines the idea that much of the **\*\*diversity\*\*** of enso events occurs because of interactions between the developing enso event and a variety of less prominent climate variability modes occurring over the global oceans. for example the pacific meridional mode (pmm) is a variability pattern in which fluctuations of the aleutian low over the north pacific generate warm ssts (or cold, in the opposite phase) which propagate slowly toward the equatorial pacific through air-sea interactions. the overlap between the domains of the pmm and enso makes the pmm a likely suspect in diversifying enso events. likewise, the episodic warming of the indian ocean in the indian ocean dipole (iod) mode affects the trade winds in the western pacific, with potential consequences for enso given the central role of trade wind fluctuations in enso evolution. to examine the effect of

secondary modes on enso **\*\*diversity\*\*** the principal investigators (pis) of this award take advantage of the ensemble method used to predict enso events. ensemble prediction means using a climate model to predict enso based on observed initial conditions (the state of the atmosphere and ocean at a given time) but performing several forecast simulations instead of one, and starting each forecast simulation with slightly different initial conditions. the resulting perturbed initial condition ensemble (pice) gives a best estimate of the evolution of enso and also estimates the uncertainty in the prediction. the idea of this project is that the individual forecast simulations in a pice contain different secondary modes, and the interactions between secondary modes and enso can be assessed by examining differences in enso evolution among the simulations. an advantage of this method is that a large database of pice simulations has been created by the earth system prediction (esp) working group of the community earth system model (cesm). the pice dataset provides a much larger sample size than the observational record, thus statistically robust results can be obtained. the work is of societal importance given its direct connection to enso prediction. in addition to its examination of enso evolution in prediction simulations the research uses the pice simulations to understand how differences among enso events lead to differences in the impacts of enso in populous parts of the world. the project also supports two graduate students and provides internship opportunities for undergraduates. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Life in Ice: Probing Microbial Englacial Activity through Time

Awardee: Montana State University

Amount: \$481,268.00

Abstract: glacial ice cores serve as a museum back in time, providing detailed records of past climatic conditions. in addition to chronological records such as temperature, chemistry and gas

composition, ice provides a unique environment for preserving microbes and other biological materials through time. these microbes provide invaluable insight into the physiological capabilities necessary for survival in the earth's cryosphere and other icy planetary bodies, yet little is known about them. this award supports fundamental research into the activity of microbes in ice, and directly supports major research priorities regarding antarctic biota identified in the 2015 national academies of sciences, engineering, and medicine report, a strategic vision for nsf investments in antarctic and southern ocean research. the broader impacts of this work are that it will be relevant to researchers across paleoclimate and biological fields. it will support two early career researchers, a graduate and an undergraduate student who will conduct laboratory analyses, participate in outreach activities, publish papers in scientific journals and present at conferences. this work will use previously collected ice cores to investigate englacial microbial activity from the holocene back to the last glacial maximum from the blue ice area of taylor glacier, antarctica. the proposal identified making significant contributions to 1) investigating how antarctic organisms evolve and adapt to changing environment, 2) understanding how microbes alter the preservation of paleorecord-relevant gas and trace element information in ice cores, and 3) identifying microbial life in cores and their activity in relation to dust depositional events. two recently developed complementary techniques (bio-orthogonal noncanonical amino acid tagging and deuterium isotope probing) in combination with raman confocal microspectroscopy will be used to assess and quantify microbial activity in ice. during phase one of the project, these methods will be optimized using deaccessioned ice cores available at the national science foundation's ice core facility. in phase two, ice cores in a time series from the taylor glacier will be analyzed for geochemistry and microbial activity. research results will provide a comprehensive view of englacial microbial communities, including their metabolic **diversity** and activity, and the effect of geochemical parameters on microbial assemblages from different climate periods. given the dearth of information available on englacial microbial communities, the results of this research will be of particular significance. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation

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Matched Words: diversity

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Title: CAS: Enhancing the Reactivity and Photoreactivity of Metal Oxide Surfaces through Fluorination

Awardee: Cornell University

Amount: \$480,000.00

Abstract: with the support of the macromolecular, supramolecular, and nanochemistry program in the division of chemistry, dr. melissa hines of cornell university will investigate the reactivity and photoreactivity of fluorinated and fluorine-doped titanium dioxide using scanning tunneling microscopy, x-ray photoelectron spectroscopy, and density functional theory. the resulting atomic-scale understanding of these surfaces is expected to contribute to the development of sustainable, non-toxic, earth-abundant nanocatalysts and photocatalysts. dr. hines and the research team are advancing discovery in nanocatalysis, sustainable chemistry, and surface science. this research is also training the next generation of scientists in a field that is important to maintaining us economic competitiveness. to increase the number and **\*\*diversity\*\*** of students entering science and technology fields, they are developing modules for middle school students that focus on quantitative measurements and scientific experiments that engage both students and faculty. this

research involves the development of chemical reactions and an ultraclean reactor to study the solution-phase chemistry and photochemistry of fluorinated titanium dioxide. this includes the determination of the primary mechanisms that lead to fluorine-functionalized titanium dioxide surfaces and the role of photogenerated charge carriers in these mechanisms, identification of new fluorination agents for preparing atomically flat fluorinated titanium dioxide surfaces, and assessment of the impact of fluorination on the photoreactivity of titanium dioxide. this research will also address the photo-fluorination of organic acids in aqueous solution. developing an atomic-scale understanding of these surfaces and their reactivity has the potential to enable the production of passivated, contamination-resistant metal oxide surfaces and high reactivity photofluorination catalysts that operate under more environmentally friendly conditions than current catalysts. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Novel Imine Formation by ATP Grasp Enzymes

Awardee: University of Florida

Amount: \$480,000.00

Abstract: with the support of the chemistry of life processes program in the division of chemistry, dr. yongsong ding will collaborate with drs. steven bruner and gustavo seabra, all from the university of florida, to study the mechanism for the formation of an imine bond (carbon connected to nitrogen by two bonds) by members of an enzyme superfamily known as atp grasp enzymes. imines are essential to a number of life processes and they are formed during many types of enzyme-catalyzed reactions. however, little is known about how enzymes in the atp grasp enzyme superfamily catalyze

imine formation. the atp grasp superfamily has about 550,000 members, some of which catalyze reactions for central biological pathways, e.g., making proteins, cell-walls, and fatty acids. using a suite of biochemical, structural and computational tools, the research team will characterize how two atp grasp enzymes promote the formation of imines for the production of complex molecules found in nature and discover new compounds and processes driven by imine-forming atp grasp enzymes. this project aims to deliver novel insights into how nature has devised novel functions in the same enzyme family and reveal how these enzymes could aid in making complex molecules for applications in biotechnology. furthermore, this project will provide opportunities for training students, particularly women and underrepresented minorities, in modern scientific techniques, thereby preparing them for advanced careers in science. through established collaborations with the center for undergraduate research, summer undergraduate research at florida, and the center for precollegiate education and training at the university of florida, this project will also engage high school and college students in the research and magnify its broader impacts through outreach activities for high school teachers. the imine is important as a key reactive intermediate species in a number of enzyme catalyzed reactions and as an emerging functional group of bioactive small molecules. atp grasp enzymes are known to form the amide, ester or thioester linkage. however, two atp grasp enzymes mysc and mysd catalyze imine formation for the biosynthesis of natural uv protectants mycosporine-like amino acids (maas), representing new chemistry for this enzyme superfamily. this project will investigate the molecular basis for fundamental deviations from the canonical reaction mechanism for atp-dependent grasp enzymes that favor imine formation here. specifically, the research team will characterize the reaction paths, substrate requirements, kinetic details, and unique structural features of mysc (objective 1) and mysd (objective 2), and explore new reaction manifolds and processes enabled by the new chemistry of atp grasp enzymes (objective 3). as such, this work will likely add to our fundamental understanding of the consequences of protein sequence variation upon protein structure and function. furthermore, the outlined studies will likely provide fresh information about the functional scope of the atp grasp enzyme superfamily in nature,



uncover hidden chemical **\*\*diversity\*\*** and biological processes, and open up longer term applications of these imine-forming enzymes in biotechnology. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Enhancing Laser Based Ion Sources with High Data Rate Techniques

Awardee: Ohio State University

Amount: \$477,683.00

Abstract: as laser technology continues to improve, it is important to investigate how laser interactions with matter can be better controlled and optimized to develop new applications. this research project will investigate two methods to enhance intense laser interactions in order to accelerate protons and ions. one method involves using a machine learning algorithm, which is a form of artificial intelligence, to control the laser system. the other method involves splitting the laser pulse into two beams and using the constructive interference to as much as double the intensity on target without requiring additional laser energy. the goal of both methods is to maximize the numbers and the energies of the protons and ions ejected from intense laser interactions. the intellectual products of this research may have a profound impact on efforts to use intense laser systems to perform proton radiography for a variety of biomedical, industrial, and defense purposes. the project will support several graduate and undergraduate students, and its members will be actively involved in several efforts to increase cultural, socioeconomic, and gender **\*\*diversity\*\*** in stem. there is great potential for intense laser systems to become a useful source of energetic ions for a variety of scientific and engineering applications, but the properties of laser accelerated protons and ions are typically far from ideal and the peak ion energy scales weakly with laser intensity. this project will address these problems by investigating two complementary techniques to enhance and control laser interactions with solid density targets. specifically, machine learning

methods will be used to control multiple experimental parameters on intense laser systems to examine how much optimization and control over the resulting proton spectrum can be achieved. the other technique involves using the constructive interference of two laser pulses to significantly increase the effective intensity and absorption of laser light. both techniques leverage high repetition rate laser systems such as the khz repetition rate extreme light intense laser system at wright patterson air force base, which will be involved in this project. particle-in-cell simulations will be performed to better understand optimal conditions for ion acceleration and to understand the physics of why the double pulse technique is so effective. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: BRITE Pivot: Machine Learning Enabled Rapid and Robust Three-Dimensional Nanomanufacturing

Awardee: Purdue University

Amount: \$475,587.00

Abstract: three-dimensional (3d) printing is one of the most important manufacturing technology developments in recent years for applications ranging from prototyping and product visualization to building functional materials and devices. nanoscale 3d printing has been used to produce a wide range of complex 3d nanostructures and nanodevices with unprecedented properties and

functionalities. however, the slow speed, variable quality and poor reproducibility of current 3d nanoprinting methods, such as point-by-point laser printing, are barriers for their adoption to commercial-scale manufacturing. machine learning (ml) and artificial intelligence (ai) are ideally suited for improving and assuring the quality of the printed structures. this boosting research ideas for transformative and equitable advances in engineering (brite) pivot award develops ai-guided, ml-enabled 3d nanoprinting methods to improve the speed, scale, print quality and robustness of the printed structures and devices. these ai and ml tools for 3d nanomanufacturing enable new applications, such as sensors and wearables, that benefit several sectors of the economy and contribute to us competitiveness and global leadership in advanced nanomanufacturing. this project contributes to **\*\*diversity\*\***, equity and inclusion by recruiting students from underrepresented groups and engaging them in research and education in ai, ml and 3d nanoprinting technologies, thus developing a diverse workforce in advanced manufacturing. the pi has extensive experience and expertise in laser-based nanomanufacturing and device manufacture. recent efforts by the principal investigator (pi)'s group have resulted in the development of a rapid, continuous, layer-by-layer 3d nanoprinting technology. this project allows the pi to acquire new expertise in ml and ai methods through in-depth investigations and applications of these methods to develop rapid and robust 3d nanoprinting technologies. this includes studies and evaluations of various ml and ai methods and selection and implementation of appropriate methods for rapid 3d nanoprinting. the research involves developing methods that combine physics-based models with advanced ml algorithms such as adaptive learning and transfer learning. the femtosecond laser-based 3d nanoprinting process involves understanding the fundamentals of controlling the laser beam characteristics, such as beam size and scan rate, its propagation in the optical system and the laser-induced reactions in the photopolymers. the physics-based models and laser photo-polymerization experiments provide key data and guidance for the development of ml and ai analytic tools for process control and optimization. furthermore, the project studies approaches to develop ml and ai tools using a relatively small amount of experimental data. using results of various printed structures, ml and ai

algorithms are developed to guide the process of printing arbitrary, user-defined structures with high precision. this project advances knowledge in ai-guided, ml-enabled femtosecond laser-based photo-polymerization as a platform for rapid and robust 3d nanomanufacturing. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: BRITE Pivot: Machine Learning Enabled Rapid and Robust Three-Dimensional Nanomanufacturing

Awardee: Purdue University

Amount: \$475,587.00

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Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: North Dakota State University Fargo

Amount: \$475,342.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a

highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Harnessing the Reactivity of Acceptor-Acceptor Diazo-Derived Metal Carbenes

Awardee: Georgia Tech Research Corporation

Amount: \$475,000.00

Abstract: with the support of the chemical synthesis program in the division of chemistry, stefan france of georgia tech is studying the properties of an important class of synthetic building blocks called acceptor-acceptor carbenes to determine how to tune their reactivity to achieve predictable and controllable new bond connections for the synthesis of value-added compounds. while other types of carbenes with greater electron-density and stability have been carefully studied with a variety of catalysts to support many elegant syntheses, acceptor-acceptor carbenes have lagged behind. dr. france and his research team are using a combined experimental and computational approach to address this limitation by compiling fundamental data to understand how to control and predict the reactivity of acceptor-acceptor carbenes in synthetic processes. different catalysts are also being investigated to achieve different reactivity patterns from the same carbene building blocks. these studies are helping to improve the synthesis and preparation of fine chemicals and pharmaceuticals by examining a long-standing problem in this area of synthetic chemistry. simultaneously, these activities are providing interdisciplinary training for a diverse group of graduate and undergraduate students at georgia tech and clark atlanta university (an hbcu) through a computational collaboration with dr. seyhan salman. dr. france is also participating in a program to assist graduate students with professional development and is committed to addressing **\*\*diversity\*\*** issues through participation in a variety of campus initiatives to improve recruiting and hiring, as well as student retention. acceptor-acceptor metal carbenes have been underutilized in intermolecular c-h functionalization chemistry due to a lack of understanding of their reactivity and stability properties. stefan france and his research group at georgia tech are combining experimental approaches, and collaborative computational efforts in collaboration with seyhan salman at clark atlanta university, to understand, parametrize, and predict substrate- and catalyst-control for acceptor-acceptor carbene  $c(sp^3)$ -h insertion. in addition, dr. france and his research team are



exploring new divergent reactivity patterns of acceptor-acceptor carbenes. this project will serve as a launching pad into new chemical space and for developing enabling technologies to improve access to desirable target molecules. these activities also will provide training to both graduate and undergraduate students on the interplay between computational and experimental organic chemistry of relevance to catalytic organometallic synthesis. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: A comparative study of the impact of displacement on multilingualism and language endangerment

Awardee: SUNY at Buffalo

Amount: \$474,457.00

Abstract: communities all over the world are frequently impacted by displacement due to events such as natural disasters or political conflict, and displaced people often experience significant changes to their linguistic environment when the areas that they move to are dominated by different languages than those spoken in the regions that they come from. for instance, members of a rural

community speaking an endangered language who move to an urban area after a natural disaster may shift from an environment where most people they meet during the course of a day speak their first language to one where only their close friends and family members do. similarly, refugees fleeing their homes may find themselves in camps occupied by people from many different areas who do not, at least initially, share a common language. moreover, displacement may change more than just the primary language that an individual uses in their day-to-day lives. in many parts of the world, users of languages associated with small communities are multilingual and actively use three or more languages. when they move, they may learn a new language but also stop using other languages that they know, including endangered languages. the impact of displacement on multilingualism and endangerment has yet to be systematically investigated, even though increased knowledge in this domain would help refine policies intended to support minority language maintenance and to improve the conditions of displaced people. this project studies three communities with demonstrated linguistic \*\*diversity\*\* that have experienced recent displacement in different ways. one community is currently experiencing displacement due to active political conflict, and another experienced displacement due to conflict that was resolved decades ago. the third community is a refugee camp housing displaced individuals from a linguistically diverse neighboring region. by studying language use across these three communities, the investigators are able to conduct a comparative analysis of how displacement impacts language vitality in multilingual contexts. the investigators use a range of qualitative and quantitative methods to collect data, including ethnographic observation, sociolinguistic interviews, and language proficiency assessment tasks. documentary records of language use among displaced people will also be created. the project is innovative in that it emphasizes understanding the social dynamics that promote language vitality rather than focusing on endangerment primarily as an outcome of global trends. this project also strengthens connections between linguistics, political science, and other disciplines studying peace and conflict. the project's outcomes can inform the study of societal resilience in the face of adversity. its results also have the potential to inform government policies seeking to promote the

use of minority languages by giving policy makers a clearer perspective of the factors that contribute to speakers continuing to use those languages. results also have the potential to lead to actionable recommendations for organizations that work with displaced people. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: IntBIO COLLABORATIVE RESEARCH: Deep Time, Development, and Design: Evolution of shark skin teeth from genotype to phenotype to prototype.

Awardee: Yale University

Amount: \$474,066.00

Abstract: the skin of sharks is unique among vertebrate animals because it contains tooth-like scales, called dermal denticles, that create a hard external armor. these tooth-like denticles evolved over millions of years and equip the shark with hydrodynamic skin that reduces the cost of moving through the water. this advanced streamlining is currently a subject of great interest, with many industries attempting to take advantage of shark skin technology to create more efficient swimming designs. this project aims to provide a complete integrated understanding of shark denticles: how they form in embryonic sharks, how denticle shape has changed over years of evolution, and which denticle types are the best for drag-reduction and further design advances. this knowledge will enable better use of shark skin technology to make advanced design solutions that help to make a better and more environmentally friendly world. for example, one possible use of shark skin technology is the development of surface structures on airplanes or boats to reduce drag during movement and decrease fuel emissions. in addition to its scientific impact, this project has impact on the stem workforce by supporting principal investigators and trainees across a wide range of career stages and by providing a unique, much-needed accessible research training program for undergraduates with disabilities in interdisciplinary research. the shape and pattern of shark skin

teeth, or denticles, has been refined over millions of years of evolution for functional improvements in aquatic locomotion. this project addresses the evolutionary and developmental trajectories that have led to a vast **\*\*diversity\*\*** of shark skin denticle types with the goals of determining why sharks have different shaped denticles among and within species and what functional advantages these different denticle shapes might offer these animals. from an integrated developmental, genetic, and evolutionary framework, the project will investigate how denticles develop and what factors lead to changes in shape. the approach will include studies of embryonic denticle development from the level of single cell transcriptomics to phenotypes and function to learn what key genes are essential to the production of various denticle shapes in a range of shark species and how these shapes are achieved via developmental innovation. goals include understanding what shapes are most efficient for drag-reduction in both modern and extinct species to enable modeling and testing of new engineering designs to reduce drag in air- and water-borne vehicles and devices. combining 3d printing with engineering methods, new shark-inspired surface structures will be used to create a shift in design solutions for a changing and more environmentally friendly world. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: Strategic Course-based Adaptations of an Ecological Belonging Intervention to Broaden Participation in Engineering at Scale

Awardee: Purdue University

Amount: \$471,103.00

Abstract: this project aims to serve the national interest by increasing the number and **\*\*diversity\*\*** of engineers produced in the united states. while science overall has made great progress in increasing the participation of women, engineering has made no overall progress in the last 20 years, with women continuing to earn only 20% of engineering bachelor?s degrees each year. improving retention in the first two years of engineering programs is important in addressing ongoing attrition. in particular, engineering will become more inclusive when the concerns that many students have about feeling alone in thinking they are incapable of mastering the course?s content are addressed. here, short interventions will be implemented that reveal to students that most of the students in their class have these same concerns, that previous students just like them with similar concerns have successfully completed this coursework, and that their instructor believes they are capable of succeeding. prior research by the project team using the intervention in first-year courses has shown that these interventions can entirely eliminate course retention differences by gender as well as by race/ethnicity. a new method for customizing this intervention will be developed, tested, and further improved so that it can have similar strong benefits in many different courses and many different universities. simple interventions that can be easily and scientifically customized to many contexts may have potential for significantly improving engineering outcomes across the united states. this project uses an ecological-belonging intervention approach that only requires a one-class or one-recitation session to implement and has been shown to erase long-standing achievement gaps by gender and race/ethnicity in several introductory stem courses. however, while

simple, the intervention cannot involve a fixed script for different university and course contexts. rather, the content of the intervention needs to be customized to the local context in order to address the specific concerns students have in that specific context. this project brings a highly interdisciplinary team across three strategically-selected universities with the goal of developing an approach to identify which 1st and 2nd year courses need this intervention, reveal student concerns in that course, adapt the intervention to address those concerns, and address other pragmatic constraints of how that course is taught. this systematic approach also includes processes for onboarding all the instructors of the given course. in answering a set of seven core research questions, the project intends to expand knowledge about 1) where (on which outcome variables), when (in which contexts, for which students), and why the ecological belonging intervention has positive effects, and 2) the extent to which this intervention on its own has measurable impacts on the overall problem of representation in the larger challenge of representation within the large engineering pathways that have struggled with representation. this kind of foundational knowledge is critical to making decisions about when to apply the intervention as well as providing important insights into how to apply the intervention. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: WoU-MMA: Galactic Gamma-Ray Astrophysics with HAWC (UW-Madison Group Grant)

Awardee: University of Wisconsin-Madison

Amount: \$470,557.00

Abstract: the high-altitude water cherenkov observatory (hawc) is located at 4100 m above sea level near puebla, mexico. the detector has monitored the gamma-ray and cosmic-ray sky in the energy range from 100 gigaelectronvolts (gev) to 100 teraelectronvolts (tev) with a nearly 100% duty cycle



and a sensitivity unprecedented for a survey instrument, offering an exceptional view into the cosmos. this award provides funding for the uw?madison hawc group to research scientific areas in which hawc can make unique contributions: a search for tev halos surrounding middle-aged pulsars identified by radio and gev gamma-ray observations and a search for microquasars. the key questions motivating these studies include: are tev halos a universal feature of middle-aged pulsars? what drives the formation of tev halos? how do microquasars produce high-energy emissions? can they emit other high-energy messengers such as neutrinos? the hawc group is in the wisconsin icecube particle astrophysics center (wipac), a scientific center at uw-madison with researchers involved in a range of particle astrophysics projects, including the icecube observatory, the askaryan radio array, the hawc experiment, and the cherenkov telescope array. the pi will join the vibrant education and outreach activities of the center and contribute to educating and training future leaders in the field of particle astrophysics. she will lead an effort to support women and gender minorities at the center. along with other colleagues, she will initiate monthly or bi-monthly social events to gather up female and gender minority (such as people who are transgender or nonbinary) students, postdocs, and researchers at wipac. these **\*\*diversity\*\*** meetings will also be open and will facilitate interactions between the local undergraduates, graduate students, and researchers working in particle astrophysics. the study of tev halos and microquasars is closely related to the understanding of high-energy neutrinos. a population of tev?pev neutrinos with astrophysical origin has been observed by the icecube observatory since 2013. the origin of the bulk of the icecube neutrinos remains a mystery. recent multi-messenger follow-up observations provide hints toward the first neutrino sources, including the blazar txs 0506+056 and the vhe gamma-ray emitting region surrounding the pulsar psr j1907.9+0602, mgro j1908+06. with an overlapping energy window, hawc?s observation of these two types of sources will provide important information for neutrino studies. the gamma-ray analyses will be combined with the study of high-energy neutrinos. microquasars are also candidate neutrino sources. the pi will work with the icecube group on the multi-messenger study of the vhe gamma-ray sources, and in particular, to explore the

possibility of a joint analysis of hawc and icecube observations of the potential sources. as a first attempt, they will use the hawc spectra to derive the number of expected neutrinos from each source, assuming that protons produce the gamma-ray emission. the results will be compared with the icecube observation of these sources to understand the role of microquasars as high-energy neutrino emitters. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Frameworks: Convergence of Bayesian inverse methods and scientific machine learning in Earth system models through universal differentiable programming

Awardee: Dartmouth College

Amount: \$461,611.00

Abstract: understanding and quantifying parameter sensitivity of simulated systems, such as the numerical models of physical systems and mathematical renderings of neural networks, are essential in simulation-based science (sbs) and scientific machine learning (sciml). they are the key ingredients in bayesian inference and neural network training. seizing on the opportunity of emerging open-source earth system model development in the julia high-level programming language, this project is endowing these open-source models with automatic differentiation (ad) enabled derivative information, making these converging data science and simulation-based science tools available to a much broader research and data science community. enabling a general-purpose ad framework which can handle both large-scale earth system models as well as sciml algorithms, such as physics-informed neural networks or neural differential equations, will enable seamless integration of these approaches for hybrid bayesian inversion and bayesian machine learning. it merges big data science, in which available data enable model discovery with sparse data science, and the model structure is exploited in the selection of surrogate models

representing data-informed subspaces and fulfilling conservation laws. the emerging julia language engages a new generation of researchers and software engineers, channeling much needed talent into computational science approaches to climate modeling. through dedicated community outreach programs (e.g., hackathons, minisymposia, tutorials) the project team will be working toward increasing equity, **\*\*diversity\*\***, and inclusion across the participating disciplines. the project is developing a framework for universal differentiable programming and open-source, general-purpose ad that unifies these algorithmic frameworks within julia programming language. the general-purpose ad framework in julia leverages the composability of julia software packages and the differentiable programming approach that underlies many of the sciml and high-performance scientific computing packages. compared to most current modeling systems targeted for hpc, julia is ideally suited for heterogeneous parallel computing hardware (e.g., cuda, rocm, oneapi, arm, powerpc, x86 64, tpus). the project is bringing together expertise in ad targeted at earth system data assimilation in high performance computing environments with sciml expertise. the project team is working with the julia computing organization and package developers to ensure sustainability of the developed frameworks. the project's earth system flagship applications consist of (i) an open-source, ad-enabled ocean general circulation model that is being developed separately as part of the climate modelling alliance (clima), and (2) an open-source, ad-enabled ice flow model. each of these application frameworks is being made available to the community for science application, in which derivative (gradient or hessian) information represent key algorithmic enabling tools. these include sciml-based training of surrogate models (data-driven and/or model-informed), parameter and state estimation, data assimilation for model initialization, uncertainty quantification (hessian-based and gradient-informed mcmc) and quantitative observing system design. academic and industry partners are involved, who are using the frameworks for developing efficient power grids, personalized precision pharmacometrics, and improved eeg design. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Collaborative Research: Frameworks: Convergence of Bayesian inverse methods and scientific machine learning in Earth system models through universal differentiable programming

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Title: Collaborative Research: Ecological legacy effects of megacarcasses in African savanna ecosystems

Awardee: Marquette University

Amount: \$460,049.00

Abstract: large animals such as elephants and rhinoceros, called "megafauna" for their extreme

size, have outsized impacts on the ecosystems they live in. they engineer their environments by knocking down trees and grazing grasses to create large lawns, helping to form habitats that facilitate other animals. but, there is little research that addresses the impact that the carcasses of these megafauna, or "megacarcasses", have on ecosystems after they die. their carcasses represent huge sources of nutrients that have a long-lasting ecological legacy on the areas of ecosystems where their carcasses occur. for example, african elephants are the largest land animals, but almost nothing is known about how the nutrients from their massive carcasses (up to 6,000 kg) affect savanna ecosystems. this award asks the main question: how do elephant megacarcasses affect the ecology of african savannas? the work will address how these megacarcasses affect nutrient cycling in the soil by microbes, plant primary production and species **diversity**, and herbivory by vertebrate herbivores, such as zebra and giraffe, and invertebrate herbivores, such as grasshoppers. this research will support the mentoring of 1 postdoctoral scholar, graduate and undergraduate students in ecology as well as science communication and outreach. the main broader impact will be the production of a scientific documentary, the legacy of megaherbivores, which will follow the life and death of an elephant in the african savanna, that will put the life cycle of these elephants into broader ecological context, understanding how they impact ecosystems and the current implications for ecosystems facing their disappearance. to address the overarching question, the award will use elephant carcasses of different ages (up to 15+ years old) in kruger national park (knp), south africa. combining soil (physical, chemical and biological properties), plant (productivity and **diversity**), and herbivore (vertebrate and invertebrate) surveys at 50 megacarcass sites along with greenhouse experiments, the award will assess how nutrient pulses from elephant carcasses drive integrated responses of ecosystem processes. importantly, the elephant megacarcasses are distributed across gradients of rainfall (375-700 mm) and soil fertility (less-fertile sandy, granitic soils vs. more-fertile clayey, basaltic soils) in knp. these gradients of rainfall and soil nutrients provide a robust experimental framework for testing how the abiotic environment impacts the ecosystem-level legacy effects of terrestrial

megacarcasses. finally, by combining the data from the field on the effects of megacarcasses on ecosystem processes with a database of elephant population across knp, the researchers will use ecological modeling to show how the distribution of megacarcasses generates variability in ecosystem processes across the savanna landscape as elephants naturally die over time. this study will represent the first examination of the ecological legacies of megacarcasses on terrestrial ecosystems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Precision Tests of Fundamental Physics via Light Pseudoscalar Mesons

Awardee: University of North Carolina at Wilmington

Amount: \$459,754.00

Abstract: understanding how quarks and gluons confine themselves into the neutrons and protons that make the elements, and searching for new physics beyond the standard model (sm) of particle physics are two frontiers in physics. the primary goal of this project is to perform two cutting-edge experiments, primex-eta and jlab eta factory (jef), at jefferson lab to explore both fundamental topics with sensitivities not previously achievable. these measurements will shed light on some fundamental questions: what is the origin and dynamics of quantum chromo dynamic confinement? what is the nature of dark matter that constitutes 85% of matter and what is the cause for the asymmetry of matter and antimatter observed in the universe? the scope of this project, including hardware development, performance of the actual experiment and data analysis, will provide advanced training for a postdoctoral researcher and a group of undergraduate students. students will acquire significant skills in hands-on experimental techniques, data analysis and computation, as well as critical thinking and problem-solving abilities to fulfill the undergraduate curricula and prepare them for careers in stem fields. the opportunities for young researchers (postdoc and students) working at jefferson lab will enhance their experience and global perspectives. the female pi of this

project serves as a role model and promotes **diversity** and inclusion in the stem fields. the primex-eta experiment will measure the  $\eta$  radiative decay width at  $\sim 3\%$  precision via the primakoff effect, using the existing gluex apparatus with a new calorimeter consisting of  $12 \times 12$  array of pbwo4 crystals. it will resolve a longstanding discrepancy ( $\sim 3\%$ ) between the previous experimental results using the primakoff effect and  $e^+e^-$  collisions, and will offer accurate determinations of the light quark-mass ratio and the  $\eta$ - $\eta'$  mixing angle. the jef experiment will measure various  $\eta$  and  $\eta'$  decays with emphasis on rare modes, producing a clean dataset with background suppression of a factor of two orders of magnitude compared to all previous experiments. in addition to the baseline gluex apparatus, the jef experiment will require an upgraded forward calorimeter (fcal-ii) with a high-granularity, high-resolution pbwo4 crystal core in the central region that minimizes shower overlaps and optimizes the resolutions of energy and position. the data collected from the jef experiment will provide sensitive probes to: (a) explore the role of scalar meson dynamics in chiral perturbation theory for the first time; (b) tighten the uncertainty in the light quark mass ratio by the  $\eta \rightarrow \pi\pi$  dalitz distributions; (c) search for various sub-gev dark gauge boson candidates (including vectors, scalars and axion-like particles) by improving the existing bounds by more than two orders of magnitude and is complementary to the ongoing worldwide efforts at high-energy collider and underground facilities; and (d) provide the best direct constraints for c-violating, p-conserving new forces. as an experiment spokesperson, the pi will play a leadership role in both primex-eta and jef. the pi and her team will: (1) analyze the data collected in the phase i run of primex-eta, prepare and perform the phase ii run in fall 2021; (2) develop an upgraded fcal-ii and prepare the jef experiment for the anticipated run in 2024; (3) continue the service responsibility for maintaining and operating the low-granularity pair spectrometer detectors to control the photon flux in hall d. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Leveraging the Power of Reflection and Visual Representation in Middle-Schoolers' Learning During and After an Informal Science Experience

Awardee: Northwestern University

Amount: \$458,419.00

Abstract: this project addresses a longstanding problem in informal science education: how to increase the likelihood of consequential science, technology, engineering, and mathematics (stem) learning from short duration experiences such as field trips. although informal learning experiences can greatly contribute to interest in and knowledge of science, there is a shared concern among educators and researchers that students may have difficulty recalling and using scientific information

and practices emphasized during these experiences, even though doing so would further their science learning. nonetheless, science learning is rarely, if ever, a "one-shot deal." children acquire knowledge about science cumulatively across different contexts and activities. therefore, it is important that informal science learning institutions identify effective practices that support the consolidation of learning and memory from exhibit experiences to foster portable, usable knowledge across contexts, such as from informal science learning institutions, to classrooms, and homes. to this end, this research in service to practice project seeks to harness the power and potential of visual representations (e.g., graphs, drawings, charts, maps, etc.) for enhancing learning and encouraging effective reflection during and after science learning experiences. the project promises to increase learning for the 9,000+ 5th and 6th grade students from across the rurality and growing **\*\*diversity\*\*** of the state of maine who annually participate in labventure, a 2.5-hour exploration of the gulf of maine ecosystem at gulf of maine research institute. the research will provide new and actionable informal science learning practices that promote engagement with visual representations and reflection, and science understandings that can be applied broadly by informal science institutions. this project is funded by the advancing informal stem learning (aisl) and the discovery research prek-12 (drk-12) programs. it supports the aisl program goals to advance new approaches to, and evidence-based understanding of, the design and development of stem learning in informal environments. it supports the drk-12 program goal of enhancing the learning and teaching of stem by prek-12 students and teachers. the project is grounded in the idea that visual representations, including drawings, can both enhance science learning and encourage reflection on doing science that can support extension of that learning beyond a singular informal science experience. the project uses design-based research to address the following research questions: (1) does reflection during an informal science learning experience promote students? retention and subsequent use of science information and practices that are part of the experience? (2) does interpreting and constructing visual representations, such as drawings, improve students? understanding and retention of information, and if so, how and when? and (3) does combining visual representations

and narrative reflections confer benefits on students? science learning and engagement in science practices both during the informal learning experience, and later in their classrooms and at home? these questions will be pursued in collaboration with practitioners (both informal educators and classroom teachers) and a diverse team of graduate and undergraduate student researchers. approximately 600 student groups (roughly 3000 individual students) will be observed during the labventure experience, with further data collection involving a portion of these students at school and at home. the project will yield resources and video demonstrations of field-tested, empirically based practices that promote engagement with visual representations and reflection, and science understandings that can travel within students' learning ecosystem. in support of broadening participation, the undergraduate/graduate student researchers will gain wide understanding and experience connecting research to practice and communicating science to academic and nonacademic audiences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: Did small, non-fossilizing plankton dominate primary productivity and shape the recovery of calcareous plankton after the end Cretaceous mass extinction?

Awardee: University of Colorado at Boulder

Amount: \$458,264.00

Abstract: phytoplankton, which live in the surface ocean, produce organic matter from sunlight and carbon dioxide. this primary production forms the base of most marine food webs and is a critical part of the global carbon cycle. in the modern ocean plankton are being impacted by warming and ocean acidification. natural changes in ocean temperature and chemistry in the geologic past can help us understand the long-term effects of stressors such as warming and acidification. the cretaceous-paleogene (k-pg) mass extinction event ~66 million years ago was one such time of global change. calcareous (fossil-forming) nanoplankton were one of the dominant primary

producers in the cretaceous ocean. however, 93% of species of this group went extinct at the k-pg boundary, and they were never again as dominant. previous studies of the plankton response to the k-pg event have generally been limited to studies of species which leave a physical fossil record. thus, these studies provided only a partial view of ancient plankton ecosystems. the proposed work will overcome this limitation by using chemical fossils called biomarkers. these new data will be used together with traditional physical fossils to reconstruct changes in the marine plankton community following the k-pg event. it has often been assumed that non-fossilizing phytoplankton filled the gap left by the decline in calcareous nannoplankton. this study will help test that hypothesis. documenting the changes in both non-fossilizing and fossilizing plankton will improve our understanding of long-term changes in plankton ecology, and of how those changes could alter the ocean carbon cycle. this project will train early career researchers and undergraduate students, and will disseminate results to broader audiences through outreach and educational activities in partnership with organizations and programs in austin, tx and boulder, co. the project will develop datasets of lipid biomarkers, calcareous nannoplankton, and planktic foraminifera from 5 sites in tunisia, spain, and the us gulf coast. three sites in tunisia (el kef, elles, and el melah) represent a depth transect on a continental shelf (paleodepths of 200-500 m), caravaca represents deeper water (~600-1000 m), while brazos represent a shallow shelf which will allow us to test regional variability between north africa and the us gulf coastal plain. these data will allow tests of the following hypotheses: 1. a low-**diversity** assemblage of non-fossilizing phytoplankton bloomed in the aftermath of the k-pg extinction, during the time of low **diversity** calcareous nannoplankton ?disaster? assemblages. 2. subsequent recovery of calcareous nannoplankton **diversity** is associated with a decline in non-fossilizing phytoplankton. 3. shifts in the heterotrophic planktic foraminifera assemblages are tied to turnover in the whole autotrophic plankton assemblage. 4. the post-extinction community of primary producers was dominated by smaller phytoplankton like algae and cyanobacteria, and would have increased carbon recycling in shallow waters and reduced carbon export to the deep sea. the study will improve our understanding of the recovery after the

end cretaceous mass extinction and in our overall understanding of the role of plankton ecology in marine ecosystem change. additionally, reconstructing the whole plankton ecosystem, and not just the part that fossilizes, would represent a significant improvement of our toolkit to investigate ancient oceans. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: The Simpson Neutron Monitor Network

Awardee: University of Wisconsin-River Falls

Amount: \$453,164.00

Abstract: this three-year collaborative project is focused on building of a network of ground-based cosmic-ray monitors, called neutron monitors (nms), operated by a consortium of three u.s. academic institutions, namely universities of new hampshire, delaware and wisconsin-river falls. invented by prof. john simpson in 1948, following his experience on the manhattan project, nms have been used to detect and measure radiation in space, starting almost ten years before the space age. they are stationed on the ground all over the globe, providing continuous measurements of cosmic radiation for over a half century. nms measure the trends and changes in the radiation levels in space, which is critical information for travel by astronauts to the moon and mars. they can also detect intense, short-term bursts of radiation from the sun that reach the ground. all this activity is driven entirely by what the sun is doing. nms are robust and reliable and have assumed a new importance in recent years when used in conjunction with the international fleet of spacecraft and with neutron monitors in other countries. now, all the nms sponsored by the u.s. are being linked into what will be the simpson neutron monitor network, which will make it more efficient to coordinate operations and science. during this three-year collaborative project, the consortium will carry out this research, teasing new information out of these heritage instruments and providing researchers around the world with up-to-date radiation climate data. cosmic rays entering the earth's



atmosphere are messengers informing us about large-scale heliosphere structure, local space environment and solar activity. they have already passed through and interacted with the interplanetary magnetic field, and they carry information of its detailed structure. some of these cosmic rays possess enough energy to reach the ground. a nm is a ground-based particle detector that records the nucleonic component in particle showers. this directly correlates with the number of high energy cosmic rays striking the earth's atmosphere. the analysis of these data is used to build an understanding of the sun's influence on the solar system. because of the large detector volume exploited by ground-based stations, neutron monitors remain the state-of-the-art instrumentation for measuring rigidity  $>1\text{gv}$  cosmic rays. the programmatic linking of these instruments run by the universities of new hampshire, delaware and wisconsin-river falls will secure a continuity of quality data for the global community, as called out in the national space weather plan and congressional legislation. the data from these instruments are used by many, including, space weather predictors, industry, space scientists, homeland security and hydrologists. the nm stations span a wide range of latitudes, from the south pole to the arctic regions. the contributors to the nm signal include cosmic rays from the galaxy that are heavily modulated by solar activity and from the sun itself in the form of high energy bursts of protons. the variability of these agents reveals conditions in interplanetary space, general solar activity and the fundamental processes that produce cosmic rays throughout the universe. with today's computing resources, we better understand how these instruments detect radiation, and the consortium will thus be able to extract new information from these workhorse devices. this will shed new light on how the distribution of cosmic rays varies with time, geography and particle energy. the consortium will study how to permanently secure the operations of the monitor network and intelligent ways of expanding the network to complement those at existing sites. the education and outreach goals of the project include a research position for a postdoc, a wide variety of opportunities and experiences for undergraduates, as well as opportunities for high school and elementary school students. the research and epo agenda of this collaborative project supports the strategic goals of the ags division in discovery, learning,

**\*\*diversity\*\***, and interdisciplinary research. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Exploring the interplay between form and function: the force-velocity trade-off in the spider predatory strike.

Awardee: Smithsonian Institution

Amount: \$453,107.00

Abstract: spiders are important predators of insects and other small animals, and the group has nearly 50,000 described species. they are one of the most diverse and numerous groups of animals and occupy a wide variety of habitats; spiders also play an essential role in controlling pest populations. while great advances have been made in understanding how spiders use silk and venom to capture prey, very little is known about the main feeding structures of spiders, the chelicerae. these in some respects function like jaws of vertebrates since they are used to grasp and process prey. this research focuses on how the chelicerae are used during the predatory strike, when the spider grasps the prey and injects it with venom, and how the shape, speed and strength of chelicerae vary in different groups of spiders. the researchers will compare the anatomy and movements of chelicerae in a wide variety of spiders to better understand the evolution of feeding in the group. this work will also examine details of the super-fast predatory strike, found in certain types of spiders, and determine how it evolved. in addition to revealing the function and evolution of spider chelicerae, the project introduces spider biology to the next generation of scientists, with outreach to several groups ranging from high-school students to postdoctoral scholars. results from this research will also be used to engage and educate the public, including school-aged children, through hands-on lessons that will be displayed at the national museum of natural history and used in a summer day camp at the university of maryland. this research focuses on the comparative

functional morphology of spider chelicerae, and tests the hypothesis that a fundamental biomechanical principle, the force-velocity trade-off, explains the diversification of their morphology and predatory strike dynamics. it is widely assumed that lever-based skeletomuscular systems are optimized to produce either high forces or high velocities, but not both simultaneously. predictions of the force-velocity hypothesis will be tested using a broad sample of species from across the spider tree of life, including the "trap-jaw" spiders, some of which have predatory strikes that are the fastest movements known among arachnids. structural details of the exoskeleton and musculature will be quantified through analysis of computed tomography scans and histological sections, and functional performance variables such as strike velocity will be measured through analysis of high-speed videos. a molecular phylogeny will be generated and used to provide the historical framework for examining the evolution of morphology and strike performance. phylogenetically-informed statistical analyses will be used to determine whether the correlations between form and function anticipated by the force-velocity trade-off are consistent with the biomechanical "diversity" observed in spiders. the results will offer insights into the evolution of form and function in skeletomuscular systems and provide a rich source of new information on spider biology. this award is co-funded by two programs in the directorate for biological sciences, the systematics and bio"diversity" science program in the division of environmental biology, and the physiological mechanisms and biomechanics program in the division of integrative organismal systems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: GP-IN: CUSP: Connecting Underserved Students to Polar STEM

Awardee: University of Maine

Amount: \$452,008.00

Abstract: recent changes in the polar regions such as atmospheric warming, permafrost thaw, sea

ice decline, and glacier retreat, are having global impacts. understanding these polar changes and predicting their future global impacts require a wide range of future science, technology, engineering, and mathematics (stem) professionals. unfortunately, less than 25% of high school students in the united states receive earth systems science training and polar studies represents a very small component of what is taught. additionally, the majority of earth systems societal challenges disproportionately impact low income and underrepresented populations, yet there is a significant deficiency in the number of underrepresented students receiving training within these fields. in fact, most earth systems science programs lack gender, ethnic, and economic **\*\*diversity\*\***. effective environmental solutions require communication between scientists, policy-makers, and the public, and must also support all communities, in particular, those most at risk. the project aims to help remedy gaps in polar stem education by developing new opportunities for underrepresented high school students to engage in real polar stem education in the classroom and via field experiences. additionally, the project aims to train teachers in high schools to integrate polar stem experiences in their classrooms to increase polar stem literacy within the united states. the researchers specifically propose to help fill the gaps in polar earth systems science education within the united states by developing a collaborative consortium of education programs including the university of maine, juneau icefield research program (jirp), and several department of education funded upward bound programs across the united states to offer 1) new project-based field opportunities in polar stem for high school students from low income or first generation college families, 2) teacher training in polar earth systems sciences 3) help to teachers developing high school lessons using authentic polar stem data, and 4) research focused on determining if our field and classroom education program improves teaching and high-school student learning about polar environments. this project will specifically support justice, equity, **\*\*diversity\*\***, and inclusion, of underrepresented students within the polar geosciences and help develop a more diverse and representative next generation of science leaders in more communities across the united states. this award reflects nsf's statutory mission and has been deemed worthy of support through

evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Noble-Metal Nanocrystals in Metastable Phases

Awardee: Georgia Tech Research Corporation

Amount: \$450,000.00

Abstract: with funding from the macromolecular, supramolecular & nanochemistry program of the chemistry division, dr. younan xia of the georgia institute of technology and dr. manos mavrikakis of the university of wisconsin-madison will conduct fundamental research toward controlling the spatial arrangement (i.e. the crystal phase or structure) of atoms in nanocrystals. such control could provide a versatile means of tailoring the electronic structure and catalytic properties of metal nanocrystals, opening the door to the development of advanced catalytic materials key to energy conversion and key for the production of important chemicals and pharmaceuticals. an important goal is to enable cost-effective and sustainable use of precious metals, some of the scarcest elements in the earth's crust. the multi-disciplinary and collaborative nature of this project offers a natural vehicle to enrich the education and training experiences of all participants. the results from this project will be adapted to enhance classroom teaching, including the development of demonstrations (animations and experiments) related to key concepts in chemistry and chemical engineering. the investigators will promote **\*\*diversity\*\*** in higher education by engaging women, member of underserved groups in this research project. specifically, dr. younan xia and dr. manos mavrikakis are developing colloidal methods for the synthesis of metal (e.g., ruthenium) nanocrystals in non-conventional, metastable crystal phases, together with well-controlled shapes or surface structures. these nanocrystals may open up avenues for observing new phenomena, enhancing existing processes, and enabling innovative applications. currently, there are only a very limited number of reports on the synthesis of metal nanocrystals in metastable phases owing to the lack of a mechanistic understanding. through an integration of experimental studies and computational modeling, the

investigators seek to elucidate the trends and mechanisms involved in the synthesis, striving to establish experimental conditions for the reliable production of a specific crystal phase. the ruthenium nanocrystals will be used as seeds to template the deposition of other noble metals for the facile synthesis of core-shell nanocrystals featuring new, metastable crystal structures. in the context of structure-property relationships, the investigators will evaluate the catalytic activities of the metastable nanocrystals toward the oxygen evolution and oxygen reduction reactions. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Linking Matrix Composition with Spatially Resolved Mechanical Properties in Polymicrobial Biofilms

Awardee: Northwestern University

Amount: \$450,000.00

Abstract: this award will support research to understand the mechanistic underpinnings of biofilm mechanical and physical properties. biofilms are soft multi-component biological materials. they are made of microbial communities attached to surfaces and encased in polymeric substances. it is thought that these polymeric substances provide mechanical stability. detrimental biofilms cause billions of dollars per year of damage via biofouling or corrosion of ship hulls, heat exchangers,

water treatment and distribution infrastructure, membranes, and in the food, oil, and beverage industries. In addition, they account for 65% of infections that originate in hospitals, affecting 17 million people and causing at least 550,000 deaths annually in the US. Conversely, beneficial biofilms can clean water and remediate groundwater and soil. Despite the crucial relevance of biofilms to diverse industrial, medical, and environmental applications, little is known about how local biofilm mechanical properties are mediated by encasement composition, community **diversity**, and biofilm physical structure. This award will support fundamental research to understand the relationship between microscale biofilm mechanical properties, encasement and community composition, and physical structure. This work will study biofilms of increasing complexity, including complex environmentally-relevant mixed-culture biofilms. The results generated from executing this award will directly inform new strategies to manage biofilms in critical applications (e.g., remove when they are undesirable, and retain when they are beneficial), leading to significant cost savings. The project provides additional benefits, including diversifying the nation's STEM workforce through multidisciplinary training for underrepresented students at grade school, undergraduate, and graduate levels. This grant will advance our understanding of critical yet poorly understood interrelationships between molecular composition, physical structure, and mechanical properties in polymicrobial biofilms exposed to disparate environmental cues. The majority of the work to date on biofilm mechanical properties has employed macrorheological tools that neglect the inherent local heterogeneity in biofilms and has focused primarily on pure culture biofilms (e.g., *P. aeruginosa* alone) that are not representative of, and likely differ significantly in extracellular polymeric substances (EPS) composition and mechanical properties from, polymicrobial biofilms that are found in medical, environmental and industrial settings. Specifically, the research team will, 1) study local structure- composition-viscoelastic property relationships in biofilms; 2) study biofilm-substratum adhesion and cohesion properties; and 3) develop homogenization-based constitutive models to predict the multi-scale mechanical properties of biofilms. Project results will elucidate, for the first time, how microscale variations in EPS constituents (e.g., polysaccharides, proteins, eDNA) mediate



local heterogeneity in shear moduli and viscosity, adhesion strength, and cohesive fracture energy in dual and mixed-culture biofilms, and how environmental cues and microbial populations present modify this relationship. this improved understanding of spatially resolved structure/ composition-mechanical property relationships will provide the basis for rational management and control of biofilms. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Linking Matrix Composition with Spatially Resolved Mechanical Properties in Polymicrobial Biofilms

Awardee: Northwestern University

Amount: \$450,000.00

Abstract: this award will support research to understand the mechanistic underpinnings of biofilm mechanical and physical properties. biofilms are soft multi-component biological materials. they are made of microbial communities attached to surfaces and encased in polymeric substances. it is thought that these polymeric substances provide mechanical stability. detrimental biofilms cause billions of dollars per year of damage via biofouling or corrosion of ship hulls, heat exchangers, water treatment and distribution infrastructure, membranes, and in the food, oil, and beverage industries. in addition, they account for 65% of infections that originate in hospitals, affecting 17 million people and causing at least 550,000 deaths annually in the us. conversely, beneficial biofilms can clean water and remediate groundwater and soil. despite the crucial relevance of biofilms to diverse industrial, medical, and environmental applications, little is known about how local biofilm mechanical properties are mediated by encasement composition, community **\*\*diversity\*\***, and biofilm physical structure. this award will support fundamental research to understand the relationship between microscale biofilm mechanical properties, encasement and community composition, and physical structure. this work will study biofilms of increasing complexity, including

complex environmentally-relevant mixed-culture biofilms. the results generated from executing this award will directly inform new strategies to manage biofilms in critical applications (e.g., remove when they are undesirable, and retain when they are beneficial), leading to significant cost savings. the project provides additional benefits, including diversifying the nation's stem workforce through multidisciplinary training for underrepresented students at grade school, undergraduate, and graduate levels. this grant will advance our understanding of critical yet poorly understood interrelationships between molecular composition, physical structure, and mechanical properties in polymicrobial biofilms exposed to disparate environmental cues. the majority of the work to date on biofilm mechanical properties has employed macrorheological tools that neglect the inherent local heterogeneity in biofilms and has focused primarily on pure culture biofilms (e.g., *p. aeruginosa* alone) that are not representative of, and likely differ significantly in extracellular polymeric substances (eps) composition and mechanical properties from, polymicrobial biofilms that are found in medical, environmental and industrial settings. specifically, the research team will, 1) study local structure- composition-viscoelastic property relationships in biofilms; 2) study biofilmsubstratum adhesion and cohesion properties; and 3) develop homogenization-based constitutive models to predict the multi-scale mechanical properties of biofilms. project results will elucidate, for the first time, how microscale variations in eps constituents (e.g., polysaccharides, proteins, edna) mediate local heterogeneity in shear moduli and viscosity, adhesion strength, and cohesive fracture energy in dual and mixed-culture biofilms, and how environmental cues and microbial populations present modify this relationship. this improved understanding of spatially resolved structure/ composition-mechanical property relationships will provide the basis for rational management and control of biofilms. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Synthetic Control over MOF Particle Growth and Surface Chemistry

Awardee: University of Oregon Eugene

Amount: \$450,000.00

Abstract: non-technical summary     membranes based on metal-organic frameworks (mofs), which are three-dimensional (3-d) organic/inorganic compounds, attract intense interest for industrial petroleum refining and gas separations due to their exceptional tunability and synthetic **\*\*diversity\*\***. for mofs to reach widespread attraction and implementation in the industrial sector, however, researchers will be required to go beyond 3-d mofs and develop new types of mof nanoparticles, as they exhibit superior separation performance and generate membranes with superior stability. for the past two decades, bulk powders of mofs occupied the focus of academic mof research, but very recent attention has turned to preparing mof nanoparticles and polymer composites with precise control of particle sizes. despite preliminary demonstrations of the great potential of mof nanoparticles, key fundamental questions remain for achieving reproducible control over mof particle composition and for understanding how particle size and composition impact membrane performance. with this project, supported by the solid state and materials chemistry program in the division of materials research at nsf, prof. carl brozek at the university of oregon and his research group will investigate the chemical principles that control the precise sizes and compositions of mof nanocrystals. mechanistic growth models will be developed in the context of growth models established for other classes of materials so that these results inform the broad field of materials chemistry. similarly, the synthetic techniques pursued in this proposal will influence materials design beyond mof particles, by outlining fundamental tools for molecular control over materials across multiple size regimes. the proposed research is practically relevant to society because precise control over mof nanocrystal sizes will open new frontiers in improved gas separation membranes for industry and the opportunity for elevating mof application performance to becoming practically relevant.

technical summary     this project, supported by the solid state and materials chemistry program in the division of materials research at nsf, will investigate the fundamental growth mechanisms of metal-organic framework (mof) particles, develop methods to control particle surface

chemistry for enhancing their colloidal stability and interfacing with polymer composites, and understand the impact of size and surface composition on molecular- and charge-transport properties. tackling this goal will require basic investigation into the parameters that dictate particle sizes, defect incorporation, and surface functionalization. insight into controlling prenucleation crystal growth of materials in general, reproducible synthesis of mof-based heterostructure composites, and improving the practical relevance of mof materials will result from this research. broader impacts of this proposal include 1) integrating these research aims into educational outreach initiatives that communicate the science of carbon capture technology to underserved students, 2) fostering interdisciplinary training programs that pairs chemistry with architecture students to design air-purification modules, 3) sponsoring industry-academia seminar series on mof-based carbon-capture, and 4) implementing a teaching course on designing outreach initiative offered year-round to university of oregon (uo) chemistry phd students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: What Black Doctoral Students in STEM Want and What Their Faculty are Giving: How the Differences Impact Students? Mental Health and Career Trajectory Decisi

Awardee: University of Massachusetts Boston

Amount: \$445,301.00

Abstract: to increase the **\*\*diversity\*\*** of the phd-prepared workforce, understanding underlying issues affecting retention and completion of doctoral degrees is essential. researchers at arizona state university and university of massachusetts boston propose to study the expressed needs of black doctoral students in relation to faculty perceptions of what they are providing during advising relationships. understanding the mental health impacts of cumulative experiences that marginalize black graduate students will advance knowledge by providing recommendations for developing

inclusive environments and mentoring strategies that are effective at supporting black students. through a two-phase design, the project aims to use detailed interviews regarding the experiences of marginalization, mental health, and career trajectory decisions of graduate students and faculty perceptions of supports and contributors and deterrents to providing supports. the project is aligned with the ehr core research program's goal of addressing challenges in stem interest, learning, and participation. the research design is framed by extending role strain theory to include the tension that black students may feel in relationships during graduate programs. the central hypothesis is that intersectional experiences of marginalization and the stem environment among black doctoral students impacts mental health and career trajectory decisions. the project aims to understand the contributors and deterrents for faculty to address systemic barriers. a nationwide sampling strategy will include representation from historically black colleges and universities (hbcus), predominately white institutions (pwis), and minority-serving institutions (msis). the project aims to match critical identity aspects in the interviewer-interviewee pairing within each phase of the project. phenomenological principles grounded in a social constructivist paradigm will guide the interpretation of individual interviews. the research responds to the need for understanding barriers to success in graduate programs for black students by a novel coordination and expansion of traditional educational research strategies with strategies typically utilized by counseling psychologists. the creation of a tip sheet on promising practices for supporting black students and an online repository aims to inform faculty advisors who seek to improve communication and mentoring for their students. the project is funded by the ehr core research program that supports fundamental research focused on stem learning and learning environments, broadening participation in stem, and stem professional workforce development. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: CSBR: Rescuing and Sharing a Unique and Irreplaceable Fossil Collection at the Duke Lemur Center

Awardee: Duke University

Amount: \$442,704.00

Abstract: the duke lemur center is responsible for two unique and irreplaceable collections: the largest living population of lemurs outside of their native madagascar and a natural history collection that includes one of the most diverse primate fossil collections in the united states. the fossil collection ? with specimens from the united states, egypt, madagascar, and colombia ? helps researchers use the tree of life to connect lemur research to other primates, including humans. unfortunately, some of the most important fossils at the dlc, including some of the oldest lemur fossils and some of the oldest monkey fossils, are actively breaking down because unstable salt minerals were embedded in the specimens during fossilization. this project is a rescue mission to stabilize and preserve these fossils in physical and digital form. highly trained fossil technicians will remove salt minerals from the most endangered specimens and store the revitalized fossils in new specimen cabinets that better control the temperature and humidity around the specimens. the team will also create 3d scans of the specimens using x-rays. the scans create a back-up record of the

fossils in case they continue to deteriorate. the scans will be uploaded to morphosource, an online repository that allows educators, students, and researchers to examine fossils in 3d from any device with internet access. with a better-stabilized collection, the dlc fossil collection can open to the public for in-person and virtual tours, and online exhibits and curriculum guides will be created by the dlc education team using scans and 3d prints. the most unstable fossils in the collection come from locality 41 in the fayum depression in egypt. the site is one of the most fossil-dense terrestrial paleogene localities in africa. along with primates like catopithecus and plesiopithecus, the site preserves giant hyraxes, rodents, bats, snakes, birds, and carnivores. the tennis-court sized fossil deposit in the western desert of egypt was actively quarried in the 1980s through 2010s. the most fossil-rich sections were targeted by the excavation teams. this makes the collection at the dlc irreplaceable through additional fieldwork. this project partially supports a fossil preparator who will focus on the egyptian collection as well as other unstable materials in the collection. it also partially supports a digital tomographer who will use the duke microct scanner to generate scans of the most at-risk specimens, and the dlc data manager who will work with the tomographer to backup and upload scan data to morphosource. the data manager will lead the effort to add higher resolution specimen data to the dlc specify database, which will integrate with idigbio (idigbio.org) and the global bio\*\*diversity\*\* information facility (gbif.org). the project also supports microct scanner access and new specimen storage cabinets. the dlc education team will use these newly stable specimens to create curriculum-targeted tours and guides for north carolina k-12 students and visitors to the dlc. ultimately, exceedingly fragile fossil specimens will be available in-person and online to researchers, students, and the general public. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Understanding and controlling low angle grain boundaries in additively manufactured metals



Awardee: University of California-Los Angeles

Amount: \$441,850.00

Abstract: non-technical abstract      additive manufacturing (am), or 3d printing, with its ability to integrate materials synthesis and manufacturing into a single print, is attractive for a broad range of technological applications and may help usher industry 4.0 revolution. however, a fundamental understanding of the processing-structure-property relationship in most am materials remains lacking. nearly all am materials are made of numerous crystals called grains. grains form interfaces when attached to each other. these interfaces can often control materials properties. it has been particularly challenging to understand and control grain interfaces in am materials, which may help us to achieve stronger and more bendable materials. this project advances understanding of the relationship between processing, interfaces between these grains, and resultant mechanical properties in a model 3d-printed material through an integrated experimental and computational effort. the ability to control these interfaces via 3d printing could allow the creation for high-performance structural materials for various engineering applications. the involvement of under-represented undergraduate research through samueli **\*\*diversity\*\*** program and collaborations with national laboratories provide educational and career advancement opportunities for young scientists in advanced manufacturing and materials science fields.      technical abstract

the objective of this project is to understand and control low angle grain boundaries (lagbs) in am metals and alloys. the research focuses on pure metals fabricated by laser powder-bed-fusion (l-pbf), which often contain a substantial fraction of lagbs that can lead to high strength, high ductility, and high thermal stability. the project aims at establishing mechanistic understanding of interconnections between laser processing parameters, interfacial microstructures (e.g., lagbs), and resultant mechanical properties. the research comprises of two major thrusts: thrust 1 involves controlled fabrication of model materials with various fractions of lagbs. an inverse pole figure orientation mapping using transmission electron microscopy (tem) is used to characterize interfacial structures and correlate their characteristics to the deformation kinetics parameters and in situ

synchrotron x-ray diffraction experiments. thrust 2 strives to develop processing sensitive models to correlate complex processing parameters and its thermal history with the observed microstructures. the processing model is tightly coupled with microstructure characterizations to reveal the fundamental relationship between the laser scan strategies and processing parameters and resultant microstructures. the mechanistic insights obtained by these studies could guide the optimization of laser processing conditions to create high performance structural materials for diverse applications. collaborations with national laboratories enhance the graduate student's research experience. partnership with the samueli \*\*diversity\*\* program to engage undergraduate students from under-represented groups into these research activities increases the \*\*diversity\*\* of the future stem workforce. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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criteria.

Matched Words: diversity

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Title: Collaborative Research: P2C2--MADagascar Caves And Paleoclimate II (MADCAP II),  
Continuing Study of Climate Variability in the Southern Hemisphere of the Western Indian Ocean

Awardee: University of Massachusetts Amherst

Amount: \$441,470.00

Abstract: the research team aims to build upon previous research using speleothems from caves in northwest and southwest madagascar to reconstruct late pleistocene and holocene climate from a southern hemisphere tropical site and to examine the role of climate in the ongoing alteration of the island's ecosystems. using previously collected samples, the researchers plan to construct high-resolution (decadal) multiproxy climate records from the last glacial maximum (26,000 years ago) to the present from high-resolution (near annual resolution) analyses for periods of particular climatic interest (e.g., the 4.2 ka event, younger dryas). the researchers will extract organic matter from the speleothems across an interval of marked change in speleothem delta carbon-13 and measure biomarker concentrations and the same to test a newly developed subsistence shift hypothesis for the disappearance of madagascar's megafauna. speleothem fluid inclusion water isotopes, combined with carbonate oxygen isotopes, will be examined as a tool to estimate paleotemperatures over the past 117,000 years for southwest madagascar and the past 26,000 years for northwest madagascar. the goal of the project is to produce long, high resolution records of climate from the southern hemisphere tropics. these data will aid in understanding the influences of inter tropical convergence zone (itcz) migration, western indian ocean sea-surface temperature (sst), and regional precipitation. in particular the project will investigate whether the indian ocean monsoon in the northern versus southern hemispheres vary in or out of phase at various timescales and test current hypotheses on tropical rainfall variation. the potential broader impacts include the integration of science across the fields of paleoclimatology, anthropology, and biology to provide

background climate data needed for interpreting the impact of climate on a variety of fossil communities of the past. the research team will produce educational materials and exhibits prepared for a general audience to heighten public awareness of tsimanampesotse national park's natural history, bio\*\*diversity\*\*, and extinction events. the project will help develop a better understanding of the causes of decadal-scale climate variability which can aid in forecasting possible changes in rainfall in a country that experiences severe drought and flooding on inter-annual time scales and relies on subsistence farming for survival. this project includes supporting an early career female post-doctoral scholar in the united states and collaboration with malagasy scientists and students as well. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Leveraging Signal Structure for Cost-Sensitive Adaptive Sampling

Awardee: Portland State University

Amount: \$441,193.00

Abstract: a persistent challenge to scientists and engineers is the ability to rapidly sense the environment. whether monitoring for harmful air pollutants, wildfires, or low oxygen levels in lakes, an essential task is to determine all locations where a factor of interest reaches a critical level. to solve this problem, practitioners are increasingly utilizing mobile sensors such as those deployed on unmanned vehicles. while these provide a safe means of exploring large spatial regions and hazardous environments, they also require extensive planning to ensure the most relevant measurements are collected and to manage battery life. this project will overcome these issues through the design of adaptive sampling algorithms, which automatically guide sampling vehicles to the most important regions while accounting for the realistic costs associated with the measurement process. the resulting approaches will provide general-purpose solutions to environmental sampling

that can be easily utilized by practitioners while also accounting for the realistic challenges that typically prevent adaptive methods from translating into practice. furthermore, this research will support education and **\*\*diversity\*\*** through the development of curriculum for a high school course on unmanned aerial vehicles as well as a citizen science campaign that leverages adaptive sampling to benefit one of the nation's largest urban parks. the objective of this project is to design and analyze cost-sensitive adaptive sampling algorithms for the problem of level set estimation. novel adaptive sampling techniques will be developed under three forms of level set structure: (1) boundary smoothness, where no domain or side knowledge is available, (2) known similarity structure that indicates which locations should have similar measurement values, and (3) unknown cluster structure, where the signal of interest is constant within each cluster of locations, and the goal is to simultaneously learn the cluster structure and measurement values. for each case, principled algorithms will be derived based on recent developments from the fields of active learning, multi-armed bandits, and reinforcement learning, with the goal of providing improved empirical performance, rigorous theoretical characterization, and incorporating realistic costs such as the distance traveled while sensing. algorithms will be evaluated on real-world datasets including those measuring air quality and geothermal energy prospects. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSFGE0-NERC:Collaborative Research: Chemistry and Biology under Low Flow Hydrologic Conditions Beneath the Greenland Ice Sheet Revealed through Naturally Emerging Subglacial Water

Awardee: Indiana University

Amount: \$440,249.00

Abstract: this project is jointly funded by the national science foundation's directorate of

geosciences (nsf/geo) and the national environment research council (ukri/nerc) of the united kingdom (uk) via the nsf/geo-nerc lead agency agreement. this agreement allows a single joint us/uk proposal to be submitted and peer-reviewed by the agency whose investigator has the largest proportion of the budget. upon successful joint determination of an award, each agency funds the proportion of the budget and the investigators associated with its own component of the work.

weathering is an important process that releases nutrients that are essential for life from rocks and minerals in the earth's surface. this project seeks to understand the effect of large glaciers on weathering processes beneath the greenland ice sheet and the consequences for life. during summer, nutrients and other products are flushed out of the greenland ice sheet with water from melting ice. while these products have been sampled in spring and summer, it is not known how weathering processes are different during winter. in this project, researchers will sample the seasonal ice that forms in front of two of greenland's glacial outlets, isunnguata sermia and leverett glacier, during the freezing months to assess the chemistry and microbiology processes that reflect wintertime conditions beneath the ice sheet ? periods when input of fresh meltwater is minimal. these samples will increase knowledge of winter conditions under the greenland ice sheet and help better understand the interior portions of the ice sheet which are largely inaccessible. such information will help in assessing past conditions, when colder atmospheric conditions resulted in minimal meltwater input through the ice sheet and to the glacial bed. these analyses will inform understanding of the role of glaciers on earth's nutrient cycles presently, under past ice age conditions, and in a future deglaciating world. the greenland ice sheet is a major exporter of biologically important elements to the world's oceans. however, most of our knowledge of chemical and biological fluxes from the ice sheet comes from the summer outflux of outlet glaciers whose channelized waters contact only a limited portion of the glacier bed. the majority of the glacier-bed interface contains slow-flowing, distributed waters not representative of this flux. the project will test the hypothesis that overwinter chemical and biological processes under outlets of the greenland ice sheet differ substantially from summer outflow and represent a window into widespread, but typically

inaccessible, distributed flow. the principal sample collection method will be early spring coring of naled ice that forms at glacial termini from wintertime subglacial flow. chemical, mineralogical, and biological constituents of this flow will be compared to material emerging from the initial, peak, and terminal phases of the melt season. elsewhere in the arctic, the chemistry of frozen overwinter subglacial material shows significant limitation in oxygen or sediment supply compared with even the first spring melt, supporting the idea that naled ice reveals a unique overwinter system. the naled ice and outflow of isunnguata sermia and leverett glacier will be sampled over two years. these west greenland outlets differ by more than an order of magnitude in the size of the catchments they drain, thereby testing the effect of scale on biogeochemistry. naled ice structure will be characterized by ground penetrating radar and ice borehole temperature profiles. the aqueous geochemistry, stable isotopes of carbonate and sulphate, and mineralogy of the suspended sediment of ice and water will be assessed. these analyses will document changes in the mineral flux and supply of atmospheric gases at the glacial bed between winter low flow conditions and peak summer melt. microbial abundance, **\*\*diversity\*\***, metagenomics, and stable isotopes of biomass will also be measured to understand the concomitant relationship between geochemical conditions and biological communities. researchers will incorporate findings into a number of outreach efforts including developing a new curriculum module for the center for earth and environmental sciences, providing research opportunities for underrepresented students as part of the bridge to research program and preparing hands-on activities for the market science program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Rare Isotope Reaction Studies for Nuclear Structure and Astrophysics

Awardee: Rutgers University New Brunswick

Amount: \$440,000.00



Abstract: this award will support the principal investigator and her group of early career scientists to advance our understanding of the structure of atomic nuclei as well as their reactions and synthesis in exploding stars. nearly all elements heavier than iron are made in stars and stellar explosions through processes that involve the capture of neutrons. to learn more about those processes the pi will lead experiments using beams of rare isotopes, concentrating on neutron-rich nuclei. this research program will use state-of-the-art instruments and accelerator facilities in the u.s. the project will also serve to enhance the **\*\*diversity\*\*** of the nuclear science workforce. the participation of these early career scientists in forefront research and the development of scientific instruments will prepare them for careers in higher education and fundamental and applied research at national laboratories and in industry. light-ion transfer reactions will be studied with beams of rare isotopes with energies near the coulomb barrier and about 45-mev per nucleon. studies will concentrate on neutron-rich nuclei near the  $n=50$  neutron shell closure and light nuclei important for understanding the synthesis of nuclei in stars and their explosions. these studies will be carried out with accelerated beams of rare isotopes at michigan state university, first with the reaccelerated (rea) beam capability and starting in 2022 with the facility for rare isotopes beams (frib). additional experiments will be performed at the atlas accelerator facility at argonne national laboratory. at frib the focus is to constrain the shape of the potential that binds neutrons in a neutron-rich nucleus and, therefore, extract spectroscopic strengths and direct neutron capture rates with reduced dependence on theoretical model parameters. the neutron-transfer reaction with deuterated targets has been validated as a surrogate for neutron capture when reaction products are measured in coincidence with gamma rays. therefore, both charged particles and coincident gamma radiation will be measured with gamma-array orruba: dual detectors for experimental structure studies (goddess), where the oak ridge rutgers university barrel array (orruba) is coupled to large, highly segmented arrays of high-purity germanium gamma-ray detectors. the results will be compared with theoretical predictions of nuclear structure and reactions away from stability and disseminated as input into calculations of nucleosynthesis in stars and their explosions. this award reflects nsf's

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Amount: \$440,000.00

Abstract: this award will support the principal investigator and her group of early career scientists to advance our understanding of the structure of atomic nuclei as well as their reactions and synthesis in exploding stars. nearly all elements heavier than iron are made in stars and stellar explosions through processes that involve the capture of neutrons. to learn more about those processes the pi will lead experiments using beams of rare isotopes, concentrating on neutron-rich nuclei. this research program will use state-of-the-art instruments and accelerator facilities in the u.s. the project will also serve to enhance the **\*\*diversity\*\*** of the nuclear science workforce. the participation of these early career scientists in forefront research and the development of scientific instruments will prepare them for careers in higher education and fundamental and applied research at national laboratories and in industry. light-ion transfer reactions will be studied with beams of rare isotopes with energies near the coulomb barrier and about 45-mev per nucleon. studies will concentrate on neutron-rich nuclei near the  $n=50$  neutron shell closure and light nuclei important for understanding the synthesis of nuclei in stars and their explosions. these studies will be carried out with accelerated beams of rare isotopes at michigan state university, first with the reaccelerated (rea) beam capability and starting in 2022 with the facility for rare isotopes beams (frib). additional experiments will be performed at the atlas accelerator facility at argonne national laboratory. at frib the focus is to constrain the shape of the potential that binds neutrons in a neutron-rich nucleus and, therefore, extract spectroscopic strengths and direct neutron capture rates with reduced dependence on theoretical model parameters. the neutron-transfer reaction with deuterated targets

has been validated as a surrogate for neutron capture when reaction products are measured in coincidence with gamma rays. therefore, both charged particles and coincident gamma radiation will be measured with gamma-array orruba: dual detectors for experimental structure studies (goddess), where the oak ridge rutgers university barrel array (orruba) is coupled to large, highly segmented arrays of high-purity germanium gamma-ray detectors. the results will be compared with theoretical predictions of nuclear structure and reactions away from stability and disseminated as input into calculations of nucleosynthesis in stars and their explosions. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: The Excited State Behavior of Ru(II) Photodrugs

Awardee: University of Texas at Arlington

Amount: \$440,000.00

Abstract: with this award, the chemical structure, dynamics, and mechanism-b program is supporting the research of professor sherri mcfarland at the university of texas, arlington to examine the excited state photophysics and redox properties of ru-based photosensitizers. photosensitizers are compounds that can trap the energy of light and use it to effect a useful chemical reaction. examples of this include solar energy conversion, catalysis, and photodrugs. this project focuses on a particular class of such photosensitizers that show promise in cancer therapy, but have many unanswered questions about their mode of action. the work will investigate the fundamental photophysical and electrochemical properties of oligothiophene-containing ruthenium compounds specifically, and reveal the details of photocatalytic mechanisms in which they can participate. it will also explore how the behavior of these photosensitizers can change as a function of its environment, e.g., agglomeration effects and the influence of simulated biological structures. the proposed work will train graduate and undergraduate students in highly multidisciplinary research at

the interface of chemistry, biology, physics, and engineering. the knowledge and skills these trainees will acquire will give them tools necessary for success as future research scientists in cutting-edge multidisciplinary fields ranging from photomedicine to solar energy conversion and chemical biology. the broader impact objectives will simultaneously equip tomorrow's leaders with skills in science communication and expose them to entrepreneurship and commercialization as it relates to bringing scientific discoveries from the laboratory to society. it will also provide curriculum-based research opportunities for undergraduate students that would otherwise not have the opportunity to experience scientific research in a real-world laboratory setting, expanding **\*\*diversity\*\*** in our next generation of emerging scientists.

this project project will examine the excited state photophysics and redox properties of oligothiophene-containing  $\text{Ru(II)}$  complexes, compounds that have important applications as photosensitizers in fields ranging from solar energy conversion to photodrugs. the project also aims to develop the photophysical model(s) for these photosensitizers in complex biological environments. we will synthesize and characterize oligothiophene-appended  $\text{Ru(II)}$  photosensitizers,  $[\text{Ru(II)}_2(\text{ip-nt})]^{2+}$  that differ in the number of thiophene rings (nt), the types of substituents on the thiophene rings, and the co-ligands (ll). the modifications are designed to systematically vary redox potentials and triplet state characteristics, and to alter the covalent and noncovalent associations typical of oligothiophenes. electrochemical and photophysical techniques will be used to test hypothetical photoredox catalysis mechanisms in complex substrates, where synthetic and cell-derived vesicles will be used to model how photosensitizer response modulates in confined matrices, e.g., a lipid bilayer. the results will advance the field of  $\text{Ru(II)}$ -oligothiophene photosensitization. with a mechanistic understanding of oligothiophene-containing  $\text{Ru(II)}$  photosensitizers, there exists the opportunity to create better next-generation photosensitizers for photocatalytic applications. the broader impact activities are equally focused on exposing stem scientists to science communication and entrepreneurship based on past translational research and commercialization efforts related to light-molecule interactions. the training program will cover outreach, education, and curriculum, emphasizing the process from

fundamental discovery to societal application, and provide opportunities for researchers to improve their science communication skills. curriculum-based research opportunities for undergraduate stem students will be designed and delivered to ensure that a larger percentage of these students receive hands-on research experience during their degree programs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Evaluating Climate Change and Kill Mechanisms Associated with the End-Cretaceous Mass Extinction: A Model-Data Comparison Approach

Awardee: Louisiana State University

Amount: \$439,432.00

Abstract: sixty-six million years ago at the cretaceous-paleogene boundary (kpb), an asteroid impact in the yucatán peninsula resulted in the loss of about 75% of all species on earth. as the most recent, well documented, and rapid mass extinction in earth's history, study of the kpb extinction is ideal for understanding the effects of climate change on bio\*\*diversity\*\*. however, the causes of the kpb extinctions remain uncertain. this project will use a combination of novel climate model simulations and geologic records to explore climate change and kill mechanisms associated with the asteroid impact. measuring various geologic records from across the kpb will constrain the types and magnitudes of emissions from the asteroid impact. these emission estimates will then be used in climate model simulations to determine the earth system responses to the asteroid impact through time. project results will provide a mechanistic understanding of kpb extinction, which, in turn, will improve interpretation of many records from this time period, deliver insights into ecosystem collapse and recovery, and lead to valuable climate model development. outreach activities include creation of a kpb exhibit, develop of a geochemistry high school project, recruitment of three underrepresented undergraduate interns, and engagement of student researchers at the university

of texas rio grande valley, a hispanic majority university. to determine the relative importance of various processes that could have led to the kpb extinction and subsequent environmental recovery, the pis will use an earth system model to perform kpb simulations that mimic forcings from the asteroid impact. the model contains an explicit aerosol resolving scheme and high-top atmosphere, both essential for capturing the processes associated with these perturbations. further, development and implementation of an ocean biogeochemistry module will allow for direct comparison with paleontological, chemical, and isotopic records across the kpb. the pis will also collect high resolution soot, temperature, and biomarker records to constrain and validate the kpb simulations. samples will be analyzed for soot and polycyclic aromatic hydrocarbons to test the asteroid impact fires hypothesis and provide refined soot emission data for the simulations. new estimates of temperature change after impact will be generated from phosphatic microfossils and biomarkers. these records will provide sub-millennial to millennial scale constraints on temperature, and in combination with simulations and soot estimates, a means to backout co2 emission associated with the impact. finally, high resolution biomarker work will shed light on the rate of marine planktonic recovery, which will be compared with the ocean biogeochemistry simulations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: Microdiversity drives ecosystem function: SAR11 bacteria as models for oceanic nitrogen loss

Awardee: Georgia Tech Research Corporation

Amount: \$436,628.00

Abstract: this project studies how low oxygen availability influences the bio\*\*diversity\*\* and ecological role of sar11 bacteria, one of the most abundant microbial groups in the ocean. the work involves oceanographic sampling across a range of oxygen and nutrient levels in the eastern tropical north pacific ocean. using a combination of genomic, microbiological, and biogeochemical methods, the study identifies the mechanisms by which sar11 strains diversify into separate niches and species and contribute biochemically to the ecosystem, likely through removing nitrogen from seawater. the project equips the next generation of researchers and educators, notably those from underrepresented minority groups, to use oceanographic, genomic, and microbiological concepts to meet contemporary scientific challenges. this goal is met through a combination of bioinformatic workshops that target undergraduate students from the university system of puerto rico, middle school teacher-training workshops, and middle or high school teacher internships in the investigator?s labs. this multifaceted research and educational agenda fills a gap in our understanding of marine biological \*\*diversity\*\*, identifies the contribution of sar11 bacteria to nutrient and carbon cycles in low oxygen oceans, and provides lessons and analytical tools to study microbial processes in other ecosystems. this project has two aims. aim 1 employs comparative metagenomic and single-cell genomic analyses to identify metabolic properties that distinguish sar11 clades from low oxygen regions and processes of selection or gene flow operating across the clades. aim 2 combines microbial transcriptomics, incubation experiments with isotope tracers, and



culturing to delimit the oxygen and nutrient conditions that define the niche space of each sar11 clade and to correlate sar11 gene transcription with community biochemical outcomes, including nitrogen loss through denitrification. the results of these aims and the informatic methods used to probe microbial micro\*\*diversity\*\* are disseminated through genomics-focused undergraduate workshops, and new teacher-training educational modules, including lab-based modules focused on the importance of microorganisms under environmental change in the oceans. data, manuscripts, and informatics workflows from this project are made publicly available. the results are critical for resolving the processes that create and sustain microbial \*\*diversity\*\* in the oceans and informing biogeochemical models that predict how \*\*diversity\*\* influences ecosystem processes. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Long Document Summarization with Question-Summary Hierarchy and User Preference Control

Awardee: Regents of the University of Michigan - Ann Arbor

Amount: \$436,313.00

Abstract: in an era when long documents are produced at an overwhelming speed, a reader may not have time even to skim over a document to decide which topics deserve a detailed look. the goal of this career project is to build text summarization systems that can understand and aggregate information from long documents, so as to allow users to explore their content with summaries that are generated in styles they prefer. the summarization tools will make long documents more accessible and comprehensible, easing the knowledge learning experience of the general public. researchers and practitioners can also use the tools to summarize long documents relevant to their work, and educators can incorporate them in their classes to bolster students' reading and writing skills. the project also broadens the investigator's efforts of engaging young students in immersive

research opportunities, allowing them to participate in the design and implementation of advanced summarization systems. this project develops a new summarization framework for long documents in which article-level abstractive summaries provide an overview, and a question-summary hierarchy presents different levels of details. the technical contributions of this project are three-fold. first, the quadratic time complexity of state-of-the-art summarization (e.g., transformer) is reduced by using adaptively predicted sparse attentions and augmented with a knowledge encoder. second, an open-ended question generation model fills automatically learned question templates to produce concrete questions that are coherent within the question-summary hierarchy. third, summaries are tailored to user-specified styles via iterative adjustments during generation, reflecting important advice in plain-language guidelines. this project experiments with new datasets collected from government reports, since their length, topic **\*\*diversity\*\***, and formulaic verbiage embody many common challenges for long document summarization. new evaluation methods are also designed, with cloze questions to target common erroneous generations, and with model confidence metrics to pinpoint errors without using references. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: The Petabyte Project for Fast Radio Transients

Awardee: West Virginia University Research Corporation

Amount: \$432,848.00

Abstract: we are in a golden era in the investigation of flashing, short-duration astronomical events detected by radio telescopes. progress in understanding novel, highly luminous phenomena like fast radio bursts (frbs) and highly intermittent pulsars is being enabled by the broad availability of archives, new observing systems on a host of telescopes worldwide, and extensive computing systems in place to provide throughput for huge amounts of data. this field has rapidly evolved in the past decade. searches for such transients have been done by constantly evolving analysis techniques, each improving on the last. however, new techniques are typically applied to only a small set of data. a research group at west virginia university (wvu) will undertake "the petabyte project," which will harness many diverse archival and new data sets to perform an unprecedented uniform search across multiple observing systems and radio frequencies. this search for transient events has key analysis structures in place that were not available in past searches, including a systematic check of completeness of the constituent surveys, and a rigorously tested machine-learning-based event classifier. to broaden the impact of their work, the researchers will work with two strong existing outreach programs at wvu, the science public outreach team (spot) to introduce area high-school students to machine learning applications, and the pulsar search collaboratory (psc) summer program, to enable high school students to participate in the research by helping to classify radio sources. there will be several key scientific, software, and data outcomes from this search. the work will lead to the discovery of new frbs and pulsars, particularly at high radio frequencies where few searches have been done. it will provide the first statements on the completeness of frb searches as a function of dispersion measure (distance) and radio frequency, leading to new knowledge on the **diversity** and range of frb properties. the team will also provide the first broad, blind multi-frequency exploration of extreme intermittency in the radio pulsar population. all code generated by this project will be open-access and accompanied by in-depth documentation, allowing broad use of the unified transient data read/write tool, machine-learning suite, pipeline, and completeness assessment software. labelled search products will be made public on a permanent server for use in future interference, fast-transients, or machine-learning

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Matched Words: diversity

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Title: Collaborative Research: Disentangling biological and environmental drivers of diversification in the Andean flora

Awardee: University of Hawaii

Amount: \$431,424.00

Abstract: the tropical andes of south america is one of the world's richest bio**diversity** hotspots. this **diversity** likely evolved due to the complex environmental and geological history of this region. however, exactly how plant **diversity** arose from the combination of mountain uplift, the development of new habitats, and species interactions is unclear. this research aims to understand how these factors led to plant **diversity** in cloud forests and high-elevation grasslands. the researchers will develop new software to compare plant genomes to understand the ancestry of four groups of flowering plants in the andes. the project will also result in new mathematical models to test the importance of different factors in shaping **diversity** in these plant groups. these new methods will have broad application to studies of bio**diversity** in the andes and beyond. additionally, this project aims to train the next generation of scientists in the study of bio**diversity** through a variety of interrelated activities, including: (1) a course for undergraduates to do guided

genomic research; (2) collaborative training for students; and (3) computational training for diverse students. the project will first establish well-supported phylogenetic hypotheses for each of the four focal clades of andean plants using low-coverage and targeted genome sequence data. samples will be collected from colombia as well as museums. this work highlights the importance of natural history collections in cutting-edge biological research, and new fieldwork will add to those collections. a component of the research will be to develop new approaches to address complexities common in plant genomes, including polyploidy and paralogy, that can affect estimates of evolutionary relationships. these methods will be made available through open-source software such that other researchers can easily estimate phylogenies and examine support for phylogenetic hypotheses using sequence data. second, the project will develop new models that jointly infer the roles of dispersal and trait evolution in species diversification. these methods will be applied to phylogenomic, morphological, and distribution data collected for this project. these methods will also be made publicly available for widespread use. finally, by comparing the roles of biogeographic and ecological processes in generating **\*\*diversity\*\*** in these clades, the research will address the generality or idiosyncrasy of the processes facilitating rapid radiation in tropical andean plants. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: A Model of Generalized Ingroup Recognition Advantage

Awardee: University of California-Riverside

Amount: \$431,338.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). people often have worse recognition memory for individuals who are not (versus are) in their racial group. this well-known cross-race effect can lead to racial disparities. as one example, in the us criminal justice system nearly a third of wrongful convictions that later are overturned were

based on errors made in cross-race identification. the cross-race effect would seem to be specific to faces: a glance at a face quickly reveals information about race, gender, age, and other social categories. yet many objects beyond a face, or even beyond a person, may signal group membership and cause a recognition bias. this research investigates the possibility that the ingroup recognition advantage exemplified by the cross-race effect is a general recognition bias. this research has the potential to transform our theoretical understanding of social influences on perception and cognition, including the basic psychological mechanisms that contribute to racial disparities.

this project builds upon research in social psychology, developmental psychology, cognitive neuroscience, and vision science to develop a comprehensive model of ingroup recognition and examine its social impact. the project is organized around three sets of experiments, all using a basic paradigm in which participants complete a learning task followed by a recognition task. the first set of experiments aims to differentiate two causes of an ingroup recognition advantage: people may better recognize information relevant to their own group because (1) they have more lifetime experiences with their group and thus have perceptual expertise, and/or (2) they are more interested and motivated to attend to their own group. each cause can be tested with experiments in which participants form new groups and are exposed to objects with which they have no prior experience but are related to their group or another group. a second set of experiments examines whether an ingroup recognition advantage occurs to the same extent for different groups to which one belongs, and a third set examines how the generalized ingroup recognition advantage can lead to stereotypic judgments of others. under conditions of tight experimental control, this research tests a novel model that accounts for: (1) the mechanisms and boundary conditions of ingroup recognition; (2) the qualitative nature of the cognitive processes underlying the generalized ingroup recognition advantage; and (3) the implications of the generalized ingroup recognition advantage. the interdisciplinary and integrative nature of this research has implications that are relevant to social psychologists, policymakers, legal scholars, law enforcement, and the general public, and it can inform interventions to reduce stereotyped judgments. the project also provides



specialized training to students at a minority-serving institution (msi) that ranks highly in terms of **\*\*diversity\*\***, social mobility, and graduation rates. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: IntBIO COLLABORATIVE RESEARCH: Deep Time, Development, and Design: Evolution of shark skin teeth from genotype to phenotype to prototype.

Awardee: Harvard University

Amount: \$431,276.00

Abstract: the skin of sharks is unique among vertebrate animals because it contains tooth-like scales, called dermal denticles, that create a hard external armor. these tooth-like denticles evolved over millions of years and equip the shark with hydrodynamic skin that reduces the cost of moving through the water. this advanced streamlining is currently a subject of great interest, with many industries attempting to take advantage of shark skin technology to create more efficient swimming designs. this project aims to provide a complete integrated understanding of shark denticles: how they form in embryonic sharks, how denticle shape has changed over years of evolution, and which denticle types are the best for drag-reduction and further design advances. this knowledge will enable better use of shark skin technology to make advanced design solutions that help to make a better and more environmentally friendly world. for example, one possible use of shark skin technology is the development of surface structures on airplanes or boats to reduce drag during movement and decrease fuel emissions. in addition to its scientific impact, this project has impact on the stem workforce by supporting principal investigators and trainees across a wide range of career stages and by providing a unique, much-needed accessible research training program for undergraduates with disabilities in interdisciplinary research. the shape and pattern of shark skin teeth, or denticles, has been refined over millions of years of evolution for functional improvements

in aquatic locomotion. this project addresses the evolutionary and developmental trajectories that have led to a vast **\*\*diversity\*\*** of shark skin denticle types with the goals of determining why sharks have different shaped denticles among and within species and what functional advantages these different denticle shapes might offer these animals. from an integrated developmental, genetic, and evolutionary framework, the project will investigate how denticles develop and what factors lead to changes in shape. the approach will include studies of embryonic denticle development from the level of single cell transcriptomics to phenotypes and function to learn what key genes are essential to the production of various denticle shapes in a range of shark species and how these shapes are achieved via developmental innovation. goals include understanding what shapes are most efficient for drag-reduction in both modern and extinct species to enable modeling and testing of new engineering designs to reduce drag in air- and water-borne vehicles and devices. combining 3d printing with engineering methods, new shark-inspired surface structures will be used to create a shift in design solutions for a changing and more environmentally friendly world. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: CIF: Single-Particle Measurements of Soot and Incandescing Aerosol

Awardee: Clemson University

Amount: \$427,895.00

Abstract: this community instruments and facilities (cif) award makes the single-particle soot photometer (sp2) at clemson university available to the broader atmospheric science community. the sp2 can be used to measure the mass of black carbon in individual aerosol particles suspended in air. in addition, the advanced capabilities of the sp2 allow direct measurement of black carbon mixing state, or the degree to which black carbon is mixed with other, non-incandescing chemical species, on a single-particle level. funds awarded for this project will provide support to keep the sp2 in a user-ready state for laboratory studies, airborne field studies, and ground-based field deployments. the sp2 will be requestable by the scientific user community and provided with support to make full use of the soot photometer data. this project also supports outreach activities to reach a broader scientific community, to garner public interest in science, and to increase **\*\*diversity\*\*** in science, technology, engineering and math (stem) disciplines. black carbon or soot is an important aerosol type found in the atmosphere which is generated from nearly every combustion process, including vehicle engines, factories, and forest or agricultural fires. soot aerosol is highly absorbing of sunlight, which makes it an important component to understanding local heating, micrometeorology, and long-range, long-term climate. broader access to the sp2 instrument has the potential to advance knowledge in several topics concerning atmospheric aerosol particles. this award will enhance the ability of the broader scientific community to use the sp2 instrument at clemson university through the atmospheric and geospace sciences facility and instrument request process. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Awardee: Clemson University

Amount: \$427,895.00

Abstract: this community instruments and facilities (cif) award makes the single-particle soot photometer (sp2) at clemson university available to the broader atmospheric science community. the sp2 can be used to measure the mass of black carbon in individual aerosol particles suspended in air. in addition, the advanced capabilities of the sp2 allow direct measurement of black carbon mixing state, or the degree to which black carbon is mixed with other, non-incandescing chemical species, on a single-particle level. funds awarded for this project will provide support to keep the sp2 in a user-ready state for laboratory studies, airborne field studies, and ground-based field deployments. the sp2 will be requestable by the scientific user community and provided with support to make full use of the soot photometer data. this project also supports outreach activities to reach a broader scientific community, to garner public interest in science, and to increase **\*\*diversity\*\*** in science, technology, engineering and math (stem) disciplines. black carbon or soot is an important aerosol type found in the atmosphere which is generated from nearly every combustion process, including vehicle engines, factories, and forest or agricultural fires. soot aerosol is highly absorbing of sunlight, which makes it an important component to understanding local heating, micrometeorology, and long-range, long-term climate. broader access to the sp2 instrument has the potential to advance knowledge in several topics concerning atmospheric aerosol particles. this award will enhance the ability of the broader scientific community to use the sp2 instrument at clemson university through the atmospheric and geospace sciences facility and instrument request process. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Diverse Evolutionary Power of Nucleic Acid Libraries Carrying Different Information Content

Awardee: Foundation for Applied Molecular Evolution, Inc.

Amount: \$426,000.00

Abstract: with the support of the chemistry of life processes (clp) program in the division of chemistry, dr. elisa biondi of foundation for applied molecular evolution, inc. will study chemical systems that could have served as precursors to the replicating macromolecules, such as rna and dna, found on earth and other places where life could exist. the macromolecules that make up current life on earth are composed of only a small subset of all possible chemical building blocks. dr biondi aims to provide insights into how only a small subset of molecules evolved and persisted into the current macromolecular systems. using the power of in-vitro evolution (evolutionary experiments performed in the laboratory), dr. biondi's laboratory will characterize potential prebiotic systems to provide insights into how the information density in the system (the number of building blocks), information amount (the minimum length of the polymer needed to display minimal activity), and information **\*\*diversity\*\*** (the types of building blocks and/or chemical groups) affect the performance and persistence of potential prebiotic systems. this project will provide fundamental intelligence on the information density requirement for an evolving nucleic acid library and shed light on many fundamental questions regarding the limits and ways in which prebiotic molecular evolution took place on our planet or others. additionally, results from this project will provide precious information to the large community of scientists who make use of in-vitro evolution to develop molecular tools applied in fields such as biomedicine, diagnostics, genetic engineering, and bioremediation. dr. biondi's outreaching activities will focus mainly on encouraging undergraduates, especially women and underrepresented minorities, to pursue stem careers. moreover, dr. biondi will participate in focus groups centered on the issue of women in science and will continue her virtual encounters with 3rd to 5th grade students to introduce them to astrobiology and general sciences. this project

will investigate what types of nucleic acid chemical systems are more suited for evolution towards catalytic functions and might have served as precursors of contemporary catalysts. the work will compare laboratory in-vitro evolution of nucleic acid libraries with different information density using biochemistry tools and high-throughput sequencing data. the chemical **diversity** of nucleic acid libraries will be adjusted with the artificially expanded genetic information system (aegis), developed in dr. biondi's laboratory. first, three parallel in-vitro selections of rna-cleaving dnazymes able to cut an rna substrate will be performed. the starting libraries will include a 25n random region and primer binding sites (pbs) composed of either standard or aegis dna, flanked by standard dna. a third selection will use libraries with a standard 25n region, but aegis in the pbs, which have been shown at fflame to improve self-pairing and yield cleaner pcrs. with this method, by removing some laboratory biases that have taunted the field for decades, it is expected that the work will not only improve the output of selection experiments, but also to gain extra insights into sequence-based fitness evolution previously 'buried' under techniques biases. in the next phase, initial experiments will be repeated with starting libraries carrying 19, 30, 40, and up to 45 random positions. these analyses will provide another level of information once biochemical and high throughput sequencing results for each selection will be compared: it is expected that not only will libraries with different information content evolve and explore the sequence space differently, but that a length difference in sequence options will also provide different evolutionary routes. further, outputs of selections performed with libraries carrying different types of modifications inside the random region, primer binding sites, or 5' and 3' ends of the molecules will be compared, with the goal of obtaining a comprehensive view of which groups and which combination of molecules have the best fitness towards a specific function. metrics for selection comparison will include number of cycles required to achieve function, catalysis parameters ( $k_{obs}$ ,  $k_m$ ,  $k_{cat}$ , turnover rates), and sequence fitness and enrichment values. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: Collaborative Research:SWIFT:Ultra Wideband Flexible MIMO Radios for Energy Efficient Secure Spectrum Sharing

Awardee: Florida International University

Amount: \$425,000.00

Abstract: worldwide growth in wireless links, navigation, automation, internet of things (iot), and mobile healthcare has challenged spectrum access. in parallel, we are witnessing rapid advances in augmented reality/virtual reality (ar/vr), autonomous driving and vehicle-to-vehicle communications (v2v). further, increased adaptation of unmanned aerial vehicles (uav) may require large swaths of bandwidth and high data rates. indeed, the **\*\*diversity\*\*** of radio spectrum utilization is quickly growing. however, existing wireless networks may no longer be able to keep pace with these technologies, implying a need for new rhythms and targeted innovations. concurrently, security protocols must be adapted to avoid eavesdropping and man-in-the-middle (mitm) attacks. coexistence of active and passive spectrum utilization is another challenge. to address the aforementioned challenges, and to circumvent radio spectrum scarcity, this research brings forward innovations and features to significantly advance next generation wireless networks. among them: 1) increased throughput using robust spectrum sensing and slicing of legacy frequency bands by identifying gray and white spaces/gaps across the available electromagnetic spectrum; 2) frequency independent and high isolation antenna feeds and rf cancellers to enable spectrum co-existence; 3) wideband autonomous multiple-input-multiple output (mimo) transceivers using flex radio architectures to maximize overall spectral efficiency; 4) significant hardware reduction via multiplexing; and 5) resilience against man-in-the-middle attacks via artificial intelligence (ai) techniques. this project will also foster workforce development in the rapidly growing area of wireless engineering. curriculum enhancements are proposed to integrate new technologies on spectrum awareness, wireless security, and cross layer rf transceiver architectures. further, new degrees and

new curricula in wireless and iot technologies will be leveraged to promote stem outreach programs and coordinate outreach activities. the latter will be aimed at recruiting larger cohorts of undergraduates and k-12 students from the local miami-dade and broward counties to be trained in wireless engineering. examples of outreach programs to be leveraged include engineers on wheels, engineering expo, enlace (engaging latino communities for education), and the miami prep (positive youth preparedness) programs. the proposed research aims to develop next generation flexible and secure wireless networking with adaptive rf front ends and back-end cross-layer algorithms that enable spectrum efficiency and high throughput via novel relay architectures, all with end user protection in mind. namely, a new class of low cost and low power secure mimo transceivers with >100 db transmit/receive isolation are proposed along with flexible radio architectures. the following innovations are proposed: 1) ai-based effective spectrum utilization and/or coexistence, 2) innovative transmitter and receiver technologies through cross-layer design, and 3) improved security by detecting man-in-the-middle attacks and other eavesdroppers. notably, the transformative nature of the proposed research stems from the introduced novelties to overcome challenges in developing low-power and low-cost flexible radio architectures and rf electronics with secure data relays to provide resilience for man-in-the-middle attacks. to accomplish the proposed goals, a strong background is required in the following areas: rf front/back-end hardware, mathematical network modeling, propagation, optimization, control, queuing, stochastic analysis, and legacy system operation integrated through the following thrusts: 1) rf reconfigurability and spectrum aggregation to support users with decoupled phy/mac protocols, 2) adaptive flexradio wireless networks with increased throughput and protection using high performance phy/mac layer algorithm, 3) rf self-interference cancellation for spectrum co-existence, and 4) ai-based models for security and privacy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: COLLABORATIVE RESEARCH: 21 cm Reionization Science with the MWA

Awardee: University of Washington

Amount: \$424,878.00

Abstract: the epoch of reionization (eor) is the period of time in the early universe when it is thought that the first stars and galaxies formed. understanding the physics of galaxy formation and feedback during the eor is one of the key goals of modern cosmology and astrophysics. observations of neutral hydrogen in the early universe have the potential to revolutionize our understanding of these first stars and galaxies. this work will improve data analysis with the murchison widefield array telescope so that researchers can make significantly better detections of such faint signals, making the observations much more useful and providing a tool for researchers engaged in similar projects. in addition, this work will continue and expand the initiative to provide research experiences for non-traditional undergraduates. undergraduate research is an essential component in preparing students both for graduate school and for positions in the broader stem workforce. providing this kind of research experience to non-traditional undergraduate students will enable more of them to go on to graduate school, increasing the **diversity** of the broader stem community. this award supports the continued work of a successful eor analysis team. over the past four years innovations by the us imaging power spectrum (ps) team have driven the field forward and have led to the deepest eor ps limits in the world. the investigators will make the next steps needed to reduce the limits by another order of magnitude with murchison widefield array (mwa) data. specifically, this work will make improvements in ps analyses with the mwa that will lower limits on the signal strength by an order of magnitude, making deep cuts into the possible parameter space for eor models. this research will be invaluable for the entire 21 cm community. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: IUCRC Phase II: Washington State University: Center for Bioplastics and Biocomposites [CB2]

Awardee: Washington State University

Amount: \$422,995.00

Abstract: the center for bioplastics and biocomposites (cb2) at iowa state university (isu), university of georgia (uga), washington state university (wsu), and north dakota state university (ndsu) seeks to develop and build on an industry/university cooperative research center (i/ucrc) that focuses on bioplastics and biocomposites. the mission of cb2 is to develop fundamental knowledge related to bioplastics and biocomposites, to disseminate research-based findings to industry to promote sustainability, and to educate future scientists and engineers. as such, there is an expressed industrial interest in leveraging research efforts to accelerate systematic development of standardized material and processing data for these novel plastics and composites. the center focusses on the development of jobs in the area of sustainable manufacturing and the conversion of agricultural and woody crops to bio-based materials that contribute to job creation in the united states. the center also strives to support education and **\*\*diversity\*\*** through engagement of undergraduate and graduate students in research on sustainable materials. the goal of cb2 is to improve the basic knowledge of synthesis, processing, properties, and compounding of bioplastic and biocomposite materials, to develop reliable materials characteristics data for industrial partners, and to support large-scale industrial implementation of renewable materials. the vision of the center is to develop knowledge that will facilitate the production of an array of high-value products, including plastics, coatings, adhesives, and composites, from renewable feedstocks. the materials are compatible with current industrial manufacturing systems and promote rural development as well as national growth. the goals of the phase ii are fourfold: 1) expand the knowledge and develop the science for recycling and end of life treatment of sustainable materials, in particular as they are mixed with petrochemical plastics; 2) expand membership by engaging new companies that have expressed a need for recycling and end of life treatment; 3) develop fundamental knowledge on sustainable materials; 4) prepare students to join the workforce equipped with the knowledge and



skills required by industry. the team of researchers includes experts in the fields of polymer processing, polymer chemistry, materials science, and crop utilization. wsu's research focuses on utilizing industry-relevant technology platforms to develop bio-based composites, coatings and adhesives, and polymers for various industry applications, as well as to recycle bio-based composite materials. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Summer Institutes in Social and Personality Psychology

Awardee: Society for Personality and Social Psychology

Amount: \$421,165.00

Abstract: theory, methodology, and statistics in support of research in social and personality psychology has grown in complexity over the past three decades. these scientific advances are partly due to increasingly connected and diverse academic and professional networks among faculty. this project supports the continuation and extension of summer institutes in social and personality psychology (sispp). graduate students from social psychology and personality graduate training programs attend the advanced two-week intensive training program, led by renowned scholars and teachers in the field. training at this level helps to advance these fields of science and supports the production of important innovations. the institute also focuses on broadening the participation of graduate students who may be from groups historically and currently marginalized in these fields and who may not have intensive access to scholars in multiple subfields of their interest. evaluation of the previous training institutes (supported by nsf) reveals that graduate students who participate are successful in obtaining academic positions, peer-reviewed publications and funding for their research. affording graduate students with cutting-edge theoretical and methodological training enhances their ability to participate in interdisciplinary and international collaborations, which are increasingly important across all of science. scheduled every two years,

sispp provides an opportunity for approximately 100 advanced graduate students in social and personality psychology ph.d. programs to obtain intensive experience and instruction in cutting-edge theories, research, and methods. because graduate programs offer strengths in different areas, preference for attendance is given to students whose home institution does not offer strengths in the topics covered during a particular summer institute. sispp has been successful in fostering **\*\*diversity\*\*** in the field, both in promoting the careers of members of historically underrepresented groups and in enhancing the graduate training of students from programs with different emphases and resources. sispp has been successful in fostering research collaboration and communication networks among individuals from different laboratories, universities, regions, and nations, and creating a collaborative scholarly community for a new generation of researchers. the diversifying experiences enabled by sispp are critical for fostering creativity, innovation, and flexible scientific practices, and for expanding the scientific potential for social and personality psychology to support solutions to important societal challenges. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Digitization TCN: Collaborative Research: Bringing Asia to digital life: mobilizing underrepresented Asian herbarium collections in the US to propel biodiversity discovery

Awardee: Regents of the University of Michigan - Ann Arbor

Amount: \$420,761.00

Abstract: Asia is the largest continent on earth, and includes the world's tallest mountains, lowest landscapes, and habitats ranging from arctic tundra to tropical rainforests and mangroves to deserts. The plants of this region are incredibly diverse in their identities and functions. More than one-third of the world's 350,000 plant species grow in Asia and include tiny alpine cushion plants, medicinal herbs, ancient crops, and some of the planet's tallest rainforest trees. But documentation of this **diversity** remains inaccessible and research about it is difficult because most herbarium specimens of Asian plants have not been digitized. The All Asia Thematic Collections Network (TCN) will mobilize online 15 million specimens of Asian plants currently housed in the US and around the world. The project will especially focus on digitizing specimens from the unique and critically endangered bio**diversity** hotspots of Southeast Asia and the Himalaya-Hengduan region. These mobilized digital data will accelerate research to conserve endangered plant species and understand the interacting effects of evolution and global environmental change on plant species **diversity**. The project will apply state-of-the-art informatics tools and high-throughput digitization methods to efficiently and affordably digitize an unprecedented number of herbarium collections. This effort will connect and build long-lasting relationships among 25 large and small consortium institutions in the U.S., Europe, and Asia. The focal areas from which specimens will be digitized encompass five bio**diversity** hotspots that include ~20% of the world's vascular plant flora and historically spanned 3 million km<sup>2</sup> of primary vegetation that now covers less than 300,000 km<sup>2</sup>. Fundamental bio**diversity** data for these bio**diversity** hotspots are lacking, along with the necessary baselines required to characterize species' identity, range, and responses to ongoing climatic change. The overall goals of the All Asia TCN are to rapidly digitize herbarium specimens of Asian plants to advance bio**diversity** discovery and provide critical baseline assessments

essential for establishing floristic change in the anthropocene. the project will accomplish this by (1) digitizing 3 million asian vascular plant specimens from u.s. herbaria; (2) developing and applying novel informatics tools and high-throughput digitization methods to massively scale herbarium digitization; (3) aggregating and mobilizing the digitized records from the project with those by international partners in china, france, the netherlands, and russia to establish a single online all asia portal of ca. 15 million specimens; and (4) enhancing opportunities for early career learners in science, technology, engineering, and mathematics by stimulating synergies between bio\*\*diversity\*\* and computer scientists who will use design thinking principles to create real-world informatics solutions to bio\*\*diversity\*\* challenges. to stimulate curiosity in plant \*\*diversity\*\* and botanical exploration among the general public, the consortium members will host several asia-themed notes from nature virtual expeditions to facilitate additional specimen digitization by citizen-scientists. digitized specimen data mobilized through this project will be shared and made available through idigbio.org. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: REU Site: Sustainable Resilient Transportation Systems

Awardee: University of Delaware

Amount: \$420,383.00

Abstract: climate change is one of the major challenges that the u.s. faces in the 21st century. carbon emissions, as a major catalyst, are in great part a result of construction, maintenance, and operation of transportation systems. with support from the nsf division of engineering education and centers, this award establishes the reu site in sustainable resilient transportation systems at the university of delaware which will contribute to the state-of-the-art technologies and design methodologies with a potential to reduce carbon emissions and, consequently, help address climate

change. the site will host a diverse cohort of undergraduate researchers who will engage in interdisciplinary research programs in electric and autonomous vehicles; green construction materials and structures; and resilient infrastructure. by enabling low-carbon footprint transportation systems, the reu site contributes towards improved global economic prosperity, the safety of our planet's residents, and future development. training provided at the reu site will help develop a diverse stem workforce capable of tackling the complex engineering challenges of the 21st century, improving the u.s. competitiveness at the global level. this unique program provides students with research experiences in sustainable resilient transportation systems; develops students' experimental, quantitative analysis, and communication skills; fosters student appreciation of interdisciplinary collaborations, the pursuit of graduate degrees and careers in transportation-related fields; and increases the **\*\*diversity\*\*** of the transportation workforce. this is accomplished by the students participating in individual and cohort experiences. individual experiences will promote students' transition from dependent to independent researcher status in their laboratory by engaging students in personalized mentoring with reu site faculty advisors. cohort experiences are designed to strengthen students' intellectual focus in sustainable resilient transportation systems, support the development of students' research skills, and encourage student-student communication and collaboration. it is anticipated that this work will contribute to the development of more diverse engineering programs for students underrepresented in stem as well as provide opportunities for students that have limited access to research experiences. this underserved population presents a significant potential benefit to society in areas in which innovation and creativity are most needed. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: SWIFT: Cognitive-IoV with Simultaneous Sensing and Communications via Dynamic RF Front End

Awardee: University of Minnesota-Twin Cities

Amount: \$420,000.00

Abstract: future transportation is promising safer and more efficient traveling via connected intelligence among vehicles as well as with the transportation infrastructure. at the same time, travelers can also be relieved from tedious driving and use vehicles as offices or entertainment rooms on the move. essential to all these is a reliable and resilient internet of vehicles (ioV). given the unique transportation environment, a satisfactorily functioning ioV is confronted with many challenges. for example, data services for transportation safety/efficiency and/or traveler convenience/comfort are often very sensitive to delays and require large bandwidth. the vehicular environments are also filled with various communication services as well as active sensing devices, which can potentially cause interferences to each other. in addition, the high mobility inherent to transportation and fluctuation of the transportation information exchange depending on the specific traffic scenario can both lead to fast-changing and possibly unpredictable dynamics. to address these challenges, this project organizes collaborative efforts to enhance spectrum utilization, sharing and management in ioV. the project will promote the interactions among multi-disciplinary experts such as electromagnetic waves, electronics, signal processing and wireless communications to create wireless innovations at different network layers. the developed technologies will provide



valuable tools for foundational science and engineering research and promote societal embracing of the emergent cognitive iov technologies. the project also has an integrated education plan that aims to prepare the workforce to address future challenges of spectrum utilization and wireless communications, while promoting and embracing **\*\*diversity\*\*** in science and engineering. this project aims to develop a cognitive iov framework with simultaneous sensing and communications via a novel dynamic rf front end. targeting the aforementioned challenges, the proposed iov research has three distinctive features. first, the proposed research is centered at simultaneous communications and sensing. based on a dynamic rf front end that is innovatively designed to facilitate full duplex modes, communications and simultaneous monitoring of multiple spectrum bands with tunable granularity become possible. secondly, the resultant iov framework is cognitive in two counts: i) cognitive in the spectrum environment - the spectrum sensing information from devices equipped with the dynamic rf front end is used to develop algorithms to learn and track the spatiotemporal radio tomography with quantifiable uncertainty; and ii) cognitive in the physical environment - with judiciously designed waveforms that enable simultaneous communications and active physical environment sensing, the acquired information will be leveraged to enhance communications. last but not least, the proposed cognitive iov framework is dynamics-ready via hardware, architecture, and algorithm design: the dynamic rf front end boasts real-time tuning and control capability, the network architecture incorporates unmanned aerial vehicles (uav) to mobilize on-demand support for transportation/traveler data service hotspots, and reinforcement learning algorithms developed to achieve closed-loop control and management of spectrum resources will remain robust when the dynamics are unknown or unpredictable. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: GP-IN: Families and University Together as a Unit for Research and Education (FUTURE):

## Connecting Hispanic Families to Geosciences Through Community Informal Learning Network

Awardee: The University of Texas Rio Grande Valley

Amount: \$419,996.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). a strong and diversified next generation geoscience workforce will play a critical role in solving crucial global threats (water, energy, natural hazards, and food) under climate stresses in the coming decades. in the u.s., the geoscience workforce has the least ethnic **\*\*diversity\*\*** compared to other stem fields (e.g., ~3% hispanics). national academies press states that minority serving institutions are america's under-utilized resource for strengthening the stem workforce for the near future. the university of texas-rio grande valley (utrgv), as the nation's second largest hispanic serving institution (with ~32,000 students and ~90% hispanic), and its location at the u.s.-mexico border, make it an ideal hub for training the future hispanic geoscience workforce. the future project integrates the hispanic culture into an informal geoscience and stem learning pathway through a family-centered model to address the challenge of enhancing hispanic participation in stem. a family-centered learning framework will help families understand one of the most critical elements in their lives ? water supply/resources? and its relationship to the geoscience/earth environment. with the experience gained in a previous geopaths project, the project team aims to expand and scale up the established platform and infrastructure of its existing program transforming the traditional geoscience learning ecosystems (gles) while nurturing the hispanic geoscience workforce in a way that can be expanded to other minority serving institutions. the future project will explore how the family can be placed at the center of informal stem learning and be the basis for understanding a geoscience issue ? how water works;? i.e., the water cycle with humans at the center, and the activities/link to earth environment (i.e., mining and agriculture in texas). the future project has four objectives: (1) establish an informal learning network with a water and earth-environmental science theme at communities; (2) change hispanic families' (parents and children) perspectives towards geosciences careers; (3) recruit students into geoscience through a

developed network and (4) provide a channel into geoscience education and career paths for local junior/senior high school and 2-year college students. the project offers activities focused on water, soil, rocks and minerals, geoscience and their relationship to rio grande valley's history and economics (oil/gas mining and agriculture). future's innovative approach will test how informal learning networks between the local community and educational institutions can transform gle for individuals from groups that have historically been underrepresented in stem. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RCN: Expanding the History of Science, Technology, Environment, and Medicine: The United States and its Regional Neighbors

Awardee: University of Maryland, College Park

Amount: \$419,209.00

Abstract: science has often been understood as a universal language, involving conversations across all parts of the planet. however, as recent controversies regarding vaccination and climate change remind us, not everyone understands science in the same way. recent research on science, technology, environment, and medicine is addressing this issue by looking at how diverse publics engage with and apply science. they are also analyzing how these disparate publics influence scientific innovation. still, most of this research focuses on the united states and europe. this project provides a more comprehensive view of how science works by examining scientific innovation and application in latin america and the caribbean and the relation of science in the region to other sites. by sponsoring a website, workshops, and publications, the project will produce new resources for teachers and researchers, providing access to cutting edge studies of science in latin america and the caribbean. it will also train a new generation of graduate students in the history of science to conduct research on latin america and the caribbean and to incorporate the region into their

courses. this research coordination network project brings together senior and established researchers and graduate students to take stock of the vibrant and burgeoning fields of science, technology, environment, and medicine in latin america and the caribbean. our network will secure ties among researchers in north and south america and unify discussions taking place with a variety of academic societies and organizations. it will produce publications that make this research available to those who are not specialists in the region. the ethnic and racial **\*\*diversity\*\*** of latin america and the existence of creolized indigenous and afro-descendant knowledge practices make it an excellent place for advancing knowledge of worldviews that challenge or coexist with scientific rationalities. project participants will include graduate students in the history of science and provide them with in-depth training and mentoring on latin america and the caribbean--training that is not readily available in the majority of history of science graduate programs. k-16 teachers will gain access to bibliographies, lesson plans, essays, and collections of syllabi that allow them to cover a broader range of scientific endeavors and of a more diverse community of scientists. their students will in turn incorporate and reproduce more complete and complex representations of how science functions globally. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: A Robust Temporal Framework for the Paleoproterozoic Crash of Atmospheric Oxygen

Awardee: University of Wisconsin-Madison

Amount: \$419,135.00

Abstract: the protracted rise of atmospheric oxygen has important implications for the trajectory of biological evolution and global nutrient cycling. this work will test ties between large-scale environmental changes and biotic macroevolution in the paleoproterozoic. investigators will obtain age constraints for sediments within the onega basin of russia and the lastoursville basin of gabon

to evaluate the synchronicity of carbon burial episodes potentially associated with an overshoot and crash of atmospheric oxygen levels in the paleoproterozoic era. the geochemical constraints they obtain will allow to critically evaluate the synchronicity and extent of marine conditions and oxygen levels at the termination of what may have been the most dramatic disturbance to the carbon cycle in earth history. these efforts will be paired with a science video-logging series, terralingua: reading the rock record, which will be broadly disseminated through the travelinggeologist platform on social media, reaching a total audience of over one million globally. this series will provide content highlighting the variety of tasks that geoscientists complete, including field work in russia with a team of international collaborators, geochemistry laboratory and mass spectrometry work, and will also cover common barriers to entry in the geosciences and academia. the goal of this project is to improve our understanding of the trajectory of atmospheric oxygen during the ~2.3-2.0 ga lomagundi-jatuli (lj) positive carbon isotope excursion and the subsequent shunga negative carbon isotope excursion in the onega basin of russia and the lastoursville basin of gabon. the proposed research will address: 1) how did oxidative weathering vary during these carbon isotope excursions? 2) do the end-lj and the shunga event occur synchronously in the onega and lastoursville basins? the petrologic, isotopic and temporal constraints to be determined will permit global correlations and shed novel insights into the rise of oxidative weathering and global carbon cycling at this critical juncture. this will support education, outreach, and **\*\*diversity\*\*** initiatives through the training of a phd student and postdoc and the production of a broadly disseminated videologging series (terralingua: reading the rock record) focused on geochemistry as well as promoting inclusivity in field- and laboratory-based geoscience fields and more broadly within academia. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MRI: Acquisition of a controllable pulse transcranial magnetic stimulator with robotic

positioning and integrated EEG / EMG for engineering and neuroscience research and education

Awardee: Northeastern University

Amount: \$417,913.00

Abstract: understanding the brain's role in behaviors such as movement, cognition and emotion is paramount to progress in science and engineering, and to advancing improvements in health and wellness. invasive approaches in animals cannot be readily adapted to humans, creating a technological barrier to causal study of the brain in awake behaving humans. one promising approach in humans, transcranial magnetic stimulation, uses magnetic pulses to noninvasively and safely modulate brain activity. however, stimulators modulate brain cells (neurons) indiscriminately, which prevents studying how distinct neurons drive behavior. this award will facilitate the acquisition of a cutting-edge stimulator that allows scientists to modulate specific neuron populations in the brain. the system includes an integrated positioning robot for precise localization and recording devices that read physiological signals from the brain or muscles to objectively quantify the effects on different neural populations and behavior. this instrumentation will enable discoveries that will catalyze new research in the study of brain and behavior. crucially, the instrumentation paired with the proposed education plan will create unique training opportunities for students in stem and health science, lowering the barrier of entry for underrepresented students, including persons of color and women. the project leverages northeastern university's experiential education model and various **\*\*diversity\*\***/inclusion initiatives to support research by diverse (under)graduate and k-12 students and teachers. the project proposes the acquisition of a controllable-pulse transcranial magnetic stimulator capable of differentially modulating specific neural populations in the human brain, with integrated robotic positioning and electroencephalography and electromyography recording. this instrumentation will be the only such system in the northeastern us. as part of the northeastern university non-invasive brain stimulation center, it will enable unprecedented basic science research into human neurophysiology and brain-behavior relationships, and significant advances in fundamental engineering research in stimulator development, automated robotic positioning,

stimulation-induced artifact removal in physiological recordings, closed-loop stimulation, and artificial intelligence / machine learning algorithms. allowing researchers to control stimulus waveforms and to differentially activate distinct neural populations will enable a scientific scope of work that will transcend multiple disciplines including motor and affective neuroscience, cognition, memory, development, aging, and biophysical modeling of brain physiology. the proposed **\*\*diversity\*\*** and education plan enabled by this instrument will lower barriers for underrepresented minority students to engage in cutting-edge experiential stem education. the project's impact will be profound on science and technology innovation, as well as in training a new, diverse, interdisciplinary workforce to drive this field forward. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Does Cytonuclear Coevolution Drive Reproductive Isolation?  
Dissecting the Architecture of Genetic Incompatibility Across a Species Range

Awardee: University of Virginia Main Campus

Amount: \$416,757.00

Abstract: the natural world exhibits a vast array of bio**\*\*diversity\*\*** which ensures the stability of ecosystems, the services they provide, and has intrinsic aesthetic value. individual species are critical elements of this bio**\*\*diversity\*\*** and understanding how new species form is key to ensuring maintenance of **\*\*diversity\*\***. interactions between the nuclear genome and organelle (mitochondria and chloroplast) genomes underlie key processes including respiration and photosynthesis. these interactions are an underappreciated and yet potentially powerful driver of the earliest stages of speciation. the planned research will investigate the contribution of intergenomic interactions to incompatibility between populations of a species. the research will use state-of-the art techniques to identify the genomic basis of incompatibility between the nuclear and organelle genomes and

determine the ability of such incompatibility to maintain genetic divergence and facilitate speciation in a contact zone. the project will also introduce undergraduate students and high-school and community college teachers to core ideas about species formation and evolution through hands-on experience with the newest genomic sequencing technologies in a novel course-based lab module and workshop. finally, the project will provide training at the undergraduate, graduate, and post-graduate level. interactions between cytoplasmic and nuclear gene products are expected to drive intergenomic coevolution, leading to the potential for genetic incompatibility and reproductive isolation between populations with divergent cytoplasmic genomes. while such cytonuclear incompatibility (cni) has been posited to be among the earliest reproductive barriers to develop during speciation, our understanding of the dynamics of cni at the early stages of speciation remains limited, particularly for plastid-driven speciation. the research will examine the dynamics of plastid driven cni in *campanula americana*, creating a powerful set of genomic resources, characterizing variation in the genetic architecture of cni across lineages, and leveraging a natural contact zone to evaluate whether exposure to selection alters the genetic architecture of cni relative to allopatry. together, these data will provide insight into the evolutionary dynamics of plastid-nuclear incompatibility and how these dynamics may drive the early stages of speciation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Chemical imaging of sheets, surfaces, and interfaces

Awardee: University of Tennessee Knoxville

Amount: \$416,184.00

Abstract: non-technical summary with this project, which is supported by the solid state and materials chemistry program in the division of materials research, professor janice musfeldt and her research group will explore the properties of material sheets, and material surfaces and interfaces



using near field-infrared spectroscopy, and will invest in the education of a diverse group of young people at the university of tennessee. both initiatives will advance the use of chemical imaging spectroscopies at synchrotron facilities and contribute to important societal values and outcomes. a variety of material systems will be imaged including van der waals, ferroic, and catalytic materials. these material sheets and textures are small in size - well below the diffraction limit of traditional infrared spectroscopies - which is why near-field imaging approaches such as those employed in this project have the potential to be transformative, also in unraveling important structure-property relationships. a broad range of educational, outreach, and service activities will also take place under the auspices of this national science foundation-funded program, especially in the areas of **\*\*diversity\*\***, conference and workshop organization, and service to various national laboratories.

technical summary    the research, which is supported by the solid state and materials chemistry program in the division of materials research, employs synchrotron-based near-field infrared spectroscopy to image a variety of materials with different functionalities. the focus is on van der waals, ferroic, and catalytic materials, as well as the structure-property relationships that can be unraveled in these systems. the goals are to: (i) explore symmetry and properties of magnetic and heavy chalcogenides and halides in the ultrathin limit, (ii) reveal interface dynamics in unusual settings such as at ferroelastic and ferroelectric domain walls, (iii) untangle chemical bonding heterogeneities and their relationship with catalytic behavior, and (iv) understand how these effects can be enhanced and controlled. what brings these efforts together is an overall interest in imaging heterogeneity in quantum materials and the opportunity to explore completely new types of light-matter interactions. findings from this program will advance the development of theoretical approaches and of energy-related applications. this program also supports the interdisciplinary education of a diverse group of young researchers for future employment in academics, government laboratories, and industry in the area of advanced materials.    this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: Redefining the footprint of deep ocean methane seepage for benthic ecosystems

Awardee: University of California-Los Angeles

Amount: \$415,399.00

Abstract: this research examines the role of deep-sea organisms in determining the fate and footprint of methane, a potent greenhouse gas, on pacific continental margins. the investigators are evaluating the deep ocean methanosphere defined by the microbial communities that consume methane and the animals that directly feed on or form symbioses with methane-consuming microbes. they are also investigating animal communities that gain energy indirectly from methane, as well as those that take advantage of carbonate rocks, the physical manifestation of methane consumption in seafloor sediments. the study of methane seeps in the deep waters of both alaska (4400-5500 meters) and southern california (450-1040 meters) is enabling comparisons of the methanosphere under different food-limitation and oxygen regimes. by applying diverse chemical, isotopic, microscopy, and genetic-based analyses to seep microbes and fauna, this study is advancing understanding of the contribution of methane to deep-sea bio\*\*diversity\*\* and ecosystem function, information that can inform management and conservation actions in us waters. in addition

to training for graduate and undergraduate students at their home institutions, the investigators are collaborating with the alaska native science and engineering program (ansep). they are recruiting alaskan undergraduates to participate in the research, contributing to ansep's online resources that promote interaction between scientists and middle and high school students, and participating in ansep's annual residential career exploration in marine science programs to engage middle school students in learning about deep-sea ecosystems and the variety of career pathways available in marine related fields.

microbial production and consumption of methane is dynamic and widespread along continental margins, and some animals within deep-sea methane seeps rely on the oxidation and sequestration of methane for nutrition. at the same time, understanding of methane-dependent processes and symbioses in the deep-sea environment is still rudimentary. the goals of this study are to 1) examine the **diversity** of animals involved in methane-based symbioses and heterotrophic consumption of methane-oxidizing microbes and how these symbioses extend the periphery of seeps, contributing to non-seep, continental slope food webs; and 2) determine whether carbonates on the seep periphery sustain active methanotrophic microbial assemblages, providing a localized food source or chemical fuel for thiotrophic symbioses, via anaerobic oxidation of methane, or free-living, sulfide-oxidizing bacteria consumed by animals. the investigators are addressing these goals by surveying, sampling, and characterizing microbes, water, sediments, carbonates and animals at a deep seep site on the aleutian margin and a shallow site off southern california. shipboard experiments and laboratory analyses are using molecular, isotopic, geochemical, and radiotracer tools to understand transfer of methane-sourced carbon from aerobic methanotrophs under multiple oxygen levels, pressures, and photosynthetic food inputs. this approach offers a wide lens by which to examine the methane seep footprint, allow reinterpretation of past observations, and identify new scientific areas for future study. improved characterization of the deep continental margin methanosphere informs climate science, bio**diversity** conservation, and resource management. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts

review criteria.

Matched Words: diversity

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Title: CCSS: Online Learning for IoT Monitoring and Management

Awardee: University of Minnesota-Twin Cities

Amount: \$415,000.00

Abstract: at the core of several emerging technological advances lies the notion of internet-of-things (iot). conceptually, iot is envisioned as an intelligent network infrastructure with a huge number of ubiquitous smart devices present in diverse application domains such as smart buildings, group and personalized healthcare, as well as self-driving connected vehicles, to name a few. today, a number of iot applications have already improved many aspects of daily life. however, critical challenges need to be addressed before embracing the full potential of iot. this in turn calls for innovative machine learning approaches that account for scalability, heterogeneity, adaptivity, and robustness to unpredictable uncertainties -- what are the central challenges facing the emerging iot monitoring and management tasks. novel algorithms and their performance need to leverage recent advances in data science, optimization, statistical signal processing, communications, and networking. in addition to markedly influencing future iot modules, insights gained from this project's learning and inference will also cross-fertilize benefits to a gamut of additional domains, including smart grids, smart cities, and self-driving vehicles. at a broader scale, the developed technologies will provide valuable tools for foundational science and engineering research, and advocate societal embracing of the emergent iot technologies. broader impact will be further effected by the integration of research with an educational plan designed to train the new cadre of next-generation of iot professionals, as well as foster cross-pollination of academic research to industry needs, while promoting and embracing **\*\*diversity\*\*** in science and engineering. to address the core iot challenges, this project puts forth foundational tools for real-time interactive function learning using an ensemble of experts. learning algorithms will be developed with adaptivity and quantifiable

performance even in environments with unpredictable dynamics, but also with ability to scale in terms of i) the huge number of "things" in iot; ii) the high-dimensional feature vectors involved in sophisticated learning tasks; and iii) the massive data collected, processed, and exchanged over the iot graph ? what is desired for iot monitoring. scalability, adaptivity, and robustness benefits in learning nonlinear functions will be further permeated to interactive black-box bayesian optimization, and reinforcement learning with an ensemble of experts -- merits that will boost performance in open- and closed-loop iot management. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Toward lifelike synthetic cells via engineered control of DNA replication

Awardee: University of New Mexico

Amount: \$414,071.00

Abstract: the ability of cells to reliably replicate and maintain genomic information is a key facet of life. recapitulating these mechanisms is a critical step towards the development of autonomous synthetic cells that exhibit self-replication and stable propagation of their genetic information. to that end, this project creates a new synthetic mechanism for dna replication control in synthetic cells that will open the door for new applications in biomedicine and biotechnology. this project carries out an integrated social science investigation into the current regulatory framework surrounding engineered synthetic cell technologies. this project also provides educational and technical training aimed at increasing the number and **\*\*diversity\*\*** of undergraduates and graduates pursuing careers in synthetic cell research. public outreach is carried out in conjunction with local partners to increase public awareness of synthetic cell technologies. natural cells have evolved sophisticated mechanisms to control dna replication, to prevent the loss of critical genes while simultaneously

preventing runaway replication. analogous replication control mechanisms will be required for synthetic cells. while natural genome replication control systems are complex, plasmids provide a simple yet powerful and modular system for building synthetic replication control systems and modular genomes for synthetic cells. this project addresses the broad challenge of engineering dna replication control mechanisms for synthetic cell systems. rna engineering techniques are used to create modular and programmable synthetic plasmid replication control systems that function in both cells and cell-like systems. this project also studies how dna replication can be utilized for novel biosensing applications. biocontainment applications are investigated through an integrated social science investigation. this award is co-funded by the systems and synthetic biology cluster in the division of molecular and cellular biosciences and the cellular and biochemical engineering program in the division of chemical, bioengineering, environmental and transport systems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: CAREER: Evolutionary Disease Ecology- Can evolutionary responses to environmental change modify the biodiversity-disease relationship?

Awardee: SUNY at Binghamton

Amount: \$413,756.00

Abstract: understanding patterns of emerging infectious diseases is at the forefront of global interest. this research asks: "why are some communities more vulnerable to diseases than others?" to address this broad question, this work focuses on understanding how bio**\*\*diversity\*\*** influences



community disease risk. while many studies find that communities with higher bio\*\*diversity\*\* have lower disease risk, some studies show no effect of bio\*\*diversity\*\* on disease risk and others even find the opposite effect (i.e. communities with higher bio\*\*diversity\*\* have higher disease risk). overall, the idea that bio\*\*diversity\*\* can reduce disease risk is attractive because it suggests that protecting bio\*\*diversity\*\* has clear benefits to both nature and society. this research tests the central hypothesis that cryptic differences in population's responses to past conditions (i.e. evolutionary history) plays an important role in understanding when bio\*\*diversity\*\* will reduce disease risk. this career award will develop a summer research and outreach program that supports undergraduate artists, engineers, biologists, and educators and a 3rd grade citizen science training program. the bio\*\*diversity\*\*-disease (bdd) relationship has generated considerable attention as a theoretical framework for predicting community disease outcomes. yet, limited consensus on the generality of the bdd relationship has been reached leading to repeated calls to uncover factors shaping the magnitude and direction of the bdd relationship. this research tests the hypothesis that intraspecific host variation, generated by divergent evolutionary histories, plays a cryptic role in shaping the direction and magnitude of the bdd relationship. to this end, the research focuses on amphibian host-parasite interactions and takes advantage of an experimentally tractable group of focal wood frog populations that exhibit intraspecific variation in parasite susceptibility as a result of evolving in contrasting environments. the researchers will first, evaluate the contribution of intraspecific variation to shaping the bdd relationship by generating mesocosm communities that vary in amphibian host species \*\*diversity\*\* and focal host intraspecific \*\*diversity\*\*. second, to integrate ecological context into our understanding of how intraspecific variation influences the bdd relationship, the researchers will conduct lab and mesocosm studies testing whether intraspecific variation in focal hosts can shape the bdd relationship by modifying (a) competitive, (b) predator-prey, or (c) host microbiota interactions. third, to complement the controlled experimental studies, the researchers will conduct a citizen-led field surveys to evaluate whether intraspecific variation modifies the bdd relationship in more complex natural ecosystems. towards this aim, the

researchers will develop a two-step integrated education-research program: (1) content development: researchers will design an interdisciplinary program where undergraduates work with local communication and education experts to develop a citizen training program. (2) implementation: citizens will complete training program and collect field data that contributes to the overarching research goals. collectively, this integration will facilitate citizen data collection efforts, diversify stem training and engagement, and broaden access to authentic research opportunities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MCA: Integrating immune system and microbiome function during amphibian development

Awardee: University of Colorado at Boulder

Amount: \$413,329.00

Abstract: microbial organisms, such as bacteria, often live in a symbiotic relationship with animals and provide beneficial functions that support health of the host animals. for many of these bacterial and animal symbiotic relationships, we know very little about their specific biology and what kinds of beneficial functions the symbiotic partners provide. like most vertebrate animals, amphibians have complex immune systems with innate and adaptive immune functions, however amphibians do not develop a fully capable immune system until after they metamorphose from the aquatic tadpole life stage. the investigator proposes a novel hypothesis postulating that the symbiotic skin bacteria on aquatic tadpoles provide protective defensive functions while the immune system is not yet mature. the project will test this idea using an experimental approach that will examine the immune system and bacterial symbionts of an amphibian during its development from the egg and tadpole stages through metamorphosis. the colorado boreal toad will be featured in this work, and it is locally endangered in the southern rocky mountains due to a fungal skin pathogen. this project will advance understanding of the ways in which boreal toads defend themselves against the pathogen which can

be helpful for conservation of the species. the investigator is a mid-career scientist who will work with a collaborator and mentor to expand learning how to apply immunology methods to amphibian disease research. the investigator is also dedicated to service in her position to support **\*\*diversity\*\***, equity and inclusion as the director of graduate studies in her unit. host-associated microbes provide a range of beneficial and necessary functions for their host organisms, yet the processes that drive the assembly of host-associated microbial communities is a significant knowledge gap. this project will study microbiome function on the skin of amphibians in order to examine the role of symbiotic microbes in pathogen defense and how that functioning changes during amphibian development. growing a complex immune system that is capable of targeting and ridding harmful pathogens takes significant developmental time, and most of the adaptive immune system of amphibians does not come online until after metamorphosis. this begs the question, how do larval, aquatic amphibians defend themselves against a sea of opportunistic pathogens prior to the full functioning of the immune system? this project will test the idea that larval amphibians assemble a symbiotic microbial community with pathogen defense as a primary function, the ?microbial surrogate defense system hypothesis?, prior to the maturation of the immune system. the investigator proposes a time-series experiment that will track the symbiotic skin bacteria and immune function during boreal toad development and conduct three pathogen challenge trials that will occur before, during, and after metamorphosis, respectively. the project will use both culture-dependent and sequencing tools to characterize the bacterial symbionts and immunogenomic and transcriptomic tools to characterize immune function. this project represents a first-time collaboration between the pi and a research partner who will provide expertise on amphibian immunogenetic tools as well as mentoring related to career advancement for the pi. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: HSI Implementation and Evaluation Project: Advancing the Reach and Scope of Supplemental Instruction

Awardee: North Park University

Amount: \$413,066.00

Abstract: with support from the improving undergraduate stem education: hispanic-serving institutions (hsi program), this track 2 project focuses on increasing stem student retention and success in entry-level courses at a hispanic serving institutions (hsi) by expanding and adapting supplemental instruction (si) to online learning environments. si is a peer-facilitated academic support program consisting of regularly scheduled out-of-class collaborative learning sessions. there is growing demand for well-trained stem professionals, but high rates of student attrition in introductory level science and engineering courses limit the number of stem degrees awarded. additionally, **diversity** and inclusion in stem fields remains a major concern, with students from traditionally underrepresented backgrounds earning stem degrees at levels well below rates of enrollment. si participation is a positive predictor of higher grades and student success in introductory stem courses, and interaction with si leaders of diverse backgrounds has been shown to further benefit underrepresented student groups in these classes. this project will expand face-to-face and online si offerings to make si more accessible and beneficial to a diverse group of stem students, including non-traditional and commuting students. in addition, the project will seek to expand si leadership opportunities to traditionally underrepresented student groups. the project aims to (1) determine the impact of the si program on student retention and success in introductory science courses, and (2) determine the effect of the si program on student's metacognition, affective components of learning, and positive attitudes toward stem education and stem careers. this multi-year project will employ a variety of quantitative and qualitative research methods over a period of three successive fall academic terms. findings will be compared among three student groups/ sets: those who attend required face-to-face si sessions, those who attend required online si sessions, and those for whom si session attendance is optional. the research will provide insight into

the effect of face-to-face and online si implementations on student success, particularly among non-traditional and commuter student populations to whom face-to-face si sessions may be less accessible. in addition, the project findings will contribute to best practices for successful adaptation of si to online learning environments. broader dissemination of the findings at national conferences and in peer-reviewed educational journals of respective stem fields will allow participants to share insights and innovations with the growing community of stem educators leveraging peer-facilitated learning models. the hsi program aims to enhance undergraduate stem education, broaden participation in stem, and build capacity at hsis. achieving these aims, given the diverse nature and context of the hsis, requires innovative approaches that incentivize institutional and community transformation and promote fundamental research (i) on engaged student learning, (ii) about what it takes to diversify and increase participation in stem effectively, and (iii) that improves our understanding of how to build institutional capacity at hsis. projects supported by the hsi program will also draw from these approaches to generate new knowledge on how to achieve these aims. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: REU Site: Research Experiences for Community College Students in Physics and Astronomy

Awardee: CUNY Queensborough Community College

Amount: \$412,659.00

Abstract: this award is funded in whole (or in part) under the american rescue plan act of 2021 (public law 117-2). this research experiences for undergraduates (reu) site at queensborough community college in new york city has a number of broader impacts that focus on providing research opportunities to undergraduates to help prepare them for future science, technology, engineering, and mathematics (stem) careers. the site focuses on providing research opportunities to students from community colleges who have had no prior research experience. the site has a

strong plan to recruit students from groups underrepresented in physics. the research projects proposed for the students to engage in are varied and reach across different physics and astronomy topics including black holes, biophysics, cosmic ray detection, x-ray spectroscopy, acoustics, and climate change. due to the **\*\*diversity\*\*** of the research topics offered the students have an opportunity to engage in research that excites them while mastering skills that can be applied to the academic journey in a number of ways. participants will have the opportunity to access and analyze big data using large national databases which will give them skills in understanding and applying large amounts of data. they will learn computational methods to create applications that can collect and manipulate data as well as run large simulations from basic equations that will predict physical outcomes. they will have the opportunity to physically build detectors and assist in collecting and analyzing data from experiments with partners all over new york. the reu site at queensborough community college provides opportunities to twelve undergraduate students at community colleges per year. one of the goals of the reu site is to prepare the students to be competitive for transfer to a four-year college in a stem discipline. in addition to participating in research with an experienced mentor, the students will engage in activities to ensure not only that their research stays on track but that they have an engaging collegial and scholarly experience. the skills of data handling and analysis, building and controlling equipment and computation methods can be applied to their academic path and many of their careers. a focus on scientific communication and collaboration will also be emphasized which is an essential skill for any stem student in all aspects of their journey. by the end of the program, every student will present the results of their work in a seminar talk. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: RoL: The intersection between cell fate decisions and phenotypic diversification in a rapidly radiating butterfly lineage

Awardee: George Washington University

Amount: \$410,662.00

Abstract: animal structures are made of combinations and arrangements of distinct cell types, the product of complex cell decision-making during development. but how do cells, which contain identical genetic information, decide their fate? this research addresses this fundamental biological question in a simple, yet spectacularly diverse animal structure?the color patterns on the wings of heliconius butterflies. although heliconius wing patterns are highly diverse, they are created by altering the distribution of just three cell types (red, black and yellow wing scales) across the wing surface. unlike in a complex organ, the cell decisions that create these patterns unfold on a flat canvas of non-migrating cells. this attribute greatly simplifies the process of understanding the interactions among genes and how these interactions change throughout development to create a specific pattern. this research capitalizes on this fact and emerging genomic tools to characterize the molecular decisions that determine how a developing wing cell becomes specified into one of the three different scale cell types. the project is strengthened by a 6-month internship program that targets traditionally underrepresented groups and offers an in-depth research experience and hands-on professional development. moreover, through partnerships with science museums, this project will create bilingual (english and spanish) experiential learning resources that harness the potential of butterflies to educate a variety of audiences (school children, teachers, and life-long learners) about genes, development, natural selection, and the role that interactions among them play in generating earth?s bio\*\*diversity\*\*. evolutionary processes constantly generate and rearrange specialized cell types, forging the morphological dimension of bio\*\*diversity\*\*. research is starting to connect changes in gene expression and open chromatin to cell fate decisions. however, this research has mostly focused on early embryonic development or on the developmental trajectories of complex organs in a few species. although powerful, these studies do not have an explicit goal of linking changes in cell fate decisions to phenotypic change. this research fills this important knowledge gap by characterizing the rules governing cell specification? from signals, to

reception, transduction, transcriptional activation, and fate determination during the critical developmental period when the wing patterns of heliconius butterflies are established. here, extensive knowledge of the ecological and evolutionary significance of wing color patterns, experimental tractability, and fantastic **\*\*diversity\*\*** make heliconius a powerful experimental system for understanding how the processes of cell specification are modified by natural selection to produce **\*\*diversity\*\***. by casting single-cell transcriptomics, open chromatin profiling and crispr loss-of-function experiments within an evolutionary framework that includes replicated cases of the independent evolution of identical wing patterns, this project will determine the rules that govern how cells communicate and acquire a specialized fate during development, and how those rules are applied to generate **\*\*diversity\*\***. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Reproductive heterogeneity in the structured coalescent framework

Awardee: Florida State University

Amount: \$410,357.00

Abstract: curbing the effects of pathogens and securing the survival of endangered or commercially exploited species is a matter of national interest. while collecting genetic data on these pathogens and endangered species has become standard over the last decade, the data requires translation and analysis to be useful for policy decisions. these data are commonly used in models that describe both the recent and ancient history of the species. these models are founded on theoretical population genetics and are often not very flexible. this research addresses the assumption that the populations that are being studied have a relatively constant number of offspring per generation. scientific observation has shown that this assumption is incorrect. for example, some sars-cov-2 strains are more successful in infecting people than others, suggesting that the ancestor with a new



mutation has many more 'offspring' than others. this research generalizes the common assumption and constructs a framework that allows for the improvement of these population models by offering an increase in accuracy and a decrease in bias. this research will result in the creation of a software tool that will benefit the research community and train the next generation researchers. accurate estimates of population size and genetic **diversity** will lead to better control of pathogen outbreaks, regulation of catch quota for commercial fishing, and maintenance of endangered species. this research explores the effect of heterogeneity of offspring production on the genealogy of a population using (1) a theoretical framework that can handle heterogeneity and the development of software to infer this heterogeneity from genomic data. this framework is based on the fractional coalescent expanded to multiple, structured populations. the research extends a single-population derivation of the fractional coalescent that incorporates offspring variability as a random variable. these new methods will be incorporated into the widely-used open-source computer software migrate. the new approach will then be compared with multi-merger coalescent methods using artificial data. these data are generated using (2) a simulator taking into account environmental quality changes within and among populations affecting the number of offspring an individual can have. (3) analyses of the effect of heterogeneity for many biological datasets over a broad range of species with different life histories: from viruses to humpback whales and from small geographic scale to large scales. these biological datasets will be analyzed in collaboration with practical scientists. software and tutorials will be reported on <http://popgen.sc.fsu.edu> and <https://peterbeerli.com>. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Characterizing Inclusive Strategies that Retain Black Students in Computer Science to Graduation and Beyond

Awardee: Clemson University

Amount: \$410,081.00

Abstract: this iuse project aims to serve the national interest by identifying factors that lead to the lack of **diversity** in computing professions. research has shown that the first two years of science, technology, engineering, and mathematics (stem) majors are often where students are lost in the pipeline. this project will identify factors that affect the retention and graduation of under-represented minority students in the computing major. the goals are to identify inclusive strategies for success in computing programs and investigate ways to increase the retention and post-graduation success of black students in computing. of particular interest are strategies that are transferable to different types of institutions and stem fields in general. this project features a collaboration between two historically black colleges/universities and a primarily white institution that will work together to understand the challenges facing each institution and the strengths each institution brings to addressing this problem. through detailed transcript analysis, this research will take an asset-based approach, focusing on the strengths of students succeeding in the major. two cohorts of lower division (freshman and sophomore) black cs students from two historically black colleges/universities (hbcus) and one primarily white institution (pwi) will be studied to measure perceived societal impacts and their understanding of content through conceptual assessment instruments. a cohort of upper division students will be studied to measure the factors that led to their success using surveys, a content assessment, and interviews. using a mixed methods analysis approach, white students will be compared to black students at the research intensive pwi and then the principal investigators will compare black students at the pwi to black students at the two hbcus. the goal is to expand knowledge of inclusive teaching strategies and provide institutional awareness of factors that can go beyond recruiting urms to focus on retention in the major and student success post-graduation. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through its engaged student learning track, the program supports the creation, exploration, and implementation of promising practices and tools.

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: US GEOTRACES GP17-OCE: Mapping nitrous oxide sources and sinks through isotopic measurements in the Pacific Ocean

Awardee: Stanford University

Amount: \$409,577.00

Abstract: nitrous oxide is a powerful greenhouse gas that is produced by microbial activity in soils and the ocean. the pacific ocean is an important component of oceanic nitrous oxide production and emission to the atmosphere due to its large area and pockets of low oxygen in the eastern tropical pacific. the largest amounts of nitrous oxide observed in the global ocean occur in these pockets of low oxygen. these regions appear to impact nitrous oxide distributions throughout the pacific ocean, but the sources of nitrous oxide in these regions may be quite different. this work will provide a better understanding of both the natural distribution of nitrous oxide in the global ocean, as well as the mechanisms and controls on its production for future emission projections. this will be accomplished by collecting nitrous oxide isotopic measurements at different water depths from the central pacific, where relatively little work has focused. measurements of nitrous oxide isotopic composition is a powerful analytical tool that will help to answer these important questions about this powerful greenhouse gas. the stanford component of this project will be carried out primarily by a phd student, who will be trained in a variety of laboratory techniques, data analysis, and computer modeling. we will also use support from this project to increase **\*\*diversity\*\*** in the geosciences by providing first-time research experiences to underrepresented minority students through stanford's surge (summer undergraduate research in geoscience and engineering) program. one of the project's lead investigators, bourbonnais, will also give a series of introductory chemical oceanography lectures at benedict college, a private historically black, liberal arts college in

columbia, sc and support two undergraduate students from benedict college through summer internships at the university of south carolina. this project will address three main questions related to n<sub>2</sub>o cycling in the pacific ocean: (1) what features of n<sub>2</sub>o distribution in the central pacific ocean are driven primarily through mixing and circulation vs. biological processes; (2) which biogeochemical processes control the distribution of biologically produced n<sub>2</sub>o in the central pacific ocean; and (3) how does the production (amount, mechanism, yield) of n<sub>2</sub>o relate to the availability of oxygen in situ? this collaborative project will be carried under the geotraces program, an international effort to understand the distribution of elements in the global ocean. with the synthesis of the geotraces gp17 and gp15 sections, we will have an opportunity to examine the distributions of n<sub>2</sub>o and its isotopes (an indicator of production mechanisms) relative to oxygen, trace elements, and water mass tracers. data from this project will be made available to the public through the biological and chemical oceanography-data management office ([www.bco-dmo.org](http://www.bco-dmo.org)). the data will also be compiled in geotraces data products that will be freely available. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: DMREF: Microstructure by Design: Integrating Grain Growth Experiments, Data Analytics, Simulation, and Theory

Awardee: University of Utah

Amount: \$409,494.00

Abstract: most technologically useful materials are polycrystalline microstructures composed of a myriad of small monocrystalline grains delimited by grain boundaries. an understanding of the evolution of grain boundaries and associated grain growth (coarsening) is essential in determining the properties of materials across multiple scales. despite tremendous progress in formulating microstructural models, however, current descriptions do not fully account for various grain growth

mechanisms, detailed grain topologies and the effects of different time scales on microstructural evolution. as a result, conventional theories have limited predictive capability. the goal of the project is to develop a predictive theory of grain growth in polycrystalline materials through the construction of novel, closely integrated data-driven numerical simulation and mathematical modeling combined with data analytics, analysis, and a set of critical experiments. this interdisciplinary project, requiring the complementary expertise of applied mathematicians and materials scientists, is firmly aligned with the materials genome initiative. the new knowledge and tools that will emerge from the project will have a profound impact on the performance and reliability of polycrystalline materials used in many technologically useful systems and structures, thereby expediting advanced materials development and deployment. predictive computational algorithms and data will be made available and accessible to other researchers. for the training of the next-generation materials workforce, in addition to mentoring of graduate and undergraduate students, the pis (from columbia university, illinois institute of technology, lehigh university and university of utah) will participate in outreach activities and will continue to work towards increasing **\*\*diversity\*\*** and broadening participation within stem.

grain growth is a very complex process and may be viewed as the anisotropic evolution of a large metastable network. one of the main thrusts of the project will be to uncover possible stochastic processes that define the evolution of various statistical measures of grain growth, discover relations among them, and establish links to materials properties. results from structure-preserving numerical simulations alongside critical sets of experiments and new experimental data will be invaluable in navigating the modeling and analysis. the project will also create and employ specific data analysis techniques for the study of dynamic evolution of grains in experimental and computational systems with the goal of validating and further refining the microstructural models. this component of the project, will lead to a) the development of new materials informatics methods, b) innovative stochastic differential equations/differential equations models of grain growth, c) new mathematical and numerical analysis techniques for coarsening systems, as well as d) improved computational tools. in turn, the results of combined data analytics,

modeling and analysis will be used to guide the design of subsequent experiments. experimentally, grain growth will be examined in prototypical metallic thin films (pd, ni, cr, fe). as most elemental metals and many metallic alloys have cubic structures, the proposed studies will have broad applicability. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: BRITE Synergy: Transforming Electron Beam Lithography with Reactive Gases

Awardee: University of Kentucky Research Foundation

Amount: \$407,998.00

Abstract: this boosting research ideas for transformative and equitable advances in engineering (brite) synergy award will support research which seeks to transform the way manufacturers perform electron-beam lithography by introducing a reactive gas that modifies the process chemistry. electron-beam lithography is critical for nearly all manufacturing at nanometer length scales and is often the first step in fabricating devices in semiconductor electronics, digital imaging, communications, and healthcare. this innovation will enable patterning of new functional materials while also improving the performance of conventional materials. the research program seeks to understand the fundamental physical and chemical mechanisms underlying the effects of reactive gases on the lithographic process, and to use this knowledge to advance lithographic performance. a broad range of industries now relies on nanoscale manufacturing, and thus on electron-beam lithography. this award could thus impact multiple sectors of the u.s. economy while accelerating product development and increasing access to nanotechnology-enabled products. this effort will also expand **\*\*diversity\*\***, equity, and inclusion in advanced manufacturing through workshops for middle-school teachers primarily serving underrepresented groups and multi-disciplinary training for graduate students recruited from underrepresented groups. electron-beam lithography is the primary pattern generation technology for nearly all nanomanufacturing, from integrated circuit mask

making to direct-writing of quantum devices. focused electron-beam induced processing in gases and liquids provides nanoscale rapid prototyping with functional materials as well as nanoscale repair and editing capabilities. this effort synthesizes research outcomes in these two areas with established knowledge in radiation chemistry and electron-material interactions to enhance understanding of the influence of reactive gases on electron-beam lithography. specifically, the research seeks to understand how reactive gases can alter radiation chemical processes to expand the range of materials that can be patterned and to improve lithographic performance for conventional electron-beam resists. a rigorous research synthesis program, hybrid monte carlo-continuum simulations, and carefully designed nanopatterning experiments will build knowledge of the relationships between process conditions, such as gas composition and pressure, and lithographic performance metrics, such as sensitivity, contrast, and resolution. success could transform electron-beam lithography because functional materials could be patterned with resolution and throughput comparable to conventional resists while the performance of conventional resists could be tuned by the reactive gas. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: MRA: Elucidating Plant and Mycorrhizal Fungal Relationships and Consequences across Space and Time

Awardee: Purdue University

Amount: \$407,353.00

Abstract: many plants are dependent on belowground fungi to help them obtain nutrients and respond to environmental stress. revealing the patterns and drivers of these interactions is important for understanding forest ecology and improving management practices. plant-fungal associations in the soil can dramatically influence plant growth and terrestrial ecosystem function. this research will take the advantage of several existing datasets, including those collected by national ecological observatory network (neon) and the u.s. forest service (usfs), to understand: 1) nation-wide patterns of plant-fungal associations; 2) key factors that influence these associations; and 3) how plant-fungal interactions influence key ecosystem functions such as carbon cycling. this research project will contribute to the fields of microbial ecology, ecosystem science, and global change biology by formulating and testing new theories about plant-fungal associations. results of the project will inform forest managers, policymakers, and other stakeholders on how to improve ecosystem management of plant and fungal bio\*\*diversity\*\* to promote sustainable ecosystems. the project will contribute to the professional development of diverse students at several stages. the goal of this project is to understand the patterns, drivers, and consequences of the linkages between plant and mycorrhizal fungal \*\*diversity\*\* across spatial and temporal scales. this information will enable better predictive understanding of essential ecosystem functions which they control. the project will use a holistic, scale-dependent framework that forecasts the strength and direction of arbuscular mycorrhizal (am) and ectomycorrhizal (em) fungal-plant associations, and provides greater insight about the consequences for ecosystem functioning across space and over time.

specific objectives of the project include: 1) elucidation of patterns of plant and mycorrhizal fungal **diversity** across scales by extensive dna sequencing and analysis; 2) determination of key abiotic and biotic drivers of observed co-occurrence patterns; and (3) forecasting the effects of plant-mycorrhizal fungal couplings on tree productivity and soil c storage, two key forest ecosystem functions. by linking multiple facets of both above- and belowground **diversity** in a scale-dependent context, the project will produce robust continental-wide distribution maps of am and em fungi for the first time. leveraging data-rich sampling of putative biotic and abiotic drivers of plant and fungal **diversity** by neon and the usfs, the project will also provide broad-scale understanding of when and where these drivers serve to couple or decouple plant and mycorrhizal fungal **diversity**. finally, by linking plant and mycorrhizal fungal **diversity** to the consequences they have for plant productivity and soil c storage and stability, the project will improve understanding of ecosystem resilience to environmental stress. the project will train diverse undergraduate and graduate students, postdoctoral scholars, and will enhance the development of three early-career scientists. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Probing Cellular Dynamic Mechanobiology Using Human Cardiomyocytes on a Stimuli-Responsive Nano-Topographic Substrate

Awardee: Syracuse University

Amount: \$406,551.00

Abstract: this grant will support a multidisciplinary research that will enable new approaches in dynamic cell mechanobiology and smart biomaterials. traditionally, cell mechanobiology is studied using static culture systems. though useful, these systems provide little knowledge as to how the cells respond to a dynamic changing microenvironment, such as in the body. this project aims to

develop in vitro models and approaches that include time-dependent mechano-structural cues to cells. these physical cues are important to regulating of cellular morphology (shape), differentiation (what cells become), and function at each phase of tissue development or healing. the knowledge gained through this project will have a broad impact and various applications in the scientific fields related to developmental cell biology and cardiac pathophysiology. this project is also designed to integrate research, education, and **\*\*diversity\*\*** with an emphasis on strengthening research exposure and opportunities at different education levels. the educational component of this project aims to help raise the awareness and familiarity of high-school students and undergraduate students with interdisciplinary, emerging and socially compelling directions within biomedical engineering. the goal of the present research is to use an in vitro shape-memory polymer (smp) platform to investigate how dynamic topographic structural cues affect cellular mechanobiology, with a particular emphasis on the focal adhesion dynamics of human cardiomyocytes. the combination of dynamic biomaterial substrates, hipsc technology and genome editing will provide a great potential to establish new analytical tools and in vitro model systems for broadly studying time-dependent mechano-structural cues in dynamic cell mechanobiology. this dynamic platform will allow us to test our hypothesis that extracellular topographic changes will dictate the different dynamic responses of both periphery focal adhesions and sarcomere-linked costameres of cardiomyocytes, thereby reorganizing myofibril structures and controlling contractile functions. this project aims to study how dynamic structural cues would regulate periphery focal adhesions (objective 1) and cardiac-specific sarcomere-linked costameres (objective 2), and how mechanotransduction signaling pathways (fak and yap/taz) are involved in these cellular developmental processes (objective 3). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: FSML: SERC Visiting Scientist Cottages

Awardee: Smithsonian Institution

Amount: \$405,804.00

Abstract: the smithsonian environmental research center (serc) provides field, lab and convening facilities at its 1,000 ha property on the shores of chesapeake bay in support of research on the interactions among ecosystems of the coastal landscape in response to climate and human impacts. with this award, serc will build on-site short-term housing for visiting scientists relieving presently inadequate and deteriorating housing facilities that lack ada accommodations. this investment is part of a much broader master plan for growing accommodation at serc; it will ensure continued access for critical on-going research and will enable expanded opportunities for outreach. serc is unique in its combined estuarine and terrestrial research that provides important long-term and large-scale data and unique experiments on land-sea interactions and responses to environmental change. it hosts numerous major research projects including participation in the national ecological observatory network; long-term research on the effects of elevated co2, stream discharge and water quality, estuarine fish & invertebrate community dynamics, tree demography; and experimental research on tree species **diversity** and ecosystem function. access to these resources provide rich and diverse opportunities for visiting scientists to conduct both new research within the context of extensive background data and synthesis of multifactorial interactions. access to serc resources also provide unique opportunities for undergraduate intern training and graduate dissertations. approximately 60 active extramural research projects leverage an array of long-term datasets, and the datasets are highly valued by our academic and governmental sponsors and collaborators. serc facilities support a 50-year history of both providing access to visiting scientists and informing environmental policy makers on emerging environmental issues. short-term housing enables visiting researchers and educators to use serc's unique resources and site most efficiently and cost-effectively. serc's site is also hosts numerous tours for congressional staff members and politicians from nearby washington, dc, and the maryland capital annapolis. u.s. state department often features serc in tours of international visitors working on environmental resource management.

serc facilities are also an important resource for serc's diverse array of collaborative research and training programs for academic partners. the facility is a central feature of serc's professional training that annually supports 55 interns, 10 grad students, 25 postdocs and 570 visiting scientists for short and long periods. approximately 130 of these visiting scientists actively conduct research on the site for multiple days at a time, and over 400 attend meetings, workshops and training annually. for more information on serc, see <https://serc.si.edu/>. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Awardee: Smithsonian Institution

Amount: \$405,804.00

Abstract: the smithsonian environmental research center (serc) provides field, lab and convening facilities at its 1,000 ha property on the shores of chesapeake bay in support of research on the interactions among ecosystems of the coastal landscape in response to climate and human impacts. with this award, serc will build on-site short-term housing for visiting scientists relieving presently inadequate and deteriorating housing facilities that lack ada accommodations. this investment is part of a much broader master plan for growing accommodation at serc; it will ensure continued access for critical on-going research and will enable expanded opportunities for outreach. serc is unique in its combined estuarine and terrestrial research that provides important long-term and large-scale data and unique experiments on land-sea interactions and responses to environmental change. it hosts numerous major research projects including participation in the national ecological observatory network; long-term research on the effects of elevated co2, stream discharge and water quality, estuarine fish & invertebrate community dynamics, tree demography; and experimental research on tree species **\*\*diversity\*\*** and ecosystem function. access to these resources provide

rich and diverse opportunities for visiting scientists to conduct both new research within the context of extensive background data and synthesis of multifactorial interactions. access to serc resources also provide unique opportunities for undergraduate intern training and graduate dissertations. approximately 60 active extramural research projects leverage an array of long-term datasets, and the datasets are highly valued by our academic and governmental sponsors and collaborators. serc facilities support a 50-year history of both providing access to visiting scientists and informing environmental policy makers on emerging environmental issues. short-term housing enables visiting researchers and educators to use serc's unique resources and site most efficiently and cost-effectively. serc's site is also hosts numerous tours for congressional staff members and politicians from nearby washington, dc, and the maryland capital annapolis. u.s. state department often features serc in tours of international visitors working on environmental resource management. serc facilities are also an important resource for serc's diverse array of collaborative research and training programs for academic partners. the facility is a central feature of serc's professional training that annually supports 55 interns, 10 grad students, 25 postdocs and 570 visiting scientists for short and long periods. approximately 130 of these visiting scientists actively conduct research on the site for multiple days at a time, and over 400 attend meetings, workshops and training annually. for more information on serc, see <https://serc.si.edu/>. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Contribution of mafic magmatism to upper crustal batholiths: A case study of the Sierra Nevada batholith

Awardee: California Institute of Technology

Amount: \$405,087.00

Abstract: the dense crust beneath earth's oceans is regularly driven beneath the continents in a

tectonic process called subduction, which results in the formation of magmas. such magmas ascend and create long chains of volcanoes like the cascades of the northwest united states or the andes in south america. over time, magmatism at subduction zones has helped build earth's continents. these magmatic processes concentrate silica to create thick and buoyant continents that stand higher than surrounding oceans and oceanic crust, which is a unique feature of our planet. this continental crust is an important source for resources essential to human existence, but the processes that concentrate silica in magmas are not fully understood. this research will study magmatic processes in the sierra nevada mountain range of california, which is the ancient 'plumbing system' from the insides of subduction zone volcanoes from hundreds of millions of years ago, now exposed at earth's surface. this work will study the chemistry of mafic (more magnesium and iron-rich, lower silica) rocks that represent an important compositional ingredient to create the high-silica rocks that form the bulk of the continents. extensive existing work on the high-silica rocks at this location will provide context for new measurements of the mafic end-member composition to understand the magmatic processes that build continents. the research will support collaboration between caltech and pomona college, including the mentoring of a female graduate student (caltech) and multiple undergraduate/post-baccalaureate students (pomona), as well as early career support for a female faculty member (caltech). in addition, earth science classroom lessons and field trips for middle and high school students from the big pine unified school district (bpusd) in owens valley, located within study area will be developed and conducted. bpusd serves a student population that is ~50% native american and >40% latinx, two under-represented groups in geosciences. the ultimate goal is to increase participation and interest of under-represented students in geosciences through place-based and culturally appropriate lessons that successfully aligned indigenous ways of knowing and scientific practices with western science models the formation of high-silica arc batholiths is an enduring petrologic problem. during flux-melting of the mantle wedge at subduction zones primitive basalts are produced. upon ascent into the crust, further differentiation of these basalts is required to form more silicic derivative melts. although field

and experimental studies highlight the importance of lower crustal ( $>0.7$  gpa) fractional crystallization of primitive basalts in generating high-silica melts, this process in detail cannot produce the composition of arc batholiths. In particular, deep crustal fractional crystallization generates peraluminous intermediate and silicic melts, compositions that are not widely observed in arc batholiths. To reconcile these observations, this research will test the following hypothesis: deep crustal differentiation produces high-al, low-mg basalts, as well as, evolved mildly peraluminous granitic melts. These melts represent endmembers that can mix to form the compositional **\*\*diversity\*\*** of granitoids observed in arc batholith. Testing this mixing-model hypothesis has been limited due to the relative lack of studies focusing on the mafic endmember. Although volumetrically minor and relatively less-studied compared to high-silica granodiorites to granites that dominate batholiths, mafic plutons (non-primitive gabbros and diorites) are widely present in the upper crust of accreted arc sections. Through a collaboration between Caltech and Pomona College this research will investigate the bulk-rock and mineral major/trace element chemistry, geochronology, and oxygen & strontium isotopic compositions mafic plutonic bodies across a transect from a classic continental arc locality, the Sierra Nevada batholith. This data will be placed in the context of both existing and new granitoid data, as well as, quantitative geochemical and rheologic models to understand whether these mafic plutonic bodies represent suitable mixing endmembers in the production of batholithic granitoids. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: REU Site: Imaging in Medicine and Biology for Underrepresented Minorities

Awardee: University of Rochester

Amount: \$405,000.00

Abstract: diverse teams are needed to solve complex engineering problems. however, the lack of research opportunities in engineering and other stem-related fields prevents undergraduates from underrepresented groups from considering stem as a viable and rewarding career path. to improve this situation, this imaging in medicine and biology for underrepresented minorities reu site will provide an environment for underrepresented minorities (urm) undergraduates to complete individual research projects under the mentorship of leaders in their respective fields, in a world-class interdisciplinary research environment. the imaging in medicine and biology for underrepresented minorities reu site will also provide structured enrichment programs to participants that will allow students to develop critical skills needed to be successful in stem graduate education (gre preparation, time management, oral/written presentation). the university of rochester (ur) is an ideal setting for this reu site; it is the home of the rochester center for biomedical ultrasound (rcbu), the institute of optics, the goergen institute for data science (gids), and the del monte institute of neuroscience?members of which will serve as mentors in this reu site. imaging is crucial to medicine (disease diagnosis, treatment planning, and monitoring), but it is also the driving force behind many transformative technologies, including robotics, self-driving cars, and facial recognition. at its foundation, imaging is a highly multidisciplinary field that combines various engineering disciplines (e.g., electrical engineering, computer science, physics, chemistry, materials science, and medicine) to create a cohesive whole. like other disciplines, artificial intelligence is changing imaging. it requires diverse teams to solve new challenges, which requires us to train and expand the **\*\*diversity\*\*** of researchers capable of making meaningful contributions to imaging science and engineering. this reu program will provide ten students annually with exciting interdisciplinary research opportunities in computational imaging, optical imaging, and ultrasonic imaging science with mentors in disciplines ranging from engineering to computer science to neuroscience to microbiology. the reu site program will organize workshops on career development, community colloquiums, scientific research in chosen laboratories, and a bootcamp on scientific programming focusing on fundamental medical imaging techniques. students will regularly meet with professional

and research mentors to formulate the next steps regarding appropriate graduate programs that align with research interests discovered during the reu experience. participants in the reu site will complete individual projects under the mentorship of leaders in their respective fields. in these projects, participants will use computational, optical, or ultrasound imaging techniques to solve significant medicine and biology problems. participants will interact with their professional advisors to demystify the graduate school program and improve their professional skills. other planned activities will include community colloquiums, a matlab programming bootcamp that teaches students image processing techniques such as image segmentation, principal component analysis, and multidimensional filter design, which are fundamental to medical imaging. students will work with their professional and research mentors to formulate the next steps to pursue their research interests. research mentors in the proposed reu will teach participants how to develop their research project; collect data from several imaging modalities (functional ultrasound, shear wave elastography, bioluminescence, micro-ct, magnetic resonance imaging); design algorithms for image analysis, 2d and 3d image reconstructions, computer vision; perform experiments on rodents, cell culture, and phantoms; and iteratively refine the solutions. students will present their research findings to other students, mentors, and the research community at ur at a research symposium at the end of the 10-week research experience. students will also be encouraged to submit their research findings to national conferences or co-author peer-reviewed publications. three thematic research areas will serve as the foundation for this reu site: 1) ultrasonic imaging, 2) computational imaging, and 3) optical imaging. this site is supported by the department of defense in partnership with the nsf reu program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: REU Site: Green Infrastructure for Sustainable Urban Environments (GI4SUrE)

Awardee: University of Tennessee Knoxville

Amount: \$404,784.00

Abstract: in this research experiences for undergraduates (reu) site program, green infrastructure for sustainable urban environments (gi4sure), a diverse cohort will participate in research supporting the advancement of green infrastructure to improve public and ecological health in urban environments. green infrastructure can be described as the interconnected natural spaces in urban environments such as parks, riparian areas, and nature-based storm water control measures that serve to clean storm water runoff, reduce urbanization impacts to local surface waters, and offer protection from flooding. research will include state of the art field, laboratory, and modeling studies to better understand and optimize these systems. students that participate in this reu will have the chance to improve their research and critical thinking skills while bolstering their ability to communicate with technical and non-technical audiences through oral and written mediums. additional experiences include access to new mentors, exposure to the various career pathways made possible by a graduate degree in engineering, and training on how to collaborate with, learn from, communicate with, and consider the perspectives of colleagues outside their discipline. this program will serve to improve the **\*\*diversity\*\*** of the engineering profession and student participation in graduate school by extending opportunities to traditionally underrepresented groups in science and engineering. through a 10-week, summer undergraduate research experience, the gi4sure reu site aims to: (1) propel scientific knowledge regarding green infrastructure (gi) contributions to sustainable urban water, and (2) provide a high quality professional and social atmosphere where attendees are educated on fundamental research methodologies and critical thinking. under the guidance of faculty mentors, students will perform field, laboratory, and/or modeling studies to explore how gi functions to mitigate the effects of urban runoff on surface water quality and hydrology. green infrastructure has been deemed as a way to build better infrastructure

as part of the national academy of engineering's grand challenge to restore and improve urban infrastructure, making it a vital topic for investigation. reu students will be exposed to state of the art techniques and convergent research by the inclusion of non-engineering co-mentors in a subset of the projects to address complex questions that consider social, hydrologic, ecologic, and/or economic outcomes. through a targeted recruiting strategy, this reu site will bolster the participation of traditionally underrepresented groups in undergraduate engineering research. students will gain skills in research methodology, communication, convergent approaches, and working in team environments which will be invaluable in their professional endeavors. further, exposure to the various career pathways that are open to individuals with advanced degrees will aid them in determining their desired career path, whether it be academia, industry, government, or non-government organizations. reu contributions to gi knowledge will be invaluable. as billions of dollars are being spent nationwide to reduce the effects of urbanization through the use of gi, there is a critical need to better understand and optimize its performance to make these efforts more scientifically informed. overall, the reu intends to establish direct, lasting mentoring relationships between participants and faculty, and long-term relationships among those in the cohort. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Quantum optics with nonlinear organic small molecule enhanced integrated photonics devices

Awardee: University of Southern California

Amount: \$404,374.00

Abstract: quantum networking has emerged as a global grand challenge in the field of quantum information sciences, identified as a critical technology for enabling general purpose quantum computing and its applications. therefore, developing implementable devices to accelerate quantum networking will advance us security and technical leadership. a flexible quantum network will have the ability to transmit an arbitrary quantum state with high-fidelity over room- (data-center), metropolitan- (lan), continental- and trans-continental-distances. in this proposal, we provide a path for the development of quantum frequency converters (qfc?s) for translating the wavelength of photons into and between pre-assigned channels of the international telecommunication union (itu) frequency grid, while preserving the delicate quantum information that is encoded on those photons. the planned approach is fully compatible with silicon photonics technology providing a scalable, robust, manufacturable platform for the generation of non-classical light and frequency translation of that light. the training and outreach efforts directly engage the scientific community and the general

public. in collaboration with usc's center for engineering **\*\*diversity\*\***, two undergraduate student researchers will be hosted in the pi and co-pi's laboratories, and a free online quantum optics conference will be organized. the past decades have witnessed a rapid increase in the performance of on-chip integrated photonic devices for studying nonlinear and quantum phenomena. these devices have enabled a wide range of discoveries and are serving as critical roles in our optical communications network. however, as we look to shift from classical to quantum networking, we must be mindful to engineer components that enable quantum communications and yet are compatible with the large existing infrastructure already in place for classical optical communications. an important capability in quantum networking is making quantum information, stored on optical qubits, compatible with the modern telecommunications infrastructure, which includes mapping quantum channels to the international telecommunication union (itu) frequency grid. one approach being explored relies on frequency conversion using integrated optical resonant cavities. while the concept is theoretically robust, in practice, there are several hurdles related to low conversion efficiencies and optical power requirements that must be solved. while it is possible to overcome the power requirements by using a cavity with a long photon lifetime, the conversion efficiency is intrinsic to the cavity material. in the present work, we will explore a new type of hybrid optical cavity comprised of a self-assembled monolayer of nonlinear optical organic materials on a silicon oxynitride microring. organic materials possess 1,000-100,000x higher non-linear optic (nlo) coefficients than conventional optical materials; thus, the proposed hybrid system could provide a transformative solution to the current challenge. the key quantum capability of the microresonators to be validated is coherent wavelength translation of an optical state while preserving the quantum coherence of observables on which quantum information is encoded. the si device architecture that will be studied is compatible with existing infrastructure; thus, this work will pave the way for establishing the quantum network using the existing itu grid. undergraduate and graduate students will be directly engaged in all aspects of the research, and all findings will be disseminated using scholarly publications as well as social media. this award reflects nsf's statutory mission and has

been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: GP-UP: Geoscience Engagement: Growing Interest at Hispanic-Serving Institutions by Scaffolding Classroom Intervention to Service-Learning Projects

Awardee: University of Texas at San Antonio

Amount: \$403,859.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). despite concerted effort over the last two decades, the size and **\*\*diversity\*\*** of the geoscience workforce has not significantly changed to meet the projected demand for geoscientists, which has major consequences for the sustainability of natural resources and overall environmental quality that supports a strong economy and ensures the health and welfare of all united states residents. this project aims to address this shortfall using an innovative curriculum program to recruit and retain more undergraduate students from historically excluded groups; it will promote interest in geoscience within 2-year institutions where geoscience courses are limited and facilitate transfer pathways from 2- to 4-year institutions and retention to degree completion so students earn the educational credential needed to enter the geoscience workforce. the new insights gained from the program will form a model of best practices that can be adapted and implemented at other universities to grow a larger, more diverse geoscience workforce. this project aims to broaden participation and enhance retention in geoscience by implementing and testing the effectiveness of a three-stage early intervention strategy within the undergraduate degree arena. conducted at the hispanic serving institutions of northwest vista college and the university of texas at san antonio, the three-year program will generate greater awareness of and interest in geoscience in introductory stem courses and promote retention through extracurricular service-learning projects. in introductory geoscience, chemistry, and physics courses, four modules will test the effectiveness of a recruitment

strategy that targets specific barriers and motivations to broaden and diversify the pool of geoscience majors and minors. participants will be supported by multi-level mentoring, advising, a transfer bridging event, and stipends; a program-specific interactive website will facilitate formal and informal learning and interactions between students, faculty, professionals, and community. the project design permits a critical test of a recruitment approach that targets a wider pool of potential majors and the critical elements of service-learning projects that promote learning and retention. the new knowledge identified from formative and summative program assessments will be widely transferrable because it focuses on introductory courses that are generally offered at many institutions and experiential learning experiences that can flourish independently from formal coursework. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RCN: Ecological and Evolutionary Effects of Extinction and Ecosystem Engineers (E6)

Awardee: University of Nebraska-Lincoln

Amount: \$400,219.00

Abstract: ecosystem engineers are organisms that change the environment in which they live, and can create or eliminate habitats for other taxa. ecosystem engineers therefore can be important drivers of local and regional **\*\*diversity\*\***. our own species ? humans ? offer a powerful example. humans have adopted behaviors that have created, modified, and/or destroyed habitats used by a wide variety of animals and plants. the effects of these activities are leading to dramatic changes in the structure and function of ecosystems, and the current global bio**\*\*diversity\*\*** crisis that has been termed the ?6th mass extinction?. thus, some consequences of human activities are comparable to the environmental perturbations associated with mass extinctions, whereas others may be creating new ecological opportunities. a key question is therefore: what effect will human ecosystem engineering behaviors have as we continue to modify the global environment? this research

coordination network will bring together ecologists and paleontologists to synthesize information on the effects of ecosystem engineers in different kinds of biological systems at different times to develop predictive models for how human activity is expected to affect ecosystems. the researchers will also conduct outreach activities designed to increase **diversity** in stem fields using partnerships with local community colleges, an undergraduate course taught concurrently at member institutions, and a conference workshop. the key to predicting the effects our activities may lie in the past. although humans are among the most recently emerged ecosystem engineers with powerful effects, they are not the first. the evolution of biological groups such as oxygenic photosynthesizing cyanobacteria, marine animals capable of burrowing beneath the sediment surface, a wide variety of reef-building organisms and land plants are all thought to have had dramatic effects on global bio**diversity**. this research coordination network will synthesize existing data across nearly 600 million years of evolutionary history to address the questions: 1) to what extent are the effects of new ecosystem engineers on communities predictable? and, 2) to what extent do we expect humans to continue to drive the 6th mass extinction, and/or create new ecological and evolutionary opportunities? the e6 rcn will unite scientists from the fields of paleobiology, geology, ecology, statistics, conservation, and phylogenetics to contrast the ecological and evolutionary consequences of ecosystem engineers. activities will include twice yearly workshops and training of graduate students, postdocs, and faculty. in partnership with the university of california museum of paleontology, researchers will develop and run a paleobotany and paleoclimatology lab for bay area community college students. an interdisciplinary course on extinction and ecosystem engineers will be taught concurrently at participant institutions, and a workshop on approaches for studying ecosystem engineers and community ecology at large spatial and temporal scales will be developed for national and international conferences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: FET: Medium: Neuroplane: Scalable Deep Learning through Gate-tunable MoS2 Crossbars

Awardee: University of Illinois at Chicago

Amount: \$400,000.00

Abstract: the increasing complexity of deep-learning systems has pushed conventional computing technologies to their limits. while the memristor is one of the prevailing technologies for deep-learning acceleration, it is only suited for classical learning layers where two operands, namely weights and inputs, are processed at a time. meanwhile, to improve the computational efficiency of deep learning for emerging applications, a variety of non-traditional layers, requiring concurrent higher-order processing of many operands, are becoming popular. for example, hypernetworks improve their predictive robustness by simultaneously processing weights and inputs against the application context. two-electrode memristor grids cannot natively support such operations of emerging layers. addressing the unmet need, this research will develop neuroplane -- a novel deep-learning accelerator of gated memtransistor crossbars. exploiting crossbars' gate controllability, multiple operands can be processed within the same crossbar unit in neuroplane. many advanced inference architectures that can generalize beyond a typical passive crossbar will thus be possible. overall, the ultra-low-power, higher-order processing of neuroplane will harness high robustness and efficiency of emerging deep-learning layers within area/power-constrained devices such as mobile, sensor, and embedded systems. the investigators will develop fabrication methods for nanometer node gate-tunable dual-gated crossbars of mos2 memtransistors. a self-aligned fabrication method with defect passivation and process variability compensation will be created. exploiting the gate-tunability of mos2 memtransistors, a new generation of crossbar platforms with many runtime control knobs will be developed, rendering the design a high elasticity and agile computing space. for example, computing methods will be created for the gated crossbars to utilize crossbar elements for product-sum digitization, thereby preventing the critical overheads in

current crossbar technologies. similarly, control-flow methods will be developed for gated crossbars to adapt their inference paths depending on the input characteristics by dynamically deactivating input/output neurons to conserve processing energy. a coherent collection of software and hardware-based correction techniques is proposed to minimize the impact of process variability. unlike the current schemes, by following the train-once-deploy-anywhere tenet, the proposed crossbar correction methods can scale to millions of deployments without considerable overhead. an annual workshop will be conducted at local high schools with substantial ethnic and gender **\*\*diversity\*\*** to mentor underrepresented students. undergraduate research projects will be sponsored using paid summer internships and university-level programs such as summer undergraduate fellowship. an inter-university senior-design mentoring program will be created for students among participating institutions. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: FET: Medium: Neuroplane: Scalable Deep Learning through Gate-tunable MoS2 Crossbars

Awardee: University of Illinois at Chicago

Amount: \$400,000.00

Abstract: the increasing complexity of deep-learning systems has pushed conventional computing technologies to their limits. while the memristor is one of the prevailing technologies for deep-learning acceleration, it is only suited for classical learning layers where two operands, namely weights and inputs, are processed at a time. meanwhile, to improve the computational efficiency of deep learning for emerging applications, a variety of non-traditional layers, requiring concurrent higher-order processing of many operands, are becoming popular. for example, hypernetworks improve their predictive robustness by simultaneously processing weights and inputs against the



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impacts review criteria.

Matched Words: diversity

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Title: Measuring and Reducing Algorithmic Discrimination with Quasi-Experimental Data

Awardee: Harvard University

Amount: \$400,000.00

Abstract: this research project will develop new tools to measure and reduce algorithmic discrimination in several high-stakes settings. algorithms guide an increasingly large number of decisions. alongside this rise is a concern that algorithmic decision-making will entrench or worsen discrimination against legally protected groups. however, quantifying algorithmic discrimination is often hampered by a selection challenge: an individual's qualification for a decision, which is often used to define discrimination, is typically only available for the group of individuals who were selected for treatment by an existing human or algorithmic decision-maker. this project will overcome this fundamental selection challenge by developing new tools to measure algorithmic discrimination. the project also will develop alternative algorithms that minimize or reduce discrimination. the researchers will apply these tools in multiple high-stakes settings, including pretrial detention, employment screening, medical testing, and child welfare investigations. the research is of considerable policy interest given the rapid adoption of algorithms in a variety of settings. the investigators are committed to increasing **\*\*diversity\*\*** in the economics research community by recruiting, training, and mentoring women, under-represented minorities, and first-generation college students as undergraduate research assistants and predoctoral fellows. code produced by this project will be made publicly available. this research project will develop tools to measure algorithmic discrimination. the project also will develop alternative non-discriminatory algorithms when qualification is unobserved for a subset of individuals. for example, in the employment context, whether an individual would be hired after an interview is not observed for applicants screened out before the interview is held. the investigators will show that

this selection challenge can be overcome with knowledge of average qualification rates across different groups. further, these average qualification rates can be estimated by utilizing random assignment of decision-makers to individuals. this insight can be used not only to measure algorithmic discrimination, but to develop alternative algorithms that reduce or eliminate discrimination. the project will consider several extensions. the investigators will utilize experimentation to measure algorithmic discrimination and improve accuracy. the interaction between algorithms and human decision-making also will be explored, as human discretion remains important in most real-world settings. the results of this research will have implications for more accurately quantifying the trade-offs between algorithmic transparency, accuracy, and fairness. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Measuring and Reducing Algorithmic Discrimination with Quasi-Experimental Data

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Matched Words: diversity

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Title: Chemical Bonding in Redox-Active Oxyfluorides

Awardee: University of Illinois at Chicago

Amount: \$400,000.00

**Abstract:** non-technical summary redox intercalation reactions are reactions during which electrons (negative charges) are transferred from one chemical building to a different one. in solid materials these reactions are essential to create battery technologies currently on the cusp of transforming human mobility. ideally new electrode materials allow large changes of charge, which maximizes energy storage, but these changes must also be reversible for extensive cycling and long battery lifetimes. this project, supported by the solid state and materials chemistry program in the division of materials research at nsf, seeks to build comprehensive descriptions of the chemical bond in oxyfluoride materials that are emerging as alternatives to pure oxides in cathodes for li-ion batteries with high energy density. the researchers investigate the role of fluoride ions to manipulate the underlying redox reaction, with especial attention to its participation in charge compensation. the research not only assesses the viability and design rules of oxyfluoride materials as practical battery electrodes, but also amplifies existing general theories of bonding in inorganic crystalline solids. the research has the potential to inform the discovery and design of mixed-anion materials with groundbreaking properties, even beyond battery applications. the research topic provides the driver for an educational plan with the unified goal to guide students toward energy applications, an area of the job market where growth and demand are still just onsetting. professor cabana's portfolio of education and outreach activities spans from elementary to graduate school, from local institutions to national events, with an emphasis in **\*\*diversity\*\*** by targeting members of hispanic communities.

**technical summary** the capacity of transition metal oxides as battery cathodes is maximized when high oxidation states can be achieved, but these states are not stable, leading to irreversibility and failure. oxyfluorides have recently been explored as alternatives, but the resulting synergies between anions remain to be ascertained, particularly the role of the halide when metals reach high formal oxidation states. this project, funded by the solid state and materials chemistry program in the division of materials research at nsf, leverages and expands methodologies of x-ray spectroscopy to uncover the balance of burden of metals and anions in redox compensation of oxyfluorides. the research spans to phases with late metals because their high formal oxidation states are known to

place the most stringent chemical demand on the anions, while also providing relevance to modern trends in batteries. this research aims to define fresh avenues to tailor materials to effectively and reversibly store large amounts of electrochemical energy, building new knowledge of the chemical bond that has the potential to transcend current boundaries of both chemistry and battery research. a tightly integrated educational component promotes materials chemistry and energy topics among the next generations. it includes outreach to local elementary schools and a national summer workshop on the frontiers of research in electrochemistry. the researchers also recruit undergraduates to conduct projects in support of this research, including through partnerships with hispanic organizations at the university of illinois at chicago. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Transforming Ethical STEM by Engaging Indigenous Research Methods in Native Environmental Science

Awardee: Northwest Indian College

Amount: \$399,935.00

Abstract: this project examines and documents the impacts of engaging with indigenous research methods and pedagogy in the science, technology, engineering and math (stem) fields. the native environmental science program (nes) at northwest indian college (nwic), situated within lummi nation's traditional territory with six extended campuses throughout the pacific northwest, is in a unique position to give voice to ethical research in stem. while there is some documentation about the impacts of engaging in indigenous research methodology in the social sciences, less is known about the impacts of engaging with indigenous research methods in stem. nwic's nes program is well positioned to influence the culture of stem education, more broadly, because of its commitment to engaging in methodologies and topics that align with community values and are identified as

community priorities. the **\*\*diversity\*\*** of students, themselves, with more than 130 different indigenous nations represented at nwc, provides a unique (and under-reported) lens to view science education and the growth of the stem field. this project addresses the need to develop culturally responsive and ethical research methodologies and practices for conducting relevant and transformational research in indigenous communities. this project documents the impacts of investing in tribal college science programs and developing culturally responsive and ethical research methodologies. specifically, this project investigates the question, "how does engaging with indigenous research methodology and pedagogy impact the educational pathways of indigenous students in the stem field?". answering this question will help contribute to a greater understanding of ethical research practices in the stem field, highlight best practices to support indigenous scientists, and lead to greater **\*\*diversity\*\*** and representation in the stem field. this investment in tribal college science programming is an investment in increasing the **\*\*diversity\*\*** in the stem fields, in general, while shaping innovative approaches to solving complex problems. engaging in ethics research involving indigenous science will provide a significant opportunity to grow and strengthen indigenous scientists while informing both minority-serving and predominately white academic institutions and stem practitioners. this project will provide a longitudinal study of indigenous students engaging in stem education over twelve years and an institutional autoethnography documenting program development. the project will also conduct focus group conversations with science faculty and advisors for high schools connected to northwest indian college and other tribal college science programs. the project addresses the need to develop culturally responsive and ethical research methodologies and practices for conducting relevant and transformational research in indigenous communities, and the research will be the first to comprehensively analyze the impacts of investing in tribal college science programs. this project will help answer the question, "how does engaging with indigenous research methodology and pedagogy impact the educational pathways of indigenous students in the stem field?" with two goals: 1) contribute to a greater understanding of ethical research practices in the stem field through

engagement with indigenous research methods and pedagogy and highlight best practices to support indigenous scientists and 2) greater **\*\*diversity\*\*** and representation in the stem field. analyzing the transformations of native environmental science research and practice in a tribal college setting will yield much-needed insights into how other research programs may adjust their research practices to promote inclusivity in research methods and design. following indigenous research methodologies prioritize community-identified research projects, reciprocity to and consistent engagement with community, and inclusivity of multiple ways of knowing. in addition, this process values indigenous knowledge holders as experts in the field and meaningful contributors to research and pedagogy. through this process, we will contribute to a wider understanding of the applications of indigenous research methodologies in stem disciplines. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SaTC: EDU: Secure and Private Artificial Intelligence

Awardee: Georgia State University Research Foundation, Inc.

Amount: \$399,681.00

Abstract: as artificial intelligence (ai) is incorporated into more systems, there are growing cybersecurity concerns related to privacy protection as well as a need for highly trained professionals who can develop and deploy trustworthy ai systems. the goal of this project is to develop instructional materials that expose students to privacy issues inherent in ai systems through real-world examples. the project will have a direct and long-term impact by addressing the growing national need for highly trained professionals capable of taking a holistic approach to solving real world problems in complex ai systems. in addition, the project will benefit numerous students from underrepresented minority groups and improve **\*\*diversity\*\*** of the workforce. georgia state university is a minority-serving institution and has strong connections with historically black colleges



and universities (hbcus) in metro atlanta and the wider region. the project will disseminate the developed materials through training workshops for the educational community and therefore promote adoption of training modules addressing privacy and ai. the interdisciplinary project team will develop a new course, "private ai", which will include instructional modules and hands-on labs that employ state-of-the-art private ai techniques addressing different privacy challenges of ai systems. these instructional modules will be designed according to learning science principles, specifically the principles of problem-centered instruction (pci). the modules will be based on real-world systems and are designed to cover fundamental privacy principles in ai systems and practical skills systematically. the learning objectives of the interactive curricular activities are for students to (i) understand fundamental concepts and principles of private ai; (ii) understand privacy attacks and defenses, different privacy-preserving techniques, and the pros and cons of each approach; and (iii) gain knowledge and skills in the development and deployment of private ai systems. the deliverables also include manuals to help instructors integrate the modules into their curricula and guidelines on implementing pci activities in the classroom since many instructors are not experts in instructional sciences. in order to simplify integration and encourage adoption, the modules and the labs will be based on open-source software and tools that are free to use for educational purposes. the modules will also be distributed via free cloud platforms. this project is supported by the secure and trustworthy cyberspace (satc) program, which funds proposals that address cybersecurity and privacy, and in this case specifically cybersecurity education. the satc program aligns with the federal cybersecurity research and development strategic plan and the national privacy research strategy to protect and preserve the growing social and economic benefits of cyber systems while ensuring security and privacy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Was There a Shift Toward Small, Non-Fossilizing Plankton after the End of the Cretaceous Mass Extinction?

Awardee: University of Texas at Austin

Amount: \$398,892.00

Abstract: phytoplankton, which live in the surface ocean, produce organic matter from sunlight and carbon dioxide. this primary production forms the base of most marine food webs and is a critical part of the global carbon cycle. in the modern ocean plankton are being impacted by warming and ocean acidification. natural changes in ocean temperature and chemistry in the geologic past can help us understand the long-term effects of stressors such as warming and acidification. the cretaceous-paleogene (k-pg) mass extinction event ~66 million years ago was one such time of global change. calcareous (fossil-forming) nanoplankton were one of the dominant primary producers in the cretaceous ocean. however, 93% of species of this group went extinct at the k-pg boundary, and they were never again as dominant. previous studies of the plankton response to the k-pg event have generally been limited to studies of species which leave a physical fossil record. thus, these studies provided only a partial view of ancient plankton ecosystems. the proposed work will overcome this limitation by using chemical fossils called biomarkers. these new data will be used together with traditional physical fossils to reconstruct changes in the marine plankton community following the k-pg event. it has often been assumed that non-fossilizing phytoplankton filled the gap left by the decline in calcareous nannoplankton. this study will help test that hypothesis. documenting the changes in both non-fossilizing and fossilizing plankton will improve our understanding of long-term changes in plankton ecology, and of how those changes could alter the ocean carbon cycle. this project will train early career researchers and undergraduate students, and will disseminate results to broader audiences through outreach and educational activities in partnership with organizations and programs in austin, tx and boulder, co. the project will develop datasets of lipid biomarkers, calcareous nannoplankton, and planktic foraminifera from 5 sites in tunisia, spain, and the us gulf coast. three sites in tunisia (el kef, elles, and el melah) represent a

depth transect on a continental shelf (paleodepths of 200-500 m), caravaca represents deeper water (~600-1000 m), while brazos represent a shallow shelf which will allow us to test regional variability between north africa and the us gulf coastal plain. these data will allow tests of the following hypotheses: 1. a low-**diversity** assemblage of non-fossilizing phytoplankton bloomed in the aftermath of the k-pg extinction, during the time of low **diversity** calcareous nannoplankton ?disaster? assemblages. 2. subsequent recovery of calcareous nannoplankton **diversity** is associated with a decline in non-fossilizing phytoplankton. 3. shifts in the heterotrophic planktic foraminifera assemblages are tied to turnover in the whole autotrophic plankton assemblage. 4. the post-extinction community of primary producers was dominated by smaller phytoplankton like algae and cyanobacteria, and would have increased carbon recycling in shallow waters and reduced carbon export to the deep sea. the study will improve our understanding of the recovery after the end cretaceous mass extinction and in our overall understanding of the role of plankton ecology in marine ecosystem change. additionally, reconstructing the whole plankton ecosystem, and not just the part that fossilizes, would represent a significant improvement of our toolkit to investigate ancient oceans. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Multi-atomic Layered Electronic Metal-organic Materials

Awardee: University of Wisconsin-Madison

Amount: \$398,848.00

Abstract: non-technical summary metal-organic hybrid materials (moms), such as coordination complexes, coordination polymers (cp), and metal-organic frameworks (mofs), possess vast structural **diversity** and thus have been extensively investigated for magnetism, catalysis, sensing, gas storage and separation, and biomedical applications. ideally, embedding the synthetic tunability of moms with the electronic properties (e.g., electrically conductive moms, called emoms)

would expand the molecular functionality of conventional inorganic electronic materials, offering new opportunities to address challenges in many vital electronic/electrochemical devices, including wearable devices, sensors, electrocatalysts, and electrochemical energy storage. unfortunately, to-date conventional mofs are primarily insulators by nature. with this career project, supported by the solid state and materials chemistry program in the division of materials research, prof. dawei feng studies a general approach to synthesize new types of emoms based on two dimensional (2d) multiple layered atomic structures (m-emoms). this research utilizes the structural **diversity** of mofs to unlock their full potential in advanced electronic and electrochemical devices. the pi and his team also partner with the materials research science and engineering centers (mrsec) education group and the institute for chemical education (ice) at university of wisconsin-madison to organize **make mofs at home?** after school enrichment program. through the integrated education plans, middle schoolers get hands-on experiences in synthesizing mofs using safe, daily accessible materials to foster their interests in stem, and undergraduate and graduate students receive interdisciplinary training in materials science, chemistry, and fabrication of energy storage devices.

**technical summary** the compositional **diversity** and synthetic tunability of metal-organic materials (mofs) give them great potential for a series of applications where precise tuning of structures and functionalities plays a vital role. integration of electronic properties (e.g., electronic conductivity) into mofs is of particular interest as it adds diverse functionalities on top of electronic properties, which greatly enriches the class of current electronic materials and the scope of their applications. however, the majority of mofs are insulators with just a few exceptional examples, most of which adopt single atomic layered p-d  $\pi$  conjugated 2d structures. this nsf career project develops new classes of electronically conducting mofs, called emoms through assembling multi-atomic layered 2d structures with p-d  $\pi$  conjugation, namely m-emoms. the metal species and organic ligands are systematically micro-tuned to manipulate the electronic characteristics and functionality of m-emoms. kinetically controlled synthetic methodologies are adopted to achieve highly crystalline m-emom products for precise measurement of their intrinsic properties. this permits

elucidation of fundamental aspects of interactions between the metal and organic building units and the subsequent impact on the bulk electronic properties. in turn, this research is poised to enable applications in various areas, including electrocatalysis and flexible electronic devices. this work not only provides a new platform to integrate metals with organic building units but also introduces new 2d material candidates with vastly expanded molecular engineering potential. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: SUNY at Binghamton

Amount: \$397,500.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Probing and Exploiting Short-range Order in Crystalline Materials for Fast Ion Transport

Awardee: University of Utah

Amount: \$397,311.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). non-technical summary: fast ion conductors are major players in energy storage, a strategically critical area for the holy grail of vehicle electrification and the best solution to the intermittent and random nature of many renewable energy sources, such as solar and wind. past research has heavily focused on ion conductors with perfect prototype structures. as a result, further materials discovery was limited to incremental improvement and a narrow range of chemistry. in this project, with support from the solid state and materials chemistry program in the division of materials research, the principle investigator investigates structurally-disordered ion conductors with compositional flexibility that can potentially alleviate the industry's reliance on any single critical metal source which has broad societal impact. the project also integrates education and research to increase enrollment, **\*\*diversity\*\***, and retention of stem students, creating america's future stem workforce. in pursuit of these goals, the pi creates demonstration kits for college teaching and k-12 outreach, a crystal growth course with hands-on research-based activities, and a novel augmented reality experience for interactive crystallography pedagogy. the pi collaborates with the utah stem action center to reach students from backgrounds underrepresented in stem and school districts historically underperforming in stem and deliver them the kits and demonstrations. technical summary: the facile transport of ions in crystalline materials enables key functionality in various devices, such as batteries, membranes, and fuel cells. the structural characterization of these materials, however, presents an outstanding challenge. their crystal structures often exhibit short-range order, whereas traditional diffraction-based techniques are only sensitive to long-range periodic features. as a result, past research either had to ignore it for lack of instrument sensitivity or avoided it completely for fear of complexity and unpredictability. this career project, supported by the solid state and materials chemistry program in the division of materials research, overcomes these difficulties by performing state-of-the-art synchrotron and neutron scattering on judiciously selected

ion conductors, to precisely characterize these structural subtleties in both the mobile ion and the framework sublattices. the project also systematically modifies the chemistry and synthesis variables and correlate these parameters with structural observations and property measurements to reveal previously overlooked structure-property relationships. these insights enable the design of disruptively new materials with fast ion transport and excellent economic sustainability. the pi also engages in a series of education and outreach activities by taking an approach centering on research-based, hands-on activities, to reinforce cognitive knowledge and retention and stimulate students' interest in higher stem education and careers. specific efforts include: (1) outreach to middle and high schools with stem activity kits; (2) expansion of the hands-on lab sessions in a crystal growth course; and (3) creation of an augmented reality app for interactive crystallography pedagogy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Continuous Twisted Nano-fibrous Yarns for Smart Piezo-Textiles

Awardee: Arizona State University

Amount: \$397,113.00

Abstract: clothing, after food, is perhaps the most common human essential, and textiles are a basic aspect of human life that has not changed from their "passive" form for many decades. current fabrics are made of passive materials such as nylon and cotton. the goal of this project is to investigate scientific foundations to realize controllable, and reproducible production of functional smart fabrics from nano-sized smart (piezoelectric) polymer yarns, and their integration with conventional fabrics. applications of smart textiles could include power generation and storage, personal protection, sports, fashion, communication, medical and physiological monitoring applications, and the internet of things. in particular, smart piezoelectric fabrics can be used for mechanical energy harvesting, for thermal energy harvesting through the pyroelectric effect, for

ferroelectric applications, as pressure and force sensors, for motion detection, and for ultrasonic sensing. smart fabrics will have the ability to react to different physical stimuli (mechanical, electrical, thermal, etc.) and as such can interact (sense, respond, communicate, and/or adapt) with their environment. this project will address the following challenges to realize smart piezoelectric polymer fabrics: development of processing and scale-up fabrication capabilities for production of continuous (weavable, knittable, and sewable) piezoelectric yarns; significant improvement in their electromechanical conversion efficiency; and design strategies for integration and packaging of piezoelectric yarns with conventional and conductive threads. the educational objective of the project is focused on increasing the **\*\*diversity\*\*** in nanotechnology-stem through summer programs for high school students. these students will be trained on nanotechnology research, in particular smart fabrics made of piezo nanofibers. in this project, a manufacturing process based on continuous electrospinning is proposed that enables continuous production of twisted yarns. a major obstacle in the utilization of piezoelectric polymers for smart fabric applications has been the low electromechanical conversion efficiency of piezo polymers (~2%) compared to the piezo ceramics (~50%), which are inherently brittle and not suitable for smart fabric applications. the scientific outcomes of this research will be the inter-relation of thermomechanical processing, percentage of crystallinity, and orientation of crystallites and elastic and piezoelectric properties of the piezoelectric nanofibers and twisted bundles. through fabrication and processing steps combined with computational analysis, the project will produce polymer yarns with significantly enhanced piezoelectric efficiency. this will be achieved through thermomechanical processing (thermal annealing, and drawing) designed to control the morphology (percentage of crystallinity, and orientation of crystallites), and hence properties (elastic and piezoelectric properties) and performance and output power under various external loads of piezoelectric polymer fibers. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity



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Title: Continuous Twisted Nano-fibrous Yarns for Smart Piezo-Textiles

Awardee: University of Texas at Dallas

Amount: \$397,113.00

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Matched Words: diversity

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Title: CAREER: An integrated study of wave-particle interaction on liquid interfaces

Awardee: University of North Carolina at Chapel Hill

Amount: \$396,909.00

Abstract: this career project will investigate how millimeter-size particles move and interact on the surface of a vibrating fluid. understanding the interplay between small particles and liquid surfaces is a broad area of research with many applications, including the transport and removal of floating litter and aerosol generation from rain drops merging with the sea surface. most of the studies available in the literature focus on situations involving either a single particle impacting on a liquid surface or multiple floating particles. however, an interesting regime, which has received much less attention, emerges when the underlying liquid bath is vibrated vertically. in this case, small droplets may bounce and even "walk" along the liquid interface as they interact with surface waves caused by rebounds. the goal of this project is to demonstrate new dynamics that characterize this intermediate

regime. the investigators will combine experiments and theory to study new bouncing and walking modes, behaviors of groups of interacting particles, and new transport effects emerging from the interaction between bouncing particles and submerged features. this project will provide new multidisciplinary research experiences and educational modules for high school, undergraduate, and graduate students. the investigators will develop a new course that interweaves rigorous mathematical training with direct exposure to realistic research settings. this project will also develop specific initiatives to instill strong communication skills in the trainees, including a dedicated bootcamp for students to develop expertise in the art of scientific visualization. the communication and visualization efforts will be leveraged to promote **\*\*diversity\*\*** in stem through a range of outreach events. this project will develop new experimental techniques and mathematical models to generate a fundamental understanding of the interaction between capillary-size particles and a vibrating liquid interface. in 2005, yves courder and co-workers discovered that a millimetric liquid drop can spontaneously walk along the surface of a vibrating fluid bath, self-propelled through a resonant interaction with the waves created when it strikes the fluid surface. by virtue of the coupling with their wave fields, these walking droplets, or "walkers", exhibit surprisingly rich dynamics, including complex bouncing modes, bound states, and dual wave-particle behaviors. this project will extend and exploit the remarkable walker dynamics for fundamental research relevant to practical settings involving granular materials on liquid interfaces. the investigator will first focus on broadening the current parameter regime of bouncing and walking dynamics to include new combinations of fluids and solid particles of different shapes. the second aim will be to investigate new self-assembly and collective dynamics with large ensembles of walkers coupled by wave-mediated forces. the final aim will be to examine the interaction between walking droplets and submerged features at the bottom of the liquid bath, including periodic and disordered bottom topographies. this class of problems will lead to a better understanding of the interplay between particles and liquid interfaces, and offer design principles for the development of new methods of self-assembly, particle sorting, and transport of granular materials on liquid interfaces. this award

reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: IRES Track II - Cape Horn ASIs: Climate change and disease ecology at the southern end of the Americas

Awardee: University of North Texas

Amount: \$396,610.00

Abstract: over sixty percent of earth's ice-free areas are best described as human-modified anthropogenic biomes. this means that pristine areas are scarce, and that most ecological studies are de facto studies of anthropogenic impacts on ecological systems. however, the study of pristine systems is necessary for developing a baseline understanding of ecological function so that we can apply this understanding to develop meaningful and appropriate conservation plans, or even know what applied research questions are worth pursuing. unfortunately, pristine systems are at a premium. in general, graduate students do not have the opportunity to develop their ecological understanding under pristine or near pristine ecological systems. in addition, the national academy of science, engineering and medicine data suggest that current stem graduate student training may not be providing a rigorous education in quantitative experimental design. quantitative experimental design is designing studies with an eye toward the statistical analyses that will be used to analyze the data. using quantitative design principles, rooted in sound ecological theory, ensures that researchers are asking relevant and testable questions that will lead to meaningful results. this is a crucial component of graduate student education and researcher professional development, as it ensures that increasingly scarce research funding are not wasted additionally, collaboration is becoming the norm in research, and international collaboration via electronic media was becoming increasingly common even before the current pandemic. in this ires track ii project, students will have the opportunity to be trained in quantitative experimental design and work as part of a

multinational research collaboration to study infectious disease emergence in one of the few remaining pristine places on earth. the cape horn biosphere reserve (chbr) off the southern tip of south america protects pristine ecosystem is perfect for this type of graduate student training. the chbr is part of the sub-antarctic magellanic ecoregion, which is globally significant because it houses the worlds southernmost forest biome, contains numerous endemic species, is remote, and is relatively free of anthropogenic impacts. in addition, with the exception of avian malaria which arrived just a few years ago, the system is relatively free of zoonotic diseases. making the region a living laboratory to study the ecosystem transformations that co-occur with human discovery and settlement of an area. the program will bring graduate students from across the us to work in international collaborative teams with chilean students from the universidad de magallanes (umag) and the institute of ecology and bio\*\*diversity\*\* (ieb) in chile, and a diverse group of faculty from across the us and chile. the focus of the program will to be provide graduate students robust and hands-on training in quantitative experimental design and international collaboration resulting in publications. the research questions themselves will be flexible, but organized thematically. specifically, this ires track-ii will focus on the merging molecular genetic analysis using a mobile next generation sequencing lab with mist netting and arthropod trapping to investigate the impacts of wildlife disease on local bio\*\*diversity\*\* and community structure. secondarily, edna and traditional wildlife disease monitoring approaches will be applied to understand the potential for zoonosis and understanding ecological factors that contribute to, or inhibit, zoonosis. resultantly, participation in this program will help train the next generation of scientists with the skills needed to make meaningful contributions to the study of ecology, conservation, and wildlife disease ecology. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: IntBIO Collaborative Research: An integrative approach for projecting insect responses to a

rapidly changing climate

Awardee: Board of Regents, NSHE, obo University of Nevada, Reno

Amount: \$396,542.00

Abstract: projecting species' responses to climate change at continental scales is a current 'grand challenge' of ecological research. insects are sensitive indicators of both climate and land-use change and recent studies indicate widespread declines in many geographic regions. to predict changes across entire ranges, a variety of species distribution models have been developed, but rarely account for regional variability, ecological interactions or a species' potential to adapt to changing conditions. this project spans multiple institutions situated in the united states' southwest, polar north, and temperate eastern regions. a series of physiological experiments will be implemented for five widespread butterfly species with populations sourced from different biomes within each of their ranges. caterpillars will be subjected to a range of conditions mimicking past, current and future climates. their development rate, survivorship, immune response, and genetic structure and gene expression (which genes are actively coding for proteins) will be measured and used to build models that predict distributional shifts. data collected by community ('citizen') scientists will be used to validate the models. this project requires substantial cross-disciplinary collaboration, and a central goal is to recruit diverse trainees at the graduate and undergraduate levels and train them in the 'science of team science'. project trainees will develop independent research ideas that align with and expand the project's scope and travel between and work at collaborating institutions as an inter-lab exchange to learn new techniques and be exposed to different research philosophies. finally, the project has significant management implications for insect bio\*\*diversity\*\* conservation. projecting responses to climate change at continent scales is a current 'grand challenge' of ecological research. insects are the most diverse and ecologically important terrestrial animal taxon and are strongly affected by climate change. to predict changes, species distribution models (sdms) have been widely implemented across many taxa. sdms, however, rarely account for ecological interactions, plasticity or evolutionary adaptive potential owing

to the extensive physiological and ecological data required to parameterize such models. the biology of lepidoptera, particularly butterflies, is extremely well observed, thus it is logistically feasible to build upon past knowledge and collect additional data that enables mechanisms to be more seamlessly integrated into sdms. multiple populations for each species will be sourced from different biomes across its range. caterpillars will be reared in common gardens under a range of temperature conditions mimicking past, current and future climates. their development rate, survivorship, immune response, genetic structure and gene expression will be measured and used to build models that predict future distributions. distribution data collected by community (?citizen?) scientists will be used to validate and improve models and allow robust estimates of uncertainty. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity



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Title: CAREER: Electrochemical Dynamic Midinfrared Metasurface for Ultra-Low Power Wearable Thermoregulation

Awardee: Duke University

Amount: \$396,513.00

Abstract: thermal comfort is one of the most essential fundamental needs for human health and productivity. the seasonality of cardiovascular diseases and influenza demonstrates the importance of stabilizing our thermal environments. however, because of its necessity, indoor temperature control is also associated with enormous energy consumption and carbon emission. this proposed work aims to break the health-energy dilemma by developing a wearable radiative thermoregulation device that can localize heat management around the human body. like a chameleon that can change its visible color, the wearable device can act like a second skin that changes the level of radiative heat loss into the environment to offset the adverse ambient temperature change. the thermal radiation is tuned by an electrochemical reaction that uses less than 1 v as operation voltage. this working principle is similar to a battery but with the focus on its mid-infrared optical property change. like a battery that can maintain its state of charge for a long time, the device can also maintain its heating/cooling state with ultralow energy consumption, which is orders of magnitude more efficient than traditional active devices such as electric blankets. to promote **\*\*diversity\*\***, equity, and inclusion, the project will organize the annual workshop series called lite (light, infrared, and thermal energy) for underrepresented students by collaborating with the step up to stem program at north carolina school of science and mathematics. the workshop series aims to inspire high schoolers' interest in photonics, thermal science, and general stem fields by providing introductory lectures and immersive hands-on experiments such as thermal vision vr goggle diy sessions. in photonic technical terms, the device adopts a metal-insulator-metal configuration and the working principle of a midinfrared metamaterial perfect absorber. it uses electrochromic conjugated polymer, such as polyaniline, as the active material. by electrochemically biasing the

polymer, its carrier density, plasmon frequency, and permittivity are tuned dynamically and reversibly, thus varying the device state between a metamaterial absorber and a simple metallic reflector, which is equivalent to emissivity tuning based on the kirchhoff's law of thermal radiation and the zero transmittance. this project will involve multiscale and multidisciplinary study in materials science, photonics, heat transfer, and wearable device engineering. specifically, the project will develop the correlation among polymer synthesis condition, structural characterization, charge transport measurement, mid-infrared permittivity, metamaterial absorber designs, and heat transfer measurement. the proposed research will scale up the adaptive metamaterial absorber and implement kirigami paper cutting technique to provide stretchability, breathability, and conformal deformability from 2d thin film to 3d shapes for wearable applications. the wearable metasurface thermoregulation will further advance the emerging field of multimodal and multispectral light and heat management for the health-energy nexus. the in-depth study of electrochemically active polymers will also become an enabler for adaptive optical metasurfaces, sustainable energy science, and personalized preventive medicine. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Phase Transformation and Proximity Coupling in Lateral Heterostructures of Metal Dichalcogenides

Awardee: Michigan State University

Amount: \$394,948.00

Abstract: two-dimensional (2d) materials are atomically thin with atoms strongly bonded within layers but weakly between layers. this weak interlayer coupling allows for the vertical stacking of different materials to form heterostructures with interesting properties and applications. in contrast, a lateral heterostructure consists of different 2d materials placed side by side with one-dimensional

boundaries with strong bonding. the difference is akin to a stack of different plates (vertical) vs. being spread out on a table (lateral). this project will investigate novel phenomena that arise in lateral heterostructures with exposed boundaries on the surface. this allows for spatially resolved exploration of new interfacial physics and the rational design of heterostructures with desired properties. for example, the pis have previously demonstrated that they can convert a 2d material from a semiconductor to a topological insulator. the latter is a state of quantum matter that behaves as an insulator in its interior but as a conductor on its surface. coupling a topological insulator with a superconductor may give rise to topological superconductivity, which can be used for quantum computers. this project also aims to providing training ground for a competitive workforce in materials research. the pis will strive to enhance the **\*\*diversity\*\*** of this workforce by actively recruiting and mentoring female and minority students. research-based educational materials are to be integrated with outreach activities to engage the public. the rapid advances in two-dimensional (2d) materials enable the integration of atomically thin layers with vastly different properties into heterostructures, where exotic behaviors that are not accessible in individual layers may emerge. most studies of 2d heterostructures have been pursued on vertical geometries to take advantages of van der waals interaction for creating a passivated interface with low density of interfacial electronic states. in contrast, lateral heterostructures uniquely allow for the heterointerfaces, which are typically buried in the bulk, to be directly exposed on surface for unravelling boundary-induced behaviors by scanning probe techniques. the pi aims to explore the versatility of phase transformation scheme empowered by the core-shell lateral architecture and apply the proximity studies to transition metal dichalcogenides (tmDCs) with correlated electronic behaviors. the local perturbations associated with the lateral boundary could provide the knob to tune the interactions and thus facilitate the understanding of collective electronic states as well as their interplay in the monolayer regime. this research also aims to address the feasibility of applying lateral heterostructures to induce topological superconductivity on the edge of 2d topological insulators. it sheds light on the investigation of majorana physics using lateral templates of 2d materials, holding potential to implement topological

qubits in fault-tolerant quantum computation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: REU Site: MURALS (Materials-focused Undergraduate Research Applied to the Life Sciences) at UMass Amherst

Awardee: University of Massachusetts Amherst

Amount: \$391,761.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). non-technical summary this reu site offers research opportunities for 10 undergraduates each summer at the university of massachusetts amherst (umass amherst). this reu site is unique in that it will give students training in how to create advanced materials and how to use these materials to tackle grand challenges in biology. students work in laboratories at the biology/materials interface, take part in both professional development and technical training provided by the reu site, and learn from near-peer and lab mentors to guide student career development. the site has outstanding mentors from leaders in the field from both chemical engineering and biomedical engineering at umass amherst. all labs are physically and intellectually connected through the institute for applied life sciences at umass. industry site visits and entrepreneurial outreach activities help expose students to potential career opportunities in biotechnology. partnership with the other professional development programs at umass supports recruitment and mentoring of reu students across all backgrounds to ensure everyone has an equal opportunity to research opportunities at umass. recruiting efforts at several minority-serving national conferences, as well as partnerships with minority-serving institutions via the \*\*diversity\*\* office in the college of engineering at umass ensures opportunities for students from traditionally underrepresented groups in stem. evaluation efforts track the long-term outcomes for students from

these groups.        technical summary        this is a new reu site (murals: materials-focused undergraduate research applied to the life sciences) at umass amherst, developed to offer research opportunities for 10 undergraduates each summer, broadly in the area of materials for bioengineering applications. the pi of this reu site, prof. shelly peyton, is an expert in bioengineering, with a focus on applying biomaterials development toward solving complex problems in biology. this site has 10 host laboratories, with faculty from the chemical engineering and biomedical engineering departments at umass amherst, who are both physically and intellectually connected through the institute for applied life sciences at umass amherst. the overarching objectives of the murals reu site are to: 1) recruit and encourage students from traditionally underrepresented groups in engineering to do research at the interface of materials and the life sciences; 2) inspire students from all backgrounds to pursue graduate studies and/or professional careers at the interface of materials and the life sciences; 3) train students to be effective scientific communicators, through carefully planned workshops on writing, presentation skills, and working amongst diverse groups of scientists; 4) integrate reu students within the broader scientific community at umass amherst by pairing students with peer mentors outside the lab; 5) allow students to explore their interests in entrepreneurship, through a partnership with the technology development office within ials, the biotechnology training program (btp) at umass, and industry site visits; 6) provide students with professional development workshops and tools (e.g., career choices, ethics in research, interviewing strategies, time management) to instill the techniques to succeed in any industry long after they leave murals. recruiting efforts at several minority-serving national conferences, as well as partnerships with minority-serving institutions via the \*\*diversity\*\* office in the college of engineering ensure opportunities for students from traditionally underrepresented groups in stem. evaluation efforts track the long-term outcomes for students from these groups.        this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Proposal: NSF-DFG Echem: Understanding the Mechanism of Urea Oxidation on Nickel-Based Electrocatalysts

Awardee: University of Washington

Amount: \$391,583.00

Abstract: urea is a common high-nitrogen chemical waste product of mammalian metabolism, and a major component of fertilizer runoff poses significant threat to water resources from agricultural runoff and municipal wastewater. A promising means for removing excess urea is to oxidize it electrochemically to produce harmless compounds. Urea removal processes can also be used to generate electricity and to produce hydrogen for fuel cells. Electrochemical urea removal therefore exhibits strong potential as a transformative technology by converting a harmful waste product to the benefit of society, industry, and the environment. The project brings together researchers from the United States and Germany to apply a synergistic blend of experimental and theoretical methods to the study of electrochemical urea removal from water. In particular, the project seeks fundamental understanding of catalytic urea oxidation that is needed to develop feasible urea removal technologies. Effective urea removal systems are key to a large number of technological applications including municipal and agricultural wastewater treatment, remediation of fertilizer runoff, ammonia synthesis, hydrogen production, and electricity generation. Other benefits from this project will include workforce development and educational outreach to underrepresented grade-school students. These efforts will promote increased diversity in STEM fields, a student exchange program between Germany and the US, and improved scientific literacy of the general public. The goal of this research project is to develop comprehensive knowledge of electrochemical urea removal over nickel-based catalysts, based on experimental and theoretical research spanning molecular and device levels. Electrochemical urea removal will be studied by density functional theory calculations, vibrationally and electronically resonant sum frequency spectroscopy, and electrochemical measurements of reaction rate and product distributions. Particular attention will be

paid to the active form of the nickel oxide electrode as it exists in different phases and oxidation states depending on electrode potential and history, such as aging and preparation method. this combined electrochemical, spectroscopic, and computational approach provides insight related to catalyst structural changes and how they affect the urea reaction mechanism, reactivity, and effectiveness of nickel, nickel-iron, and nickel-chromium catalysts. the outcomes of this research will greatly advance the scientific understanding of electrochemical urea removal -- about which little is known -- and establish a foundation in the wider field of electrocatalysis regarding electrochemical reactions on oxide surfaces and on surfaces that undergo a change in oxidation state as part of the overall reaction mechanism. successful completion of this research will benefit society through sustainable methods for treating wastewater and agricultural run-off that will reduce demand on water supply systems and enhance the bio\*\*diversity\*\* of marine ecosystems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Mechanics of Crystallization, Deformation and Phase Transformation in Granular Materials with Engineered Grain Geometries

Awardee: University of Colorado at Boulder

Amount: \$391,525.00

Abstract: this grant will focus on the engineering, modeling, fabrication and testing of new types of solid granular materials. granular materials like sand are seemingly simple, but their mechanics is remarkably rich and complex. in this project, the geometry of individual grains will be manipulated to generate crystallization and deformation mechanisms not seen in traditional granular materials, creating ?granular materials by design?. this project will establish a mechanics-based fundamental understanding of crystallization in granular materials, enabling manipulation and assembly at large scales. this project will also generate mechanics-based models for the inelastic deformation of

granular crystals based on contact mechanics and geometrical hardening. the new granular materials that will emerge from this work will have high strength, unique combinations of assembly / disassembly, strength and self-healing, making them attractive as lightweight materials and aggregate architectures. the reversible nature and the large deformation capabilities of these granular materials will also make them attractive as shape morphing materials, programmable ?smart? matter, robotics and biomedical materials. vigorous outreach activities will be developed in this project including curriculum development at the university of colorado, research projects for undergraduate students, active learning module for high school students, as well as promotion and improvement of **\*\*diversity\*\*** in stem. a major scientific objective for this project is to create a unified and mechanics-based framework that captures the assembly, phase transformations, deformation and failure of engineered granular materials. granular systems of specific interest and critical scientific questions include: (i) high packing and space filling in ?granular crystals? with stiffness and strength orders of magnitude higher than traditional granular materials; (ii) steering of grains through amorphous-crystalline transitions using mechanical stimuli; (iii) effects of confinement and unlimited deformations to create and control attractive functionalities such as shape morphing, healing, tuning of stiffness and strength; (iv) mechanics of interlocking in branched particles to generate high strength and toughness in tension. methods include discrete element modeling using geometry-sensitive contact algorithms, 3d printing of grains, and mechanical experiments with in-situ 3d imaging (refractive index matching scanning). a fundamental understanding of these new ?engineered? granular materials will lead to new paradigms for the manufacturing and mechanics of granular materials and structures, and for the generation of advanced functionalities such as adaptability, shape morphing or self-healing. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: GCR:Can improved ecological forecasting accelerate sustainability transformation in urban lighting?

Awardee: Colorado State University

Amount: \$389,774.00

Abstract: achieving national sustainability goals will require rapid adoption of more sustainable practices in many areas of society but transitions to sustainable practices are often slow. this project tests whether these transitions can be accelerated by (1) creating innovative ecological forecasts that predict where and when more sustainable practices would have the greatest benefits and (2) engaging impacted communities in the process of co-implementing forecasts and advocating for sustainability transitions. the study system is the proliferation of artificial lights at night (alan) and its impacts on migrant birds. alan is increasing rapidly worldwide, and its benefits are countered by pervasive negative consequences for bio\*\*diversity\*\*, ecosystems, and human health. a major ecological consequence of alan is disruption of bird migration ? millions of birds die annually in collisions with well-lit buildings ? which contributes to widespread bird population declines. the alan-bird migration system is ideal for this study because, like many wicked environmental

problems, environmental concerns emerge as a product of complex social and cultural processes that have proven difficult to resolve using traditional approaches. this project employs a transdisciplinary convergence approach to integrating advances in ecological forecasting with those in the social and political science of community engaged scholarship. experiments testing sustainability impacts of innovations in ecological forecasting will be co-designed and implemented with a coalition of convergence research partners. the project will generate an understanding of pathways by which sustainable practices are adopted for alan, this new knowledge can be used to help address other societal-environmental conflicts. the project focuses on testing a key prediction of sustainability transformations science theory ? that innovations originate within advocacy coalitions then accumulate at the subsystem level to drive sustainability transformations (e.g., new policies). during phase one the investigation gathers detailed national survey information on the alan system and creates transformational technological improvements in existing bird migration forecasts specific to impacts of alan. this new social and ecological knowledge will then be used to engage with advocacy coalitions in specific urban testbed sites to co-implement sustainability transformation experiments during phase two. these experiments will use targeted messaging campaigns to foster alan mitigation. experiments will be focused on sustainability-oriented coalitions because these advocates are predicted to have high leverage to affect radical transformation toward sustainability across the alan subsystem. impacts of the experiments on alan, impacts of alan on migrant birds, and human behaviors and attitudes toward alan will be quantified. through this two-phase approach this project will produce a new understanding of how innovations derived from a convergence research approach can be employed in a sustainability science and policy framework to accelerate transformations. these outcomes will contribute understanding of how communities and researchers can co-engage with wicked environmental problems more broadly to drive transformations toward sustainability. results will create new, and potentially transformative, understanding of how ecological forecasting contributes to sustainability transformations. this project is jointly funded by the growing convergence research program and the established program to stimulate competitive

research (epscor). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: BPC-AE: STARS: Catalyzing Action-Oriented Academic Communities for Broadening Participation in Computing

Awardee: Kent State University

Amount: \$388,484.00

Abstract: it is critical to address the longstanding issue of underrepresentation of women, black, and hispanic students in computing degree programs to provide an equitable foundation for all to participate in our society and the global economy as controllers and creators of technology, and to advance the preparation of a diverse, innovative, and competitive tech workforce. building on the prior success of the stars computing corps alliance for broadening participation in computing, the goal of the stars catalyst project is to: 1) increase the number of women, black, and hispanic students that persist in computing degree programs, and 2) advance the careers of students and faculty from groups that have been historically underrepresented in computing. through research and evaluation around stars catalyst activities, this project will advance knowledge about practices designed to increase persistence and support career advancement in computing for college computing students and faculty, particularly for those from underrepresented and intersectional groups in computing. the stars catalyst alliance is a collaborative effort across temple university, north carolina state, kent state, florida state university, morgan state, and university of north carolina charlotte. the stars computing corps alliance for broadening participation in computing (bpc) engages computing faculty and students at colleges, universities, and community colleges in a community of practice with a shared commitment to take action to advance **diversity**, equity, and inclusion in computing. stars computing corps conferences, communities, and networks create

significant institutional and human resources that can expand bpc research to a larger audience of researchers, educators, administrators, cs departments, and k-20 students, and can dramatically increase the number of people taking action in bpc efforts. prior results show that the stars computing corps alliance increases intentions to persist in computing among stars students and faculty, with enhanced outcomes for black students and faculty. this project will significantly extend the stars alliance to expand upon those impacts, by 1) including new partners that expand the reach of stars and that emphasize participation of black and hispanic students and faculty, particularly from emerging hispanic serving institutions and community colleges, 2) creating new program elements that test new and propagate evidence-based bpc practices within computing departments, and 3) leveraging partnerships to support identity-focused affinity groups, and 4) developing stars alumni groups employed in industry positions to promote transition to and retention within the tech workforce. extensions to the stars leadership corps program, stars launch program, and the stars celebration conference will serve to develop and propagate evidence-based approaches aimed at improving the teaching and learning of computing for black and hispanic students and build evidence of their effectiveness, and the respect research conference will continue to advance peer-reviewed bpc scholarship. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Abstract: it is critical to address the longstanding issue of underrepresentation of women, black, and hispanic students in computing degree programs to provide an equitable foundation for all to

participate in our society and the global economy as controllers and creators of technology, and to advance the preparation of a diverse, innovative, and competitive tech workforce. building on the prior success of the stars computing corps alliance for broadening participation in computing, the goal of the stars catalyst project is to: 1) increase the number of women, black, and hispanic students that persist in computing degree programs, and 2) advance the careers of students and faculty from groups that have been historically underrepresented in computing. through research and evaluation around stars catalyst activities, this project will advance knowledge about practices designed to increase persistence and support career advancement in computing for college computing students and faculty, particularly for those from underrepresented and intersectional groups in computing. the stars catalyst alliance is a collaborative effort across temple university, north carolina state, kent state, florida state university, morgan state, and university of north carolina charlotte.

the stars computing corps alliance for broadening participation in computing (bpc) engages computing faculty and students at colleges, universities, and community colleges in a community of practice with a shared commitment to take action to advance **diversity**, equity, and inclusion in computing. stars computing corps conferences, communities, and networks create significant institutional and human resources that can expand bpc research to a larger audience of researchers, educators, administrators, cs departments, and k-20 students, and can dramatically increase the number of people taking action in bpc efforts. prior results show that the stars computing corps alliance increases intentions to persist in computing among stars students and faculty, with enhanced outcomes for black students and faculty. this project will significantly extend the stars alliance to expand upon those impacts, by 1) including new partners that expand the reach of stars and that emphasize participation of black and hispanic students and faculty, particularly from emerging hispanic serving institutions and community colleges, 2) creating new program elements that test new and propagate evidence-based bpc practices within computing departments, and 3) leveraging partnerships to support identity-focused affinity groups, and 4) developing stars alumni groups employed in industry positions to promote transition to and retention within the tech

workforce. extensions to the stars leadership corps program, stars launch program, and the stars celebration conference will serve to develop and propagate evidence-based approaches aimed at improving the teaching and learning of computing for black and hispanic students and build evidence of their effectiveness, and the respect research conference will continue to advance peer-reviewed bpc scholarship. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Achieving Real-Time Machine Learning with Sparsification-Compilation Co-design

Awardee: College of William and Mary

Amount: \$388,400.00

Abstract: machine learning (ml), particularly deep learning (dl), has gained great success in recent years, especially with the use of deep neural networks (dnns) of different types. varied dnns serve as the state-of-the-art foundation and core enabler of many key applications, such as robotics, high-quality video stream processing, augmented reality, wearable devices, smart health devices, etc. achieving high accuracy typically requires dnns with large and complex model structures, which also translates into high computing requirements for both training and inference steps. accelerating the training process on a modern high-performance computing (hpc) node or cluster and inference process on a lower-end power-efficient device have both emerged as major challenges. this project focuses on this problem, viewing dnn training and inference as hpc workloads that need to exploit available multi-level parallelism, complex memory hierarchy, and device heterogeneity; while automating the optimizations through a compiler. if this project succeeds, it will, for the first time, enable real-time machine learning for many edge devices, enabling the greater success of ml-based end applications that are important for the society, economy, and other science and engineering areas. this project will also make several contributions towards both education and improving

**\*\*diversity\*\***, including: (1) introducing hpc in an ml course, and ml workloads optimization experience in both undergraduate systems and graduate research courses, particularly with interesting demonstration videos; (2) outreaching to undergraduates with the goal of creating interest in (systems) research, and to k-12 with the goal of attracting underrepresented groups to computer science.

the key idea of this project to address the above challenge is sparsification-compilation co-design. it first introduces a general sparsification idea called fine-grained structured pruning, which prunes the weights according to certain fine-grained structures and preserves non-zero weights in a more regular way. based on this idea, this project designs a high-level abstraction called layer-wise intermediate representation (ir) to capture the sparsity information with the goal of enabling aggressive compiler optimizations. building on a successful application of this idea on two-dimensional dnns, this project undertakes a comprehensive agenda to fully apply the benefits of this approach. first, it unifies convolutional neural networks and recurrent neural networks acceleration with a more general fine-grained structured pruning instance and a set of enhanced compiler-based automatic optimizations. second, it improves the pruning or retraining process itself by extending the compiler optimizations from inference to pruning and exploiting domain properties to carry-out optimized application-level checkpointing. third, it extends the (compiler automated) optimization framework to support high-dimensional and extremely deep dnns. finally, it explores data reuse across dnns for situations where multiple dnns are co-executed on the same device.

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Does Cytonuclear Coevolution Drive Reproductive Isolation?  
Dissecting the Architecture of Genetic Incompatibility Across a Species Range

Awardee: James Madison University



Amount: \$386,265.00

Abstract: the natural world exhibits a vast array of bio\*\*diversity\*\* which ensures the stability of ecosystems, the services they provide, and has intrinsic aesthetic value. individual species are critical elements of this bio\*\*diversity\*\* and understanding how new species form is key to ensuring maintenance of \*\*diversity\*\*. interactions between the nuclear genome and organelle (mitochondria and chloroplast) genomes underlie key processes including respiration and photosynthesis. these interactions are an underappreciated and yet potentially powerful driver of the earliest stages of speciation. the planned research will investigate the contribution of intergenomic interactions to incompatibility between populations of a species. the research will use state-of-the art techniques to identify the genomic basis of incompatibility between the nuclear and organelle genomes and determine the ability of such incompatibility to maintain genetic divergence and facilitate speciation in a contact zone. the project will also introduce undergraduate students and high-school and community college teachers to core ideas about species formation and evolution through hands-on experience with the newest genomic sequencing technologies in a novel course-based lab module and workshop. finally, the project will provide training at the undergraduate, graduate, and post-graduate level. interactions between cytoplasmic and nuclear gene products are expected to drive intergenomic coevolution, leading to the potential for genetic incompatibility and reproductive isolation between populations with divergent cytoplasmic genomes. while such cytonuclear incompatibility (cni) has been posited to be among the earliest reproductive barriers to develop during speciation, our understanding of the dynamics of cni at the early stages of speciation remains limited, particularly for plastid-driven speciation. the research will examine the dynamics of plastid driven cni in *campanula americana*, creating a powerful set of genomic resources, characterizing variation in the genetic architecture of cni across lineages, and leveraging a natural contact zone to evaluate whether exposure to selection alters the genetic architecture of cni relative to allopatry. together, these data will provide insight into the evolutionary dynamics of plastid-nuclear incompatibility and how these dynamics may drive the early stages of speciation. this award

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Louisville Research Foundation Inc

Amount: \$385,167.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: REU-Site: Regional Initiative to Promote Undergraduate Participation in Experimental and Computational Materials Research

Awardee: University of Alabama at Birmingham

Amount: \$384,789.00

Abstract: non-technical summary: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). the university of alabama at birmingham (uab) in partnership with historically black colleges and universities (hbcu?s) in alabama will host a research experiences for undergraduates (reu)-site in experimental and computational materials research. this reu-site project plans to recruit students from underrepresented groups and academic institutions where research opportunities are limited. this project offers a broad range of interdisciplinary materials research experiences to undergraduate students with a **\*\*diversity\*\*** of backgrounds in physics, chemistry, applied mathematics, and engineering. the undergraduate students will gain experience in materials synthesis, materials characterization and computer modeling and simulations during their ten-week research stay at the uab campus. the scientific research projects have been specifically developed for undergraduate students by an interdisciplinary team consisting of science and engineering faculty at uab. this project will continue to provide lecture series and workshops in materials growth and characterization, research ethics and professionalism, innovation and entrepreneurship and preparation for graduate school to all participants. the reu participants will publish their findings in peer-reviewed journals and/or present at professional meetings leading to a broad dissemination of new knowledge created in the undergraduate research projects. this reu-site plans to develop a pipeline of undergraduate researchers who will become leaders in advances in science and discovery of novel materials and contribute to economic development and national defense. technical summary: reu-research projects are organized in four research clusters: (1) materials under extreme conditions (2) machine

learning and simulations in materials research, (3) infrared lasers and spectroscopy, and (4) polymeric biomaterials and capsules for drug delivery applications. the undergraduate research projects will contribute to fundamental understanding of phase transformations and degradation of materials under extreme conditions, machine learning enabled materials discovery, materials for mid-ir lasers and quantum information systems, and 3-d printed biomaterials and stimuli responsive polymers. some research projects will also involve the use of national x-ray synchrotron facilities and neutron diffraction facilities in materials research. the undergraduate student projects have short-term achievable milestones, while simultaneously contributing to longer-term scientific goals and technological applications. our teaming arrangement of reu-participants with faculty and graduate students, giving poster and oral presentations, writing a research-style paper, and attending training seminars in scientific communications and ethics will help reu students see the big picture of what it takes to develop into a research scientist with the critical skills needed for analyzing, interpreting, and presenting scientific data. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: REU Site: The Stressed Life of Cells

Awardee: University of Kansas Center for Research Inc

Amount: \$384,630.00

Abstract: this reu site award to the university of kansas, located in lawrence, ks, will support the training of 10 students for 10 weeks during the summers of 2022-2024. students will formulate their research plans with their mentors, spend the majority of their time on a research project, and will present their findings in a university-wide research symposium at the end of summer. the underlying aim is to provide students with a strong basis and incentive for pursuing careers in research, with a specific goal of increasing **\*\*diversity\*\*** and participation in the sciences. it is anticipated that a total of 30 students, primarily from schools with limited research opportunities, or from underrepresented groups, will be trained in the program. mentor-directed scientific activities will be performed in the department of molecular biosciences in faculty labs in the fields of biochemistry, cell, molecular and developmental biology, virology and microbiology, and computational biology. in the context of the common research theme of 'stress,' students will learn how environmental and biological conditions may affect development, function, and survival of cells and organisms, as well as the nature of stress response mechanisms. examples of student projects may involve use of genetically tractable organisms (drosophila, c. elegans) to model evolution of stress responses or neurological responses to stress, use of modified infectious agents (bacteria, coronavirus) in studies of host/pathogen interactions and mechanisms, and biochemical analysis of infection-associated strategies in microorganisms (t3ss, quorum sensing). weekly programs and social activities will

develop student career progression, foster independence as a scientist, hone presentation skills, and foster community. students will attend interactive workshops on responsible conduct of research, scientific writing, and applying to graduate school. assessments of the program will be performed using the salg urssa tool. program members and faculty will maintain continued communications with participants as they plan for conference presentations and prepare for graduate school, allowing their career trajectories to be assessed. participants should have completed freshman biology and chemistry, and must be u.s. citizens or permanent residents. more information about the program is available at mbreu.ku.edu, or by contacting the pi, dr. lisa timmons, at mb-reu@ku.edu. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: CNS Core: Medium: Data Augmentation and Adaptive Learning for Next Generation Wireless Spectrum Systems

Awardee: Auburn University

Amount: \$383,835.00

Abstract: deep learning has shown great promise in solving many open challenges in wireless networking research and applications. deep learning is data hungry, and one of the critical obstacles towards fulfilling its promise is facilitating the acquisition of sufficient amounts of data to train and validate deep learning models. the primary goal of this project is to devise innovative approaches that enable wireless researchers and practitioners to acquire data more efficiently at reduced cost and to utilize existing data more effectively. findings from this project are expected to fuel future breakthroughs in wireless research by making deep learning models more widely applicable. by integrating research and education, the proposed work will provide excellent hands-on exercises, research, and educational opportunities for undergraduate and graduate students at the three



collaborating universities. the project will leverage the existing **\*\*diversity\*\***-related outreach programs at the three institutions to broaden participation from under-represented groups. a team of four investigators with complementary expertise from auburn university, temple university, and california state university, sacramento will carry out a coherent research agenda consisting of the following four thrusts: (1) spectrum data synthesis and augmentation aided by generative adversarial networks; (2) exploiting historical and synthetic wireless networking data through novel transfer learning algorithms; (3) characterizing the relationship between dataset size and performance; (4) integrate, validate and apply approaches developed in the first three thrusts on spectrum database construction, rf spectrum anomaly detection, and transmitter classification. thrusts 1-3 are application-agnostic and focused on studying fundamental concepts and techniques that facilitate the acquisition of sufficient amounts of wireless data, enable more effective utilization of existing data, and enable the prediction of how much data is needed to meet desired performance. thrust 4 is application-specific and focused on specific wireless applications where deep learning has been applied and demonstrated great potential. the data, software and education materials developed from this project will be widely disseminated. the project will engage industry stakeholders on project-related issues, with the aim to disseminate ideas and learn relevant challenges faced by the industry when applying deep learning to wireless applications. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: FAI: Quantifying and Mitigating Disparities in Language Technologies

Awardee: Carnegie-Mellon University

Amount: \$383,000.00

Abstract: advances in natural language processing (nlp) technology now make it possible to perform many tasks through natural language or over natural language data -- automatic systems can

answer questions, perform web search, or command our computers to perform specific tasks. however, ``language" is not monolithic; people vary in the language they speak, the dialect they use, the relative ease with which they produce language, or the words they choose with which to express themselves. in benchmarking of nlp systems however, this linguistic variety is generally unattested. most commonly tasks are formulated using canonical american english, designed with little regard for whether systems will work on language of any other variety. in this work we ask a simple question: can we measure the extent to which the **diversity** of language that we use affects the quality of results that we can expect from language technology systems? this will allow for the development and deployment of fair accuracy measures for a variety of tasks regarding language technology, encouraging advances in the state of the art in these technologies to focus on all, not just a select few. specifically, this work focuses on four aspects of this overall research question. first, we will develop a general-purpose methodology for quantifying how well particular language technologies work across many varieties of language. measures over multiple speakers or demographics are combined to benchmarks that can drive progress in development of fair metrics for language systems, tailored to the specific needs of design teams. second, we will move beyond simple accuracy measures, and directly quantify the effect that the accuracy of systems has on users in terms of relative utility derived from using the system. these measures of utility will be incorporated in our metrics for system success. third, we focus on the language produced by people from varying demographic groups, predicting system accuracies from demographics. finally, we will examine novel methods for robust learning of nlp systems across language or dialectal boundaries, and examine the effect that these methods have on increasing accuracy for all users. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Adaptive Optics Astrometry for Black Hole Science

Awardee: University of California-Berkeley

Amount: \$380,062.00

Abstract: black holes are one of the most exotic phenomena in astrophysics and represent a breakdown in fundamental physics between gravity and quantum mechanics. at the center of our galaxy, a supermassive black hole was discovered thanks to high-precision astrometric observations from the world's largest telescopes ? a discovery awarded the nobel prize in 2020. in addition to the central black hole, the milky way galaxy likely contains between ten million and a billion stellar-mass black holes, or black holes with masses a few times that of the sun. to date, isolated stellar-mass black holes have not been definitively detected and only two dozen black holes have measured masses ? all in binaries. fundamentally, the study of black holes, both large and small, depends on our ability to make extremely precise measurements of the motions of stars on the plane of the sky. a research group at the university of california-berkeley will improve our ability to make such measurements using adaptive optics (ao) they are developing to remove the blurring of the earth's atmosphere at the w. m. keck observatory telescopes. the investigators will also enhance the training and **\*\*diversity\*\*** of the next generation of astronomical instrumentalists, a historically homogeneous group, through an expansion of the astrotech program to include sessions that bridge between the one-week summer school and external internship programs. the roughly 30 astrotech participants each year will be a diverse cohort with an estimated 75% women or under-represented minority students. the world's largest (> 8 m), ground-based telescopes equipped with ao deliver the best astrometric capabilities for black hole studies. however, current astrometric measurements from ao systems are limited to a relative precision of ~0.1 milli-arcseconds and an absolute precision of ~1 milli-arcseconds. the investigators aim to improve our ability to obtain high-precision

astrometric measurements by a factor of 5x, allowing them to find and weigh large samples of stellar mass black holes both free-floating and in binaries, measure the spin of the supermassive black hole at the galactic center, and improve tests of general relativity in a strong-gravity environment. first, the team will reduce the largest astrometric error term by building and deploying a precision calibration unit to calibrate geometric distortions. second, the team will improve the second dominant error by using state-of-the-art point-spread-function (psf) reconstruction techniques to better model the psf variability in space and time. finally, the team will apply machine learning techniques to telemetry from the ao system, telescope, weather monitors, and atmospheric monitoring stations in order to learn about and optimize system performance, ultimately improving the image quality. the proposed astrometric improvements, needed for black hole studies, will also lay a foundation for new explorations in many other areas of astrophysics. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Taming Nonlinear Inverse Problems: Theory and Algorithms

Awardee: Carnegie-Mellon University

Amount: \$379,999.00

Abstract: while modern developments in large-scale sensing and imaging modalities bring great promise in discovering novel scientific phenomena and improving the quality-of-life, making sense of the sensed data in an efficient and accurate manner require transformative designs of scalable and effective optimization methods for solving inverse problems that go beyond classical linear models. there is a significant need to advance the theory, algorithms, and applications of nonlinear inverse problems, where the collected data exhibit a nonlinear relationship with respect to the unknowns being sought after. focused on taming nonlinear inverse problems, this project will be tightly integrated with education, outreach and dissemination activities including mentoring both graduate and undergraduate students with diverse backgrounds, developing courses and monographs on nonlinear inverse problems in data science, and organizing special sessions at suitable conference venues. the intellectual goal of this project is to develop theoretical and algorithmic foundations for solving nonlinear inverse problems, including the design and analysis of efficient algorithms with provable guarantees, characterization of fundamental trade-offs between resources (sample, computational and memory complexities, signal-to-noise ratio, etc.) and performance (statistical error rates, resolution, etc.), and validations on real data whenever applicable. the project seeks to leverage the **diversity** of multiple measurements and the invariance of data representation in the algorithm designs to minimize complexity and improve performance. the tools and techniques developed in this project will lead to further cross fertilization among the fields of signal processing, inverse problems, optimization theory, and machine learning. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Digitization TCN: Collaborative Research: Bringing Asia to digital life: mobilizing underrepresented Asian herbarium collections in the US to propel biodiversity discovery

Awardee: Trustees of Boston University

Amount: \$379,781.00

Abstract: Asia is the largest continent on earth, and includes the world's tallest mountains, lowest landscapes, and habitats ranging from arctic tundra to tropical rainforests and mangroves to deserts. The plants of this region are incredibly diverse in their identities and functions. More than one-third of the world's 350,000 plant species grow in Asia and include tiny alpine cushion plants, medicinal herbs, ancient crops, and some of the planet's tallest rainforest trees. But documentation of this **diversity** remains inaccessible and research about it is difficult because most herbarium specimens of Asian plants have not been digitized. The All Asia Thematic Collections Network (TCN) will mobilize online 15 million specimens of Asian plants currently housed in the US and around the world. The project will especially focus on digitizing specimens from the unique and critically endangered **bio-diversity** hotspots of Southeast Asia and the Himalaya-Hengduan region. These mobilized digital data will accelerate research to conserve endangered plant species and understand the interacting effects of evolution and global environmental change on plant species **diversity**. The project will apply state-of-the-art informatics tools and high-throughput digitization methods to efficiently and affordably digitize an unprecedented number of herbarium collections. This effort will connect and build long-lasting relationships among 25 large and small consortium institutions in the U.S., Europe, and Asia. The focal areas from which specimens will be digitized encompass five **bio-diversity** hotspots that include ~20% of the world's vascular plant flora and historically spanned 3 million km<sup>2</sup> of primary vegetation that now covers less than 300,000 km<sup>2</sup>. Fundamental **bio-diversity** data for these **bio-diversity** hotspots are lacking, along with the necessary baselines required to characterize species' identity, range, and responses to ongoing climatic change. The overall goals of the All Asia TCN are to rapidly digitize herbarium specimens of



asian plants to advance bio\*\*diversity\*\* discovery and provide critical baseline assessments essential for establishing floristic change in the anthropocene. the project will accomplish this by (1) digitizing 3 million asian vascular plant specimens from u.s. herbaria; (2) developing and applying novel informatics tools and high-throughput digitization methods to massively scale herbarium digitization; (3) aggregating and mobilizing the digitized records from the project with those by international partners in china, france, the netherlands, and russia to establish a single online all asia portal of ca. 15 million specimens; and (4) enhancing opportunities for early career learners in science, technology, engineering, and mathematics by stimulating synergies between bio\*\*diversity\*\* and computer scientists who will use design thinking principles to create real-world informatics solutions to bio\*\*diversity\*\* challenges. to stimulate curiosity in plant \*\*diversity\*\* and botanical exploration among the general public, the consortium members will host several asia-themed notes from nature virtual expeditions to facilitate additional specimen digitization by citizen-scientists. digitized specimen data mobilized through this project will be shared and made available through idigbio.org. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Tuning the Frequency Response of Fractional-Order Microsupercapacitors

Awardee: Florida International University

Amount: \$379,215.00

Abstract: electric double-layer capacitors (edlc) are a subset of electrochemical capacitors that can store and deliver electrical energy at dc and relatively far-from-dc frequencies with effective capacitance between that of aluminum electrolytic capacitors and secondary batteries. they are mostly employed in conventional energy storage applications as secondary power source, such as microprocessors and solar batteries. they have also been demonstrated as efficient energy devices

in oscillators and filters circuits, fractional-order controllers, and fractional-order resonators. however, because of the nature and porous structure of their electrodes and the interfacial electrochemistry of their electrodes/electrolyte phase, many fundamental aspects of their performance metrics are still not well understood, and rational design is practically nonexistent. in particular, edlcs exhibit a dissipative, resistive-capacitive behavior when operating away from dc with an impedance angle anywhere between  $-90$  and  $0$  deg. in this project, miniaturized edlcs based on structured 2d and 3d electrode arrays will be designed and fabricated with the objective of understanding and controlling their non-ideal, fractional-order behavior. we will develop and study the effect of doped electrolytes in order to tune the electric-field-induced ionic transport in the presence of physical obstacles. the expected outcome is a general procedure and design rules to apply in order to fine-tune and control the impedance phase shift of edlcs and their energy-power performance. modeling and simulation using mean-field poisson-nernst-plank model will be carried out in order to provide a fundamental understanding of the frequency response of the devices. system-level modeling using fractional-order mathematical tools and equivalent circuit models will also be developed in connection with rc-based circuitry. the controllable fractional-order behavior of the edlcs will be verified and their frequency-domain application will be demonstrated. this project will contribute to the research, education, and **\*\*diversity\*\*** goals of florida international university.

the objectives of this project are to tackle the lack of knowledge on the frequency-domain metrics and performance of factional-order capacitors using both experimental and modeling approaches. we aim to investigate the following: (1) electrode-electrolyte interface specifications and electrolyte parameters that enable the tuning of the electrical characteristics of an edlc over an extended frequency bandwidth; (2) the electro-kinetic effects taking place in the supporting electrolyte of an edlc, and how they affect the frequency-domain metrics of the device; (3) modeling using 3d-circuit interconnects and finite-element methods to understand the overall electric characteristics; and (4) the frequency response of the edlcs and their application in (frequency-domain) filtering and (time-domain) memory applications. this award reflects nsf's statutory mission and has been

deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: OCE-PRF Detecting signatures of multigenerational plasticity in a marine forage fish

Awardee: Woods Hole Oceanographic Institution

Amount: \$378,315.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). coastal marine ecosystems face multiple anthropogenic stressors including increasingly severe events of co-occurring acidification and hypoxia. these periodic but acute environmental stressors can directly impact the abundance, **\*\*diversity\*\***, and commercial value of coastal fish stocks. rapid acclimation of key physiological processes can provide short-term protection against extreme conditions. importantly, these phenotypic modifications can be passed on to subsequent generations thereby priming offspring for increased tolerance. however, for most

fish species the scope for phenotypic plasticity and the precise mechanisms of action are poorly understood. this severely limits our ability to anticipate responses in the majority of ecologically and economically important marine species. the overarching objective of this proposal is to investigate the potential for within-generational and multigenerational plasticity in response to co-occurring hypoxia and acidification in the forage fish atlantic silverside (*menidia menidia*). the atlantic silverside is a foundational species and an essential trophic component of coastal food webs along the north american atlantic coast and serves as key prey item for many seabirds and commercially important fish. understanding the long-term bioenergetic impacts and the potential for rapid adaptation in this species will therefore fundamentally advance our understanding of the ecological consequences of rapid environmental change in coastal marine ecosystems. the project will be centered around a series of laboratory exposure experiments and state-of-the-art metabolic assays utilizing wild-caught atlantic silversides collected during their spring spawning season. the pi will investigate how parental environments influence offspring phenotype by conditioning mature wild atlantic silversides (f0) to contrasting fluctuating co<sub>2</sub>/o<sub>2</sub> treatments. the f1 generation will be then reared in a reciprocal transplant experiment to quantify how parental and offspring treatment levels affect key life-history traits including survival, growth, and aerobic performance. surviving f1 offspring will be reared until maturity to evaluate how environmental stress experienced during early development affects adult reproductive capacity. furthermore, the pi will investigate the role of biological memory in multigenerational plasticity by exposing f2 offspring to factorial combinations of grandparental and parental environments. in parallel, the pi will investigate how molecular mechanisms may mediate rapid adaptation to changing environments using transcriptomics (rnaseq) and genome-wide dna methylation profiling (methylseq). linking molecular changes with whole organism phenotypic responses will broaden our understanding of the effects of multiple stressors on an ecologically important species which will provide clues for developing mitigation plans to protect coastal food webs from various climatic factors. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's

intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: REU Site: Geosciences Program in Energy and Environmental Resource Sustainability (GeoPEERS)

Awardee: Pennsylvania State Univ University Park

Amount: \$377,035.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). the goal of the geosciences program in energy and environmental resource sustainability (geopeers) reu is to train the next generation geoscience workforce for industry and academia. while oil and gas jobs will likely continue to decline slowly over the next several decades, the industry will remain, and we must train geoscientists who can skillfully, ethically, and strategically locate and extract these resources. at the same time, demand for resources such as clean water, fertile soil, and renewable energy is increasing. diversification of the global energy and resource portfolio is already underway, and new skill sets will be required of geoscientists entering academia and the workforce. the geopeers reu program will train participants holistically to approach the industry of resource extraction and energy production from a sustainability perspective. the field of geosciences is also reckoning with a profound lack of **\*\*diversity\*\*** in its workforce. we will advertise broadly and draw upon existing partnerships with minority-serving institutions in order to find highly qualified applicants from a diverse range of backgrounds. because simply recruiting a diverse cohort is not enough, we will strive to intentionally and explicitly create a supportive, inclusive, and equitable educational environment. by incorporating new skills sets and perspectives into our training program, and by intentionally building a diverse and inclusive participant community, geopeers will prepare a new generation for the geosciences of the future. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MCA: Genomic diversification and speciation along ecological gradients in a marine fish radiation

Awardee: California State L A University Auxiliary Services Inc.

Amount: \$373,704.00

Abstract: understanding the formation of new species in the marine environment has proven to be a challenging task for evolutionary biologists. the potential for high levels of migration and the apparent lack of geographical barriers create a scenario where ecological diversification and life history shifts are likely important in the speciation process. this research program will determine the genomic basis of divergence among closely related species and populations along latitudinal and depth gradients to determine the role of adaptation in the speciation process. rockfish (sebastes) are an ideal system to examine these questions as they are a diverse group of temperate fishes inhabiting a wide array of habitats, and they have been subject to numerous phylogenetic studies. this study will build upon a growing set of studies aimed at better understanding the speciation process in the marine environment. training opportunities will be provided to undergraduate and graduate students at cal state la, and data from this project will also serve as a resource for the management of rockfish, many of which are commercially important. this project will utilize genome scans and de novo genome assemblies to test for speciation histories of rockfish associated with divergence along ecological (depth) or geographic (latitude) gradients. these findings can be used to better understand the role of natural selection on the genome and how this contributes to the diversification of this group. the first aspect of the study will examine the role that ecological adaptation along a depth gradient has played in the formation of new species. the second aspect will contrast these findings with latitudinal divergence among closely related species. together these results will provide novel insights into the speciation history and genomic divergence for closely related marine species, and provide a framework for understanding the relative roles of

selection and genetic drift on generating and maintaining marine **\*\*diversity\*\***. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Engineering All-Solid Metal-Sulfur Batteries: Transport, Speciation, and Kinetics in Sulfur Copolymer Composite Cathodes

Awardee: University of Notre Dame

Amount: \$371,439.00

Abstract: metal-sulfur rechargeable batteries are a potentially cost-effective solution for replacement of li-ion batteries for use in electric transportation. the energy density of lithium-sulfur and magnesium-sulfur batteries can exceed that of li-ion, but only at low electrolyte-to-sulfur ratios. however, it is difficult to engineer sulfur batteries for high performance with low levels of liquid electrolyte. in addition, elimination of volatile battery components to improve safety is preferred. in this project, the investigator will investigate solid-state metal-sulfur batteries based on copolymerized sulfur cathodes. the influence of the chemistry and morphology of the sulfur copolymer cathode on the ion transport, sulfur speciation, and reaction rates will be investigated. the use of a solid copolymer interlayer to prevent the dissolution of sulfur species into the bulk polymer electrolyte will also be explored. this research will engage graduate and undergraduate notre dame students and visiting undergraduates from the xavier university of louisiana to promote the training and retention of researchers in the field of electrochemical engineering. additionally, the number, **\*\*diversity\*\***, and training of the next generation of researchers in the chemical sciences and engineering will be enhanced by development of afterschool enrichment programming. this fundamental engineering science research will be transformative for its contributions to the understanding of the effects of local environment on sulfur and poly(sulfide) electrochemical properties in the solid-state. copolymerization of elemental sulfur and organic monomers will be



leveraged to facilitate tune the sulfur cathode environment, including the size and morphology of sulfur-rich and ion-rich domains, the interactions of ion-solvating components with poly(sulfide)s, and charge-transfer kinetics. spectroelectrochemical techniques will be used to investigate sulfur/(poly)sulfide speciation and reaction pathways. separately, copolymer interlayers for active cation transport and polysulfide rejection in the solid-state will be investigated. ion transport in both the cathode and interlayer nanostructured solid-state environments will be probed. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: REU Site: Chemistry and Biochemistry REU Site to Prepare Students for Graduate School and an Industrial Career

Awardee: Brigham Young University

Amount: \$371,250.00

Abstract: this research experiences for undergraduates (reu) site award, with a research experiences for teachers (ret) component, provides ten reu and two ret participants with ten-weeks of research training and professional development. in this program, supported by the division of chemistry, reu and ret participants will conduct individual chemistry or biochemistry research projects using state-of-the-art equipment and techniques. these chemistry and biochemistry research projects focus on critical problems related to chemical and biochemical industries. planned professional development activities for reu and ret participants include visits to chemical and biochemical companies; workshops discussing current and grand challenges in industry and the most important skills to success in industry; and the creation of presentations for a national chemistry conference. inspiring the next generation of scientists, both reu and ret participants will work with the byu summer chemistry and biochemistry camps for children and youth. reu and ret participants at this site will conduct independent research on projects spanning chemistry and

biochemistry, particularly on fundamental research projects with an industrial connection. slated projects include the development of heterogeneous catalysts for co2 removal, the design of miniaturized mass spectrometers and of micrometer microfluidic devices, organic synthesis endeavors toward targets with putative anticancer activity, and computational chemistry directed at the modeling and design of new catalysts. alongside the professional development activities, these projects, facilitated by byu chemistry and biochemistry faculty, will provide participants with experiences in problem solving and scientific discovery, preparing them to earn advanced degrees and enter the industrial chemistry workforce. to increase the \*\*diversity\*\* of the stem workforce, reu recruitment at this site will emphasize participation of students from two-year colleges and those from underrepresented minority groups. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: The Merian Survey. Characterizing Dark Matter and Feedback in Star Forming Dwarf Galaxies

Awardee: Princeton University

Amount: \$370,793.00

Abstract: while most of the mass in the universe is unseen, the smallest galaxies in the universe (the so-called dwarf galaxies) pose significant challenges to this ?dark matter? model. in order to further test our best dark matter models, a large observational survey of dwarf galaxies is needed. this project focuses on the meriam survey, which will observe 100,000 dwarf galaxies with known

distances. furthermore, each of the dwarf galaxies in this survey has constraints on their dark matter content from other methods. the new data will provide their stellar structure and colors. these results can all be taken together to test our ideas of dark matter in the universe. the team will place priority on recruiting a diverse group of students who will carry out the data mining that will be required in the era of the vera rubin observatory. established programs at both princeton and uc santa cruz recruit historically underserved students for summer research and then continuing cohort support. these students will be trained in "big-data" and modern science analysis with merian. extensive studies of dwarf galaxies have revealed a considerable scatter in many of their fundamental properties. in particular, galaxies with stellar mass of  $10^8 - 10^9$  msun present a **\*\*diversity\*\*** of star formation rates and rotation-curve shapes which are in tension with theoretical models. reliably characterizing the dark matter distribution and baryonic processes in these galaxies, such as feedback, is key to in order to establish a complete picture of dark matter on small scales. the merian survey will obtain a volume-limited census of dwarf galaxies in this mass range at  $z=0.058-0.1$ . using two custom made filters, merian will provide redshifts to a complete sample of 100,000 star forming dwarf galaxies (two orders of magnitude larger than sdss+gama) over an area of 870 deg<sup>2</sup>. combined with deep+high spatial resolution imaging from the hyper-suprime camera, this program will result in high s/n weak lensing profile measurements for dwarf galaxies, probing their dark matter halos out to their virial radii. also, hyper-suprime camera imaging will be used to measure dwarf sizes and shapes. the next generation of scientists must be trained to deal with the deluge of vera rubin observatory data coming in the next decade. programs at both princeton and uc santa cruz recruit historically underserved students for summer research and then continuing cohort support. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CIF: Storm Peak Laboratory ? Facility for Research and Research Training in Atmospheric

Sciences

Awardee: University of Utah

Amount: \$370,127.00

Abstract: this community instruments and facilities (cif) award is for support of the storm peak laboratory (spl), a mountain-top research station in northwestern colorado. spl is a unique, cutting-edge, high-elevation, mid-continental, atmospheric research station. instruments available at spl will provide valuable measurements for research focused on aerosol chemical and physical properties; cloud and snow microphysics; atmospheric transformation and transport of mercury; and detection of long-range transported dust and regional wildfire smoke. nsf funding will provide baseline support to sustain atmospheric measurements, and provide quality-controlled data, including quality assessments, metadata, and supporting ancillary information from existing spl instrumentation to the broader atmospheric science community. programs to support education and training are part of the proposed effort. the proposal also includes plans to enhance **\*\*diversity\*\*** in the atmospheric and related sciences. the facility infrastructure and an array of fifteen cutting-edge meteorological instruments at the storm peak laboratory serve as a national resource to advance research and research training in high elevation atmospheric science. the laboratory also fosters interdisciplinary research collaboration by hosting intensive field campaigns and field training courses, providing long term measurements of meteorology, clouds, aerosols, snow hydrology, and atmospheric gases. this award will enhance the ability of the broader scientific community to use spl instruments and the laboratory as a research site through the ags facility request process. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: ISS: Collaborative Research: Individual and Collective Behavior of Active Colloids in Microgravity

Awardee: Florida International University

Amount: \$367,549.00

Abstract: this nsf-casis project involves microgravity experiments on the international space station (iss), complementary terrestrial experiments and theoretical/numerical modeling to improve understanding of active colloid transport. active colloids move by extracting energy from their surroundings and transforming it into mechanical work. these materials have similarities with biological matter, especially for concentrated suspensions where particle-particle interactions yield collective behaviors similar to those found in nature such as swarming flocks of birds, schools of fish and bacterial colonies. although most theoretical models pertain to an isolated particle traveling in the bulk, the weight of active colloids on earth causes them to settle at the bottom of the experimental chamber where they translate parallel to the surface. long term microgravity conditions on the iss offer a unique opportunity to mitigate buoyancy and sedimentation and obtain bulk measurements that can be compared with theoretical models and elucidate the role of particle-wall interactions, which complicate terrestrial experiments. the results of this project may transform a variety of applications in biomedicine and applications at the food-water-energy nexus including colloidal assembly and bubble/droplet transport. the project is a collaboration between colorado mesa university (cmu) - a primary undergraduate institution with a diverse student body ? and florida international university (fiu) - a research intensive minority serving institution (msi). it offers a unique opportunity to promote **diversity** through exposure of undergraduate students to timely research and industry collaboration with the implementation partner space tango. the research team will develop a module for fiu's ?engineers on wheels? program, which visits local schools, and will collaborate with the eureka science museum and maverick innovation center in colorado. this nsf-casis project will provide a comprehensive understanding of complex physical mechanisms controlling the mobility of individual active colloids and their collective behavior with two distinct goals: (1) optimizing active colloid transport, and (2) understanding effects of microgravity on collective dynamics and non-equilibrium interactions of active matter. the absence of buoyancy in

microgravity is expected to resolve a conundrum in terrestrial experiments wherein theoretical models of these systems are derived for isolated particles in the bulk while experimental measurements are almost always made near a wall owing to gravity-induced sedimentation. proximity to a wall and the accompanying particle-wall interactions (hydrodynamic, phoretic, electrostatic etc.) are often invoked as corrections to explain discrepancies between theory and experiment. however, the precise roles of particle-wall interactions cannot be isolated without comparable measurements far from the wall. sustained microgravity conditions will enable measurement of particle mobility in the bulk, providing an experimental reference for theoretical models and insight into competing buoyancy effects and wall-particle interactions. comparison of particle-particle interactions on earth and on the iss will also elucidate effects of microgravity on collective behavior in active matter and dense colloidal systems including 3d phase separation. microgravity experiments will be complemented with terrestrial bulk measurements using optical tweezers as an external forcing mechanism, which will provide insight into other active colloid transport mechanisms (e.g., catalytic) and the applicability of such external forcing for future fundamental studies. the collaboration between fiu and cmu and the partnership with space tango offers a unique opportunity to engage students. undergraduate students will participate through capstone projects at fiu, while cmu students will travel to fiu and gain exposure to a research intensive institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Unusual Concentration Phenomena in Probability, Analysis, and Geometry

Awardee: Princeton University

Amount: \$364,540.00

Abstract: many complex systems behave in a random fashion at the smallest scales. why then does

the world around us appear to be so predictable? this is explained in a very general context by a principle known as concentration of measure: smooth functions of many independent random variables behave in an essentially predictable manner. precise mathematical formulations of this phenomenon provide powerful tools for studying complex random structures. this project aims to study new concentration phenomena that arise from unexpected connections with several different areas of mathematics: from the study of embeddings (how well can data be represented in a particular space?); from the study of exotic shapes which date back to old problems in geometry from over a century ago; and from the study of non homogeneous random matrices, which are widely used in modern data science. the unusual features of these problems motivate the development of the theory in new directions, as well as the introduction of new tools that may be applied to a wide range of random structures that arise in both pure and applied mathematics. the project includes educational, mentoring and outreach activities that are aimed at attracting and training the next generation of mathematicians, and at increasing participation and **\*\*diversity\*\*** in the mathematical sciences. it also provides research training opportunities for graduate students.

the aim of this project is to systematically develop novel concentration phenomena that arise from problems in probability, functional analysis, metric geometry, and convex geometry. the project is organized around three topics. the first topic aims to develop a general theory of concentration inequalities for functions taking values in normed spaces. the second topic aims to understand certain long-standing questions in convex geometry that may be viewed as unusual analogues of the concentration phenomenon. the third topic is concerned with concentration inequalities for the norms of non-homogeneous random matrices. the investigation of concentration phenomena in nonstandard settings motivates new questions and the development of new tools that are both of direct probabilistic significance, and that provide new perspectives on problems in other areas of mathematics. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity



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Title: Collaborative Research: GRate ? Integrating data and modeling to quantify rates of Greenland Ice Sheet change, Holocene to future

Awardee: University of Montana

Amount: \$364,234.00

Abstract: the greenland ice sheet has experienced devastating melt in recent years. recent scientific reports highlight how vulnerable the greenland ice sheet is to arctic climate change and draw a dire picture of the impact of sea-level rise. in order to equip society with the best forecasts of sea level rise for planning, scientists need to improve the ability to simulate ? or model ? the response of ice sheets to climate change. for this project, scientists from different branches of ice-sheet research will work together to improve ice sheet modelling. the researchers will leverage recent scientific advances to model the entire greenland ice sheet in order to investigate long-term ice-sheet sensitivity to changes taking places in the ocean and atmosphere. the research group is committed to creating an inclusive environment where all team members can learn and excel. the team contains **\*\*diversity\*\*** in ethnicity, gender and rank, and will train six early career scholars, recruiting specifically from groups underrepresented in the geosciences, which is among the least diverse stem fields in the u.s. results will be made publicly available and will facilitate a broad range of future research about the arctic system, including ice sheet modeling, model spin-up, paleoclimate reconstruction/synthesis and glacier history. to elevate the capacity of outreach and education programs developed during their first project, the team will build on their ?scientists are superheroes? outreach program and leverage other, existing outreach frameworks, including making connections with greenlandic communities and with high school student intern programs at their universities linked to the young women?s leadership school (bronx, ny) and the spring valley (ny) branch of the naacp, coordinated by our dedicated project educator and outreach specialist. reducing uncertainties in ice-sheet model predictions is crucial in society?s handling of the sea level crisis. uncertainties related to ice-sheet instability arise from limited observations, inadequate model

representation of ice-sheet processes, and limited understanding of the complex interactions between the atmosphere, ocean, and ice sheets. how atmospheric and oceanic forcing vary through time, and at what timescales each are capable of forcing rapid change, are critical for predicting future ice mass loss, but scientists have been observing ice sheet change for only a short period of time (decades). the pis propose to scrutinize greenland ice sheet change spanning from the beginning of the holocene (12,000 years ago) to 2100 ce, making it possible to evaluate the varying roles of atmospheric and ocean forcing on decadal-to-centennial timescales relevant for the future greenland ice sheet evolution. the pis will utilize their established multi-disciplinary collaboration to combine ice sheet modelling, climate forcing and reconstructions of past ice-sheet change. this will position the team to make predictions of future ice sheet change that are grounded in greenland ice sheet behavior during past climate swings that occurred prior to our brief window of modern observation. the work will lead to lasting products to serve the community's collective effort to better understand ice sheet change: 1) a state-of-the-art ice-sheet model optimized for simulations over long timescales, 2) a holocene-through-modern set of atmospheric and ocean state estimates optimized for forcing an ice-sheet model, and 3) a database of past-ice sheet configurations and paleoclimate records formatted for model-data comparison. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Targeted Infusion Project: Increasing Mathematics Achievement Gains by Engaging Students of STEM at Tennessee State University

Awardee: Tennessee State University

Amount: \$363,788.00

Abstract: the historically black colleges and universities undergraduate program (hbcu-up), through targeted infusion projects, supports the development, implementation, and study of evidence-based

innovative models and approaches for improving the preparation and success of hbcu undergraduate students so that they may pursue stem graduate programs and/or careers. accordingly, tennessee state university will establish its ?increasing mathematics achievement gains by engaging students (images)? project that will support the enhancement of introductory mathematics courses to the benefit of undergraduate students who will pursue degrees in science, engineering, technology, and mathematics (stem). the images project is designed to provide a pathway for on-time graduation, to increase student learning and engagement, and to promote academic and professional development for stem students. this project will target first year students who are majoring in mathematical sciences, architectural engineering, civil engineering, electrical engineering, or mechanical engineering and who do not meet the act requirement for enrolling in calculus i during their first semester at tennessee state university. the project comprises of three major components: the redesign of a one-semester pre-calculus course, the implementation of adaptive and active learning strategies, and the provision of student support services. the first-year mathematics experience will include pre-calculus i with adaptive learning strategies during the fall semester, calculus i with active learning strategies during the spring semester, and calculus ii during the summer term with active learning strategies in an online format. the student support services will include peer tutoring, peer mentoring, a stem student seminar series, and opportunities for experiential learning. the images project will enhance the academic infrastructure of existing stem disciplines at tennessee state university and contribute to strengthening \*\*diversity\*\* in stem career fields. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Proposal: NSF-DFG Echem: Understanding the Mechanism of Urea Oxidation on Nickel-Based Electrocatalysts

Awardee: Oregon State University

Amount: \$362,348.00

Abstract: urea is a common high-nitrogen chemical waste product of mammalian metabolism, and a major component of fertilizer. It poses significant threat to water resources from agricultural run-off and municipal wastewater. A promising means for removing excess urea is to oxidize it electrochemically to produce harmless compounds. Urea removal processes can also be used to generate electricity and to produce hydrogen for fuel cells. Electrochemical urea removal therefore exhibits strong potential as a transformative technology by converting a harmful waste product to the benefit of society, industry, and the environment. The project brings together researchers from the United States and Germany to apply a synergistic blend of experimental and theoretical methods to the study of electrochemical urea removal from water. In particular, the project seeks fundamental understanding of catalytic urea oxidation that is needed to develop feasible urea removal technologies. Effective urea removal systems are key to a large number of technological applications including municipal and agricultural wastewater treatment, remediation of fertilizer run-off, ammonia synthesis, hydrogen production, and electricity generation. Other benefits from this project will include workforce development and educational outreach to underrepresented grade-school students. These efforts will promote increased diversity in STEM fields, a student exchange program between Germany and the US, and improved scientific literacy of the general public. The goal of this research project is to develop comprehensive knowledge of electrochemical urea removal over nickel-based catalysts, based on experimental and theoretical research spanning molecular and device levels. Electrochemical urea removal will be studied by density functional theory calculations, vibrationally and electronically resonant sum frequency spectroscopy, and electrochemical measurements of reaction rate and product distributions. Particular attention will be paid to the active form of the nickel oxide electrode as it exists in different phases and oxidation states depending on electrode potential and history, such as aging and preparation method. This combined electrochemical, spectroscopic, and computational approach provides insight related to catalyst structural changes and how they affect the urea reaction mechanism, reactivity, and

effectiveness of nickel, nickel-iron, and nickel-chromium catalysts. the outcomes of this research will greatly advance the scientific understanding of electrochemical urea removal -- about which little is known -- and establish a foundation in the wider field of electrocatalysis regarding electrochemical reactions on oxide surfaces and on surfaces that undergo a change in oxidation state as part of the overall reaction mechanism. successful completion of this research will benefit society through sustainable methods for treating wastewater and agricultural run-off that will reduce demand on water supply systems and enhance the bio\*\*diversity\*\* of marine ecosystems. this project was awarded through the "nsf-dfg lead agency activity in electrosynthesis and electrocatalysis (nsf-dfg echem)" opportunity, a collaborative solicitation that involves the national science foundation and deutsche forschungsgemeinschaft (dfg). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: HSI ATE Hub 2: Professional Development for Culturally Responsive Technician Education

Awardee: Arizona State University

Amount: \$361,307.00

Abstract: this project aims to better serve and support a diverse population of students who are pursuing credentials in skilled technical fields. to do so, the project will guide faculty to adapt and implement culturally responsive instruction in technician education courses. the project is designed to increase the retention of hispanic students in stem career pathways, particularly in advanced-technology fields. the project builds on the hispanic serving community college kickstarter project, the hispanic serving institutions hsi/ate hub project, and the westchester community college photonics and laser project. the project team will develop, pilot test, and disseminate a faculty professional development model that can help to shift faculty understanding, practice, and mindset

from emphasis on perceived student deficits to asset-based thinking and mutual respect. the professional development will be organized into three tiers. tier 1 is designed to establish awareness and support first steps. tier 2 will focus on the development, implementation, and testing of culturally responsive instruction practices in technician education. tier 3 will focus on creating a community of instructors and emerging leaders that engages in practice, theory building, and applied research into effective educational practices. the overall project goal is to develop faculty knowledge, skills, values, attitudes, and mindset so that more hispanic students will complete advanced technology programs. in doing so, the project can increase the **\*\*diversity\*\*** of the technician workforce and help to mitigate disproportionate impacts of covid-19 on hispanic communities. this collaboration includes faculty and administrators in technician education programs, higher education researchers, experts in culturally responsive instruction, and industry partners to further conceptualize, operationalize, and test the validity of culturally responsive instruction in the skilled technical fields of applied engineering and applied computing and cyber-security. additionally, the project will test the hypothesis that micro-credentials are valuable for incentivizing faculty participation in project activities and that micro-credentials will be recognized by educational and industry stakeholders as valuable evidence of expertise and experience. the mixed method evaluation is process -oriented to facilitate development of a model and outcomes-oriented to assess faculty and student outcomes that includes assessment of changes in knowledge/awareness, skills/behavior, and attitudes/mindset. this project is funded by the advanced technological education program that focuses on the education of technicians for the advanced-technology fields that drive the nation's economy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: REU Site: Collaborative Research: Research Opportunities in Rock Deformation

Awardee: Washington University

Amount: \$359,067.00

Abstract: rock deformation, a sub-discipline of earth science, uses geology and engineering methods to measure the strength of rocks. information about rock strength can be applied to a wide range of problems in engineering, natural hazards, and material science, as well as geology. however, very few scientists specialize in the field of rock deformation; thus, many important research questions remain unexplored or underexplored, slowing advances in science and engineering. geoscience departments at primarily undergraduate or primarily minority-serving institutions often do not have active rock deformation research programs and labs that deal with rock deformation are relatively rare. this reu site aims to increase access and exposure of a diverse population of students to career opportunities in this area. the project offers undergraduate students the unique opportunity to conduct summer research at one of eleven state-of-the-art, experimental rock deformation labs across the country. experts in rock deformation will serve as mentors to a cohort of 10 students each summer. this reu site provides access and training, professional and career development activities, and robust workforce development for students from all backgrounds.

the reu site will provide research and mentorship opportunities for undergraduate students in the field of experimental rock deformation. the long-term objective is to increase the number and **\*\*diversity\*\*** of students pursuing research or industry careers in rock deformation. student participants will receive training in research methods and professional development topics that will provide a stable foundation for graduate school or related career paths. a large team of pIs and senior participants ensures that students who participate in the program will have a deep professional network to support their future endeavors. students will be drawn from the full spectrum of higher education institutions. strong emphases will be placed on recruiting students from diverse and under-represented backgrounds, and smaller colleges and universities that do not have research programs in rock deformation. the reu site will include three integrated sessions: a field session to introduce students to the geological study of deformed rocks, a laboratory session where

students conduct experiments on specimens collected during the field session, and a conference session where students can present the results of their research projects. the reu site will adopt a distributed model, leveraging the combined lab capacity of the pis and other senior participants to support 10 students per year. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Leveraging the Power of Reflection and Visual Representation in Middle-Schoolers' Learning During and After an Informal Science Experience

Awardee: Loyola University of Chicago

Amount: \$358,229.00

Abstract: this project addresses a longstanding problem in informal science education: how to increase the likelihood of consequential science, technology, engineering, and mathematics (stem) learning from short duration experiences such as field trips. although informal learning experiences can greatly contribute to interest in and knowledge of science, there is a shared concern among educators and researchers that students may have difficulty recalling and using scientific information and practices emphasized during these experiences, even though doing so would further their science learning. nonetheless, science learning is rarely, if ever, a "one-shot deal." children acquire knowledge about science cumulatively across different contexts and activities. therefore, it is important that informal science learning institutions identify effective practices that support the consolidation of learning and memory from exhibit experiences to foster portable, usable knowledge across contexts, such as from informal science learning institutions, to classrooms, and homes. to this end, this research in service to practice project seeks to harness the power and potential of visual representations (e.g., graphs, drawings, charts, maps, etc.) for enhancing learning and encouraging effective reflection during and after science learning experiences. the project promises



to increase learning for the 9,000+ 5th and 6th grade students from across the rurality and growing **\*\*diversity\*\*** of the state of maine who annually participate in labventure, a 2.5-hour exploration of the gulf of maine ecosystem at gulf of maine research institute. the research will provide new and actionable informal science learning practices that promote engagement with visual representations and reflection, and science understandings that can be applied broadly by informal science institutions. this project is funded by the advancing informal stem learning (aisl) and the discovery research prek-12 (drk-12) programs. it supports the aisl program goals to advance new approaches to, and evidence-based understanding of, the design and development of stem learning in informal environments. it supports the drk-12 program goal of enhancing the learning and teaching of stem by prek-12 students and teachers. the project is grounded in the idea that visual representations, including drawings, can both enhance science learning and encourage reflection on doing science that can support extension of that learning beyond a singular informal science experience. the project uses design-based research to address the following research questions: (1) does reflection during an informal science learning experience promote students' retention and subsequent use of science information and practices that are part of the experience? (2) does interpreting and constructing visual representations, such as drawings, improve students' understanding and retention of information, and if so, how and when? and (3) does combining visual representations and narrative reflections confer benefits on students' science learning and engagement in science practices both during the informal learning experience, and later in their classrooms and at home? these questions will be pursued in collaboration with practitioners (both informal educators and classroom teachers) and a diverse team of graduate and undergraduate student researchers. approximately 600 student groups (roughly 3000 individual students) will be observed during the labventure experience, with further data collection involving a portion of these students at school and at home. the project will yield resources and video demonstrations of field-tested, empirically based practices that promote engagement with visual representations and reflection, and science understandings that can travel within students' learning ecosystem. in support of broadening

participation, the undergraduate/graduate student researchers will gain wide understanding and experience connecting research to practice and communicating science to academic and nonacademic audiences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Developing a Seismic Model for Investigating Layering in Cratonic Lithosphere beneath Africa

Awardee: University of Rochester

Amount: \$357,817.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). the lithosphere is the stiff outer shell of our planet - it is the rigid plate of plate tectonics. in the oldest and most stable regions of continents (cratons) the lithosphere is expected to be cold and thick, yet we observe a wide-spread, near-constant layer internal to the lithosphere, almost akin to the crust-mantle boundary, but expressed as a velocity reduction. this puzzling and ubiquitous observation of 'mid-lithospheric layering' has resulted in different, sometimes contradictory, explanations (i.e., partial melt, anisotropy, chemical stratification, or short-term rheological weakening). in this study, the investigators will develop a new seismic model of the lithosphere useful for testing proposed models of lithospheric layering beneath africa. the multi-decadal investment in the innovative africaarray initiative, the **\*\*diversity\*\*** of cratons, and a growing number of permanent and temporary seismic networks on the continent, with publicly available data, has opened a new vista on our ability to resolve fine-scale lithospheric layering on the continent. similarly, new passive-source imaging using spectral coherence of ambient noise, machine learning, and probabilistic analysis of converted body waves is poised to ensure maximum utility from the archived seismic datasets. this project will engage early career scientists, train minority ph.d. students, and promote education and outreach goals for recruiting under-represented

undergraduate students by designing new courses that expose students to the optimal use and management of high-performance computing resources. the project will address gaps in current efforts to study lithospheric layering on the continent. the investigators will conduct analysis of all publicly available seismic data on the continent, with sensitivity to the crust and upper mantle lithosphere, and prepare and publishing measurements of: (1) group and phase velocity of broad-band ambient noise and earthquake records for love and rayleigh surface waves, (2) depth and sharpness of compressional and shear body wave reflectivity of lithospheric discontinuities, (3) quantify uncertainty in phase velocity maps and, (4) provide an updated continent-wide reference model of the african crust and upper mantle (lithoaf+), using a probabilistic joint inverse approach to reporting uncertainty in each stage of measurement and model-construction (i.e., 1-4). the expected peer-reviewed studies, when interpreted with complementary experimental and geophysical constraints (i.e, conductivity and mineral physics), will advance our understanding of cratonic lithospheric layering and the geological evolution of continents. integrated modeling, using other geophysical constraints, will also advance the understanding of (1) the origin of the elevated african topography, (2) the origin of orphan tremors, intra-plate earthquakes, and volcanism, and their connection to the well-known african superplume, (3) the broad-scale evolution of continental rifting and formation of new ocean basins, and (4) multi-stage assembly and break up of gondwanaland. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Examining the Geography of Pathogen Spillover

Awardee: Virginia Polytechnic Institute and State University

Amount: \$357,749.00

Abstract: this project examines disease spillover, which refers to the transmission of parasites and pathogens from one species to another. the transmission of parasites and pathogens between

species is a source of infectious diseases that impact human populations, including past examples such as ebola, sars, and covid-19. as a complement to theoretical models, this study focuses on the pathways that lead to spillover of rabies among populations of bats. the transmission of rabies among bats is relatively common, which enables tests of predicted spillover dynamics. the study includes sampling of bat populations in multiple locations to determine the prevalence of rabies, which potentially varies in response to multiple factors, including the genetic **diversity** of the respective populations. the researchers also draw on archival data to assess the probability of spillover events in relation to landscape disturbancethe project provides training opportunities for students, and the results will be shared with diverse institutions that monitor public health and wildlife populations. this study contributes to understandings of the risks of disease spillover between species, including humans. the research focuses on bat-borne rabies transmission, which occurs relatively frequently, permitting insights of transmission pathways that could similarly characterize other infectious pathogens. to assess the determinants of rabies transmission, the researchers use multiple methods. blood samples collected from bats at diverse locations permit laboratory work to assess the extent of rabies infections in relation to the genetic **diversity** of the populations and ecological variables. the researchers also use archival records on rabies infections to assess the predictors of spillover events, such as landscape disturbance and the expectation that spillover is relatively more common near the center of the bats? ecological niche. the study includes the development of theoretical models that reflect the inferred dynamics of spillover events over time, and these models could be applied to studies of similar pathogens. the findings inform diverse efforts to mitigate the risks of spillover events for human populations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MRI: Acquisition of a fluorescence activated cell sorter (FACS) supporting multi-disciplinary

approaches to exploring biological responses

Awardee: Rhodes College

Amount: \$357,741.00

Abstract: an award is made to rhodes college to support the acquisition of a fluorescence activated cell sorter (facs) to enhance the research of faculty and training of undergraduate students at rhodes college and institutions in the memphis area. this instrument allows separation of small particles, including living cells, from large populations and is based on very specific features such as particle size or the presence of a protein. as cells are isolated, very detailed information can be gathered about each cell and the living cells can be further studied. addition of the facs instrument will transform the ability to train the next generation of scientists in rhodes faculty-led coursework, mentored research, and outreach programs at this research-active primarily undergraduate institution (pui). this instrument allows fast and precise analysis and separation that is very robust so that it will help scientists and undergraduate students answer a broad range of biological questions, including the how genes function, how cells respond to stress, and questions regarding bio\*\*diversity\*\* in ecological systems. projects will focus on (1) epigenetic gene regulation; (2) parental control of gene expression; (3) response to viral infection; (4) metal intake in a type of salmonella bacterium; (5) immune system response to a type of fungal pathogen; (6) vitamin dependent cell cycle progression; (7) phytoplankton communities in freshwater ecosystems; and (8) speciation response to changes in ploidy. this work will be shared with the scientific community through presentations at national conferences and publication with undergraduate co-authors in peer-reviewed journals. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: American Meteorological Society Summer Policy Colloquium 2021-2023; Washington, DC

Awardee: American Meteorological Society

Amount: \$356,100.00

Abstract: this award supports participation of students and early-career scientists in the summer policy colloquium of the american meteorological society. the summer policy colloquium addresses the need for interaction between policy makers and researchers who have domain expertise in areas relevant to policy decisions. it provides an opportunity for researchers interested in decision support to interact with policy makers and learn about policy making. each year the colloquium brings 20 to 40 participants to washington dc for two weeks of intensive interactions with scientist-leaders from the legislative and executive branches, executives from ngos, policy analysts, science journalists, and other stakeholders working in the policy arena. in addition to in-person dialog and interaction colloquium participants are given pre-assigned reading and work through group exercises and case studies to learn about the policy making process. funds provided through this award support the participation of 15 graduate students and early-career scientists in the colloquium. nsf-funded participants are selected through a competitive process, based on the applicant's potential and accomplishments and taking into account **\*\*diversity\*\***, equity and inclusion.

the primary broader impact of the award is the development of a cohort of researchers in disciplines related to weather and climate who can provide decision support for policy decisions in these areas. such decision support is increasingly valuable as stakeholders and decision makers at all levels of government face a growing variety of challenges related to the management of weather and climate risk. many researchers are interested in providing decision support, but the education and experience of scientists does not adequately prepare them to perform this role. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: An Evidence-Based Approach Towards Technology Workforce

## Expansion by Increasing Female Participation in STEM Entrepreneurship

Awardee: University of Maryland, College Park

Amount: \$351,259.00

Abstract: this is a collaborative project, with the university of wisconsin-madison as the lead institution and the university of maryland as the partnering institution, to explore the entrepreneurial proclivity of undergraduate women majoring in stem fields. the researchers propose a multi-method approach led by an interdisciplinary team to (1) identify factors that influence entrepreneurial proclivity and (2) develop and test interventions related to closing gender disparities in stem entrepreneurship. the research includes the analysis of a comprehensive administrative database to identify mechanisms for potential interventions and field experiments to achieve greater gender parity in entrepreneurial career choices for stem students. results of the field experiments will be integrated with the database to produce outcome measures. the project will produce empirical evidence to increase the understanding of student entrepreneurship and inform interventions that improve entrepreneurship participation for women in stem. the researchers will frame the research design and methods using the individual-opportunity nexus theory that knowledge is a precursor to entrepreneurship. there are four hypotheses: (1) greater entrepreneurial proclivity will be found in women in stem fields with higher curriculum **\*\*diversity\*\***, who have taken at least one business class, who are enrolled in stem courses with students with higher **\*\*diversity\*\*** in their courses, and who are enrolled in stem courses with students who have taken one or more business classes. (2) women stem students demonstrate higher entrepreneurial proclivity when they are exposed to relatable role models in entrepreneurship. (3) women stem students demonstrate higher entrepreneurial proclivity when entrepreneurship is presented as a gender-neutral field. (4) women stem students demonstrate higher entrepreneurial proclivity when they are exposed to entrepreneurial success stories. the researchers will make causal inferences about factors that influence entrepreneurial proclivity of women in stem by measuring self-reported activities, analyzing administrative data, and documenting student start-ups. the core of the project is based on data

drawn from a data infrastructure that combines administrative data with results of an annual survey. the researchers will use those data to evaluate the mechanisms that influence the underrepresentation of women in entrepreneurship. they will augment the data infrastructure with a field experiment to test hypotheses informed by existing literature and findings from their data analysis. this project is co-supported by the ehr core research program that funds fundamental research on stem learning and learning environments, broadening participation in stem fields, and stem workforce development and by the science of science bpinnovate program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Ecological legacy effects of megacarcasses in African savanna ecosystems

Awardee: Utah State University

Amount: \$350,371.00

Abstract: large animals such as elephants and rhinoceros, called "megafauna" for their extreme size, have outsized impacts on the ecosystems they live in. they engineer their environments by knocking down trees and grazing grasses to create large lawns, helping to form habitats that facilitate other animals. but, there is little research that addresses the impact that the carcasses of these megafauna, or "megacarcasses", have on ecosystems after they die. their carcasses represent huge sources of nutrients that have a long-lasting ecological legacy on the areas of ecosystems where their carcasses occur. for example, african elephants are the largest land animals, but almost nothing is known about how the nutrients from their massive carcasses (up to 6,000 kg) affect savanna ecosystems. this award asks the main question: how do elephant megacarcasses affect the ecology of african savannas? the work will address how these megacarcasses affect nutrient cycling in the soil by microbes, plant primary production and species



**\*\*diversity\*\***, and herbivory by vertebrate herbivores, such as zebra and giraffe, and invertebrate herbivores, such as grasshoppers. this research will support the mentoring of 1 postdoctoral scholar, graduate and undergraduate students in ecology as well as science communication and outreach. the main broader impact will be the production of a scientific documentary, the legacy of megaherbivores, which will follow the life and death of an elephant in the african savanna, that will put the life cycle of these elephants into broader ecological context, understanding how they impact ecosystems and the current implications for ecosystems facing their disappearance. to address the overarching question, the award will use elephant carcasses of different ages (up to 15+ years old) in kruger national park (knp), south africa. combining soil (physical, chemical and biological properties), plant (productivity and **\*\*diversity\*\***), and herbivore (vertebrate and invertebrate) surveys at 50 megacarcass sites along with greenhouse experiments, the award will assess how nutrient pulses from elephant carcasses drive integrated responses of ecosystem processes. importantly, the elephant megacarcasses are distributed across gradients of rainfall (375-700 mm) and soil fertility (less-fertile sandy, granitic soils vs. more-fertile clayey, basaltic soils) in knp. these gradients of rainfall and soil nutrients provide a robust experimental framework for testing how the abiotic environment impacts the ecosystem-level legacy effects of terrestrial megacarcasses. finally, by combining the data from the field on the effects of megacarcasses on ecosystem processes with a database of elephant population across knp, the researchers will use ecological modeling to show how the distribution of megacarcasses generates variability in ecosystem processes across the savanna landscape as elephants naturally die over time. this study will represent the first examination of the ecological legacies of megacarcasses on terrestrial ecosystems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Diversity as an Organizational Capability: A Multilevel Examination of Board Composition and

## Firm Effectiveness

Awardee: Michigan State University

Amount: \$350,000.00

Abstract: in the midst of increasing legislation to diversify the boards of publicly held organizations, insight into why such **diversity** matters has remained relatively stagnant. several states have instituted requirements that the boards of public companies become more diverse in terms gender, race, and sexual orientation or provide evidence of the company's broader commitment to developing and maintaining board **diversity**. yet, while researchers have explored the performance impacts of board demographic composition, the findings remain equivocal given little attention to the mechanisms through which such relationships occur. this project endeavors to fill this gap within the **diversity** and strategy literatures to advance insight into the value of and for **diversity** in corporate governance. with a central hypothesis that board demographic **diversity** impacts organizational performance through experience-based **diversity**, this project will examine the effects of director demographic and experience-based characteristics on organizational strategic actions and financial performance. the project will utilize data on director and board characteristics across approximately 1,500 publicly traded firms in the u.s. over a ten-year period from 2007-2017. these data along with data on firm governance quality, strategic choices and firm performance will be obtained from several databases, including boardex, compustat, the institutional shareholder services (iss), ravenpack news analytics, and morgan stanley capital international (msci). director data will be aggregated and combined with firm-level data to estimate the effects of board **diversity** variables on firm organizational actions and performance. overall, this project offers an integrative, process-based perspective for understanding value creation and capture as it pertains to board **diversity**. by encouraging and establishing a future research agenda for a more systemic approach to the study of board **diversity** and firm performance, this project has the potential for enhancing the explanatory power and practical usefulness of future firm-level **diversity** research. more broadly, project has the potential for building **diversity**-related

partnerships between academia and industry and transforming the ways in which organizations approach **\*\*diversity\*\***. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: REU Site: Undergraduate Research Opportunities in Cave and Karst Science (U-ROCKS)

Awardee: James Madison University

Amount: \$349,914.00

Abstract: undergraduate research opportunities for cave and karst science (u-rocks) is a unique research experience for undergraduates (reu) site that gives students an opportunity to explore the multi-disciplinary field of cave and karst science. karst is a type of landscape where rocks (usually made of carbonate, like limestone) are dissolved by interaction with water. as the rocks dissolve, subsurface caves and underground river systems are created, and surface features such as sinkholes, disappearing streams, and springs may form. karst makes up about 20% of the land surface in the u.s., and nearly half of the drinking water in the us comes from karst groundwater sources (also known as karst aquifers). drinking water from karst aquifers is particularly vulnerable to contamination, and karst surface features can affect the ability to build on the land. therefore, specialists trained in cave and karst science, such as those who participate in u-rocks, are attractive not only in the academy, but for careers and work involving land management, water resources, transportation, and civil engineering. the recruitment process for this reu site will focus on the integration of students from historically underrepresented groups, including a cohort of 3-4 students per year from the university of puerto rico system, and a similar number from regional community colleges near james madison university. u-rocks reu site is designed to provide an original and independent well mentored undergraduate research experience, as well as a thoughtful approach to the students' personal and professional growth. the primary goal of the u-rocks program is to

provide a catalytic, intentional, and sustained experience for a diverse group of ten promising undergraduate students each year. this will be accomplished via four different pathways. first, the students will conduct mentored independent research projects working on projects related to karst over a broad range of disciplines; some example projects might involve the geophysical characterization of void spaces, isotopic geochemical analysis of stalactite samples to get at paleoclimate, analysis of a fragile cave ecosystem, and development of land use policy to protect water resources. secondly, we will organize scientific workshops in cave and karst science to provide a broad and solid foundation and give students opportunities to share their work with the cohort. thirdly, the workshops will have a strong personal and professional development component, with a focus on **\*\*diversity\*\*** and inclusion, scientific ethical behavior, scientific identity, belongingness, independence, and self-efficacy. finally, there will be a focus on building a diverse learning community through peer mentoring and social activities. the secondary goal of u-rocks will be to generate original, multi-disciplinary research related to cave and karst science, leading to abstracts and publications. this will be accomplished by strongly encouraging research projects and the mentor/mentee relationships to continue beyond the ten-week summer session. the tertiary goal of the u-rocks program will be to further enrich jmu's culture of undergraduate mentoring. this will be accomplished by offering a mentor workshop using the entering mentoring curriculum developed by christine pfund and others. mentors from four different reu programs housed within jmu's college of science and mathematics will be invited to participate in this roundtable workshop, enabling the sharing of experience and expertise to increase the mentoring capacity within the already formidable jmu community. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Amount: \$349,914.00

Abstract: undergraduate research opportunities for cave and karst science (u-rocks) is a unique research experience for undergraduates (reu) site that gives students an opportunity to explore the multi-disciplinary field of cave and karst science. karst is a type of landscape where rocks (usually made of carbonate, like limestone) are dissolved by interaction with water. as the rocks dissolve, subsurface caves and underground river systems are created, and surface features such as sinkholes, disappearing streams, and springs may form. karst makes up about 20% of the land surface in the u.s., and nearly half of the drinking water in the us comes from karst groundwater sources (also known as karst aquifers). drinking water from karst aquifers is particularly vulnerable to contamination, and karst surface features can affect the ability to build on the land. therefore, specialists trained in cave and karst science, such as those who participate in u-rocks, are attractive not only in the academy, but for careers and work involving land management, water resources, transportation, and civil engineering. the recruitment process for this reu site will focus on the integration of students from historically underrepresented groups, including a cohort of 3-4 students per year from the university of puerto rico system, and a similar number from regional community colleges near james madison university. u-rocks reu site is designed to provide an original and independent well mentored undergraduate research experience, as well as a thoughtful approach to the students' personal and professional growth. the primary goal of the u-rocks program is to provide a catalytic, intentional, and sustained experience for a diverse group of ten promising undergraduate students each year. this will be accomplished via four different pathways. first, the students will conduct mentored independent research projects working on projects related to karst over a broad range of disciplines; some example projects might involve the geophysical characterization of void spaces, isotopic geochemical analysis of stalactite samples to get at paleoclimate, analysis of a fragile cave ecosystem, and development of land use policy to protect water resources. secondly, we will organize scientific workshops in cave and karst science to

provide a broad and solid foundation and give students opportunities to share their work with the cohort. thirdly, the workshops will have a strong personal and professional development component, with a focus on **\*\*diversity\*\*** and inclusion, scientific ethical behavior, scientific identity, belongingness, independence, and self-efficacy. finally, there will be a focus on building a diverse learning community through peer mentoring and social activities. the secondary goal of u-rocks will be to generate original, multi-disciplinary research related to cave and karst science, leading to abstracts and publications. this will be accomplished by strongly encouraging research projects and the mentor/mentee relationships to continue beyond the ten-week summer session. the tertiary goal of the u-rocks program will be to further enrich jmu's culture of undergraduate mentoring. this will be accomplished by offering a mentor workshop using the entering mentoring curriculum developed by christine pfund and others. mentors from four different reu programs housed within jmu's college of science and mathematics will be invited to participate in this roundtable workshop, enabling the sharing of experience and expertise to increase the mentoring capacity within the already formidable jmu community. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Proposal GEOPATHs:IN Recruiting through location-based Curriculum and Field and Laboratory Research Experience for High School Students, Teachers and Undergraduates

Awardee: University of Nevada Las Vegas

Amount: \$349,710.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). improvements to stem k-12 education and increasing the number and **\*\*diversity\*\*** of young people headed into stem careers have been identified as national priorities. this project seeks to address aspects of both of these priorities in the context of geoscience education and workforce

**\*\*diversity\*\***. the project will encourage high school students including many from historically excluded groups, to become involved in the geosciences or other stem disciplines by 1) engaging them in lesson plans developed by participating teachers to explain the local landscape and natural environment in which they live, 2) offering them opportunities to participate in geoscience research projects at the university of nevada, las vegas and 3) by building personal connections between students and faculty at unlv. to facilitate interactions with high school students pis will build long term relationships with high school earth science teachers by hosting summer workshops in which teachers will be provided with information about the local geology and natural environment and assist them in creating lesson plans for their classrooms. the activities will build up to a culminating experience where the teachers and high school students have an opportunity to claim their own identity as budding geoscientists.

this project will encourage high school students including many from historically excluded groups to become involved in the geosciences or other stem disciplines. the program will strengthen the relationship between the university of nevada (unlv) and the local community, including the local school district. project objectives will be accomplished through a comprehensive program that will include: 1) building a professional earth science learning community to facilitate collaboration between local high school teachers and unlv faculty/students; 2) generating high school earth science curriculum materials based on the local geologic resources that will provide stem education opportunities while also introducing potential career paths in the earth sciences; 3) creating a service learning course that will pair undergraduate ?geoscience ambassadors? with high school classes that are utilizing the newly developed curriculum materials; and 4) engaging highly motivated high school students, high school teachers, and unlv undergraduate students in high profile, locally relevant scientific research questions in a way that leverages cutting edge analytical equipment in the unlv geoscience department. the workshop curriculum content and materials will be designed in consultation with curriculum experts so that they mesh well with the teachers? needs and address concepts outlined in the nevada academic content standards for science. resultant outcomes will bear benefits to teacher and student

participants, faculty and the community as the project demonstrates how to build the geoscience workforce at the local level. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Future Ready Engineering Leaders

Awardee: SUNY at Stony Brook

Amount: \$349,601.00

Abstract: this project will prepare female leaders for the engineering workforce. graduate students will acquire the skills demanded by engineering employers, while developing their self-confidence to overcome obstacles. as universities are not naturally structured to marshal disparate resources scattered across departments to maximize support, this project will cross organizational boundaries and cut through silos to create a multi-divisional and multi-organizational ecosystem of support for students. the short term and long-term impact of the programmatic interventions and mentoring components on women's engineering identity and efficacy, career decision making and persistence in engineering will be studied. the project is aligned to the nsf bpe program as it focuses on enhancing the **\*\*diversity\*\*** and inclusion of underrepresented populations in engineering. the project will transform graduate education by marshaling resources from both academic and student affairs? entities while engaging industry partners, and providing holistic support for students? academic, social, and career success. female graduate students in engineering will acquire the career competencies employers want through curricular and practical experiences monitored by peer and industry mentors, that will connect students? accomplishments to the job market. industry-endorsed micro-credentials will be awarded to recognize, and display knowledge, skills, and abilities acquired. the research plan will synthesize elements of psychosocial models of academic and social engagement and will investigate, through a longitudinal, repeated measures design, the



underlying psychosocial mechanisms that promote (or undermine) academic and career development and engagement as well as social engagement among the participants. this project will create a powerful ecosystem and will demonstrate strong collaborations between different campus offices to leverage industry connections and knowledge to maximize support for graduate students.

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Matched Words: diversity

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Title: Collaborative Research: ERASE-PFAS: A "concentrate-and-destroy" technology for treating per- and polyfluoroalkyl substances using a new class of adsorptive photocatalysts

Awardee: Auburn University

Amount: \$347,984.00

Abstract: per- and polyfluoroalkyl substances (pfas) have been manufactured and widely used in hundreds of consumer products and industrial processes for decades. release of pfas into the environment has resulted in drinking water supplies for millions of u.s. residents to become contaminated at levels exceeding united states environmental protection agency health advisory limits. unfortunately, conventional water treatment processes are not effective at removing or destroying pfas due to the unique molecular properties of these compounds. this has created an urgent national need for water treatment technology to address this problem. the goal of this research is to address this problem through a multi-phase research project focused on developing ?trap and destroy? technology. this technology utilizes a new class of adsorptive materials to efficiently capture pfass from water, followed by degradation using targeted ultraviolet and sunlight-assisted reaction. successful completion of this research will benefit society through the production of effective pfas treatment technology. additional benefits result from increased scientific

literacy through enhanced public awareness of pfas contamination, as well as by increasing the **\*\*diversity\*\*** of the nation's stem workforce by engagement of k-12, undergraduate, and graduate students from underrepresented groups in research and training. the overarching research goal of this project is to develop and fully characterize an innovative technology to cost-effectively remove and degrade pfas from contaminated water. the technology is based on a new class of adsorptive photocatalysts that can selectively adsorb pfas from water to the photoactive solid surface, and then destroy pfas in situ under uv or solar light. this project will target both legacy pfas and their newer substitutes such as genx. the research goals will be accomplished through a series of interconnected research tasks to: i) develop adsorptive photocatalysts optimized for treatment of a wide range of pfas, ii) characterize the speed, selectivity, and capacity of the adsorptive photocatalysts for pfas treatment, iii) characterize uv- and solar-light solid-phase photocatalysis of the pre-adsorbed pfas, and iv) explore ways to enhance photocatalysis through amendment with low-cost oxidants and manipulation of reaction conditions. the underlying reaction mechanisms will be investigated through all stages of the research using state-of-the-science microscopic and spectroscopic analyses of the materials, high-resolution spectroscopic analysis of the reaction products, and modern density functional theory calculations. a preliminary cost analysis will be carried out to assess the cost-effectiveness of the technology compared to alternative treatment options. successful completion of the project will potentially lead to an innovative technology that can cost-effectively treat low concentrations of pfas in large volumes of contaminated water. more broadly, the knowledge gained from this project will also advance our understanding of the synergistic effects of nanoscale hybrid phases and multiple redox cycles on the overall performance of reactive composite materials, and potentially transform our knowledge on fabrication and application of carbon-modified, multi-phase photocatalysts. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: 21 cm Reionization Science with the MWA

Awardee: Arizona State University

Amount: \$347,237.00

Abstract: the epoch of reionization (eor) is the period of time in the early universe when it is thought that the first stars and galaxies formed. understanding the physics of galaxy formation and feedback during the eor is one of the key goals of modern cosmology and astrophysics. observations of neutral hydrogen in the early universe have the potential to revolutionize our understanding of these first stars and galaxies. this work will improve data analysis with the Murchison Widefield Array telescope so that researchers can make significantly better detections of such faint signals, making the observations much more useful and providing a tool for researchers engaged in similar projects. in addition, this work will continue and expand the initiative to provide research experiences for non-traditional undergraduates. undergraduate research is an essential component in preparing students both for graduate school and for positions in the broader STEM workforce. providing this kind of research experience to non-traditional undergraduate students will enable more of them to go on to graduate school, increasing the **diversity** of the broader STEM community. this award supports the continued work of a successful eor analysis team. over the past four years innovations by the US Imaging Power Spectrum (PS) team have driven the field forward and have led to the deepest eor PS limits in the world. the investigators will make the next steps needed to reduce the limits by another order of magnitude with Murchison Widefield Array (MWA) data. specifically, this work will make improvements in PS analyses with the MWA that will lower limits on the signal strength by an order of magnitude, making deep cuts into the possible parameter space for eor models. this research will be invaluable for the entire 21 cm community. this award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: P2C2--The Changing Width of the Tropics in Past, Present and Future Climate

Awardee: Colorado School of Mines

Amount: \$346,427.00

Abstract: the research centers on the hypothesis that extreme warming, such as during the early eocene and under potential unmitigated climate scenarios, drives a substantial expansion of the tropical belt accompanied by poleward shifts in other aspects of the atmospheric circulation and large-scale hydroclimate. this interdisciplinary research integrates paleo-proxy data with climate modeling to investigate the changing width of the tropics during late paleocene and early eocene. the observational component of the research aims to provide a comprehensive paleocene-eocene hydrological data synthesis and data for a model-data comparison. the modelling component will analyze pre-existing coupled deepmip climate simulations of paleocene-eocene, conduct targeted atmosphere-only simulations to explore the sensitivity of the results to sea surface temperatures, and perform the data-model comparison. the poleward edge of the tropical hadley cell is a fundamental characteristic of earth's climate. the edge of the hadley cell marks the boundary between the tropics and extratropics - the earth's two main climate zones at the most basic level. observations reveal a poleward expansion of the hadley cell in recent decades, driving an expansion of the tropical belt with potentially significant implications for worldwide climate. the expansion has the potential to shift rain belts and cyclone tracks, expand deserts, and exacerbate droughts and wildfires. climate models simulate the tropical expansion, albeit at lower rates than what is observed. this raises important questions about the causes behind the expansion and the ability of models to simulate the expansion as well as questions surrounding the magnitude of the widening under future global warming. the potential broader impacts include involving graduate and undergraduate students will be involved in the project, a plan for improving **\*\*diversity\*\*** and inclusion through existing programs, and a creative visual science journalism film project. specifically, the **\*\*diversity\*\***

activities include collaboration with the women in science, engineering and mathematics program (wisem) by contributing hands-on activity modules for their annual outreach programs, participation in the girls lead the way program for high school students, and also providing science experiment modules for mines girl scout engineering day which welcomes 100 junior girl scouts to participate in stem activities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: THE SCOPE AND SIGNIFICANCE OF TUNGSTEN ISOTOPE VARIATIONS: IMPLICATIONS FOR MANTLE EVOLUTION

Awardee: Rutgers University New Brunswick

Amount: \$345,352.00

Abstract: tungsten isotopic variations have been documented in modern and ancient rocks over the past decade, yet their role in constraining mantle evolution remains debated. this is because their origin and mode of preservation in the mantle are unclear. tungsten isotopic compositions, however, could provide unparalleled constraints on mantle evolution as tungsten is one of the few isotopic tracers able to track the final stages of accretion, early planetary differentiation, and potentially ongoing core-mantle interaction. to effectively utilize this tracer, the scope of tungsten isotopic variations must be robustly identified and incorporated into physical mantle evolution models. our

starting point is a survey of the most ubiquitous rock type sampling the mantle: mid-ocean ridge basalts. we will test hypotheses of the origin and preservation modes of tungsten isotopic anomalies in the mantle by synthesizing new and existing tungsten isotopic data with numerical models of thermochemical mantle convection. the proposed integration of data, techniques, and interpretations is novel and has the potential to significantly advance the understanding of mantle evolution beyond the tungsten isotope community. three additional broader impacts planned. (1) development of interdisciplinary partnerships by coordinating early career scientists who are experts in different disciplines. this includes support for a postdoctoral associate to conduct state-of-the-art research. (2) advancement of teaching and participation in science by providing a structured research program for an undergraduate student at rutgers university facilitated by the aresty research center for undergraduates and **\*\*diversity\*\*** and inclusion centers affiliated with the university. (3) further development of the planetary science research track at the department of earth and planetary sciences, rutgers university. with the recent discoveries of tungsten isotopic heterogeneity in ocean island basalts, it is now necessary to understand if mid-ocean ridge basalts possess tungsten isotopic variation and investigate what causes these variations. using proven analytical methods, we will measure high-precision tungsten isotopic compositions in samples from compositionally diverse mid-ocean ridges. this task will address the issue that little research has been reported to define mantle reservoirs which are purportedly normal for tungsten isotopic composition. to advance broader scientific implications provided by tungsten isotopic studies to the community, we will test the plausibility of the leading hypotheses of the origin of tungsten isotopic anomalies in the mantle by integrating our new and existing tungsten isotopic data with numerical models of thermochemical mantle convection. these results are anticipated to have broad implications for our understanding the dynamic evolution of our planet. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity



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Title: Collaborative Research: PurSUIT: Species diversity and evolution of parasitic microfungi

Awardee: University of Colorado at Boulder

Amount: \$343,925.00

Abstract: fungi are essential to ecosystem functioning, occur virtually everywhere, and form complex relationships with diverse organisms including prokaryotes, algae, plants, invertebrates, vertebrates, and other fungi. nonetheless, fungi are the most undersampled and poorly documented major lineage of eukaryotes, even though total species estimates range conservatively from 1.5-6.1 million species. this uncertainty reflects numerous gaps in knowledge about fungal distributions, especially regarding range and extent of unculturable fungi, microscopic fungi (microfungi), parasitic fungi, and tropical fungi. this project will document **diversity** of fungi in two groups that represent major gaps in our knowledge: the first are unculturable microfungi that associate with insects, called labouls, and the other are unculturable microfungi that associate with plants, called rust fungi. members of labouls and rust fungi are expected to have profound effects on ecosystem health and functioning through both beneficial and harmful interactions with their animal and plant hosts. the research team will explore several global habitats in tropical and temperate regions that have not previously been surveyed for these fungi. it is expected that hundreds of new species will be discovered and described during this project. in addition to enhancing the documented bio**diversity** on the planet, this project will resolve the "tree of life" for both groups and use this information to resolve long-standing questions regarding the evolution of the fungi. broader impacts include graduate and undergraduate training, international workshops to enhance collaboration between us and local researchers, and outreach to the public through "bat night" and "roach hunt" field trips. these fungal lineages are being studied for several reasons: 1) both represent groups poorly documented from tropical world regions; 2) both represent groups that are not detected by commonly applied culture-based and high throughput sequencing efforts; 3) neither group has been resolved, phylogenetically, by application of multi-locus analyses of known species; 4) both represent

obligately parasitic lineages that are rarely studied but expected to have profound effects on ecosystems; and 5) both are or are related to heteroecious fungi (requiring two different hosts), a phenomenon that is extremely rare in fungi. a complementary team of us and other global experts on these fungi, ranging from junior to senior scientists, have designed an experimental approach that includes standardized sampling strategies from tropical and extra-tropical regions with multi-locus phylogenetic, phylogenomic, comparative genomic, and statistical analyses to: 1) determine whether accurate estimates from obligate microparasitic fungi, not included in any other estimates, will affect overall fungi species estimates; 2) whether parasitic microfungi follow the reverse latitudinal gradient posited for other fungal groups; and 3) resolve long-standing unresolved phylogenetic nodes by the incorporation of ?missing? lineages. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Testing the reduction of aerobic habitat as a common kill mechanism for major mass extinction events

Awardee: University of California-Riverside

Amount: \$342,080.00

Abstract: the project will study the response of marine animal ecosystems to environmental change using three mass extinction events from the geological record as study systems. specifically, the project will test the hypothesis that a large proportion of extinction during these events can be explained by the stresses that elevated temperatures and reduced oxygen availability place on animal respiration. geochemical data will be used to constrain computer simulations of changing ocean conditions during these mass extinction events. results from laboratory studies on animal respiration will then be paired with fossil data to assess whether differences in extinction intensity in space and across taxonomic groups can be explained by spatial variation in environmental change

or differences among taxonomic groups in their ability to withstand environmental change. the project will provide interdisciplinary training to a group of graduate students and post-docs. it will further impact stem education through the creation of a website that will allow access to model results so that students can visualize and explore model output to understand cause-effect relationships between continental configuration, ocean conditions, and biological **diversity**. the investigators will also offer short-courses on earth system modeling and data interpretation at major conferences that will be recorded for asynchronous use. the project will also involve the development of a podcast series addressing how we reconstruct the ancient earth system and use these reconstructions to better understand the present and predict the future. in this project, the hypothesis will be tested that the loss of habitat through constraints on aerobic respiration under climate change and ocean deoxygenation can explain the magnitude, taxonomic selectivity, and latitude variation in intensity for the late devonian (frasnian-famnenian), end-permian, and end-triassic mass extinction events. paleoredox and paleoclimate proxy data and geochemical indicators of diagenetic alteration will be used for both global average and local conditions before and after each major event combined with predictions from earth system models and occurrence data from the fossil record of marine animals to separate aspects of extinction that can be explained by physiological stress from those that require other explanations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: REU Site: Increasing Native American perspectives in field and experimental linguistics

Awardee: University of Oregon Eugene

Amount: \$342,051.00

Abstract: this project is funded from the research experiences for undergraduates (reu) sites program in the sbe directorate. it has both scientific and societal benefits, and integrates research and education. the aim of this project is to make stem and higher education more accessible to and inclusive of american indian/alaska native students through a research experience that relates directly to a topic of particular interest to american indian/alaska native communities ? the revitalization and scientific study of native languages. american indian/alaska native students are greatly underrepresented in academia and this situation has remained virtually unchanged for decades. a growing body of research points to the importance and need for higher education to increase its cultural competency as a critical strategy for becoming accessible to underrepresented groups, such as american indian/alaska native students. conversely, academia cannot achieve excellence without perspectives from a **\*\*diversity\*\*** of backgrounds to inform and improve it. thus, the broader impact of this reu site is manifold: it uses a culturally informed and competent approach to introduce american indian/alaska native students to linguistics and the various research disciplines with which linguistics intersects; in doing so it contributes towards an increase in participation of american indian/alaska native students in higher education and research; and as a result, this project contributes towards strengthening academia broadly through a diversification of perspectives. through the reu site, participants complete research rotations in multiple areas of linguistics, specifically focusing on experimental linguistics and language documentation and revitalization. the program embraces a usage-based study of language within a community-centered cross-disciplinary approach, which is relatively novel in undergraduate linguistic training. reu participants are exposed to the full range of skills necessary to conduct research in linguistics. these

research rotations are supplemented with coursework in topics on descriptive and experimental linguistics and academic and professional development workshops. the workshops focus on providing participants with skills to initiate careers in stem, as well as pursuing master's and ph.d. degrees in linguistics or related fields. the fundamental goal of this work is to help students become active agents of innovation in stem through linguistics, seeking to break down disciplinary silos and reprioritize the societal value of science. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: CPS: Medium: RUI: Cooperative AI Inference in Vehicular Edge Networks for Advanced Driver-Assistance Systems

Awardee: Temple University

Amount: \$342,035.00

Abstract: artificial intelligence (ai) has shown superior performance in enhancing driving safety in advanced driver-assistance systems (adas). state-of-the-art deep neural networks (dnns) achieve high accuracy at the expense of increased model complexity, which raises the computation burden of onboard processing units of vehicles for adas inference tasks. the primary goal of this project is to develop innovative collaborative ai inference strategies with the emerging edge computing paradigm. the strategies can adaptively adjust cooperative inference techniques for best utilizing available computation and communication resources and ultimately enable high-accuracy and real-time inference. the project will inspire greater collaborations between experts in wireless communication, edge computing, computer vision, autonomous driving testbed development, and automotive manufacturing, and facilitate ai applications in a variety of iot systems. the educational testbed developed from this project can be integrated into courses to provide hands-on experiences. this project will benefit undergraduate, master, and ph.d. programs and increase under-represented

groups? engagement by leveraging the existing **diversity**-related outreach efforts. a multi-disciplinary team with complementary expertise from rowan university, temple university, stony brook university, and kettering university is assembled to pursue a coordinated study of collaborative ai inference. the pis explore integrative research to enable deep learning technologies in resource-constrained adas for high-accuracy and real-time inference. theory-wise, the pis plan to take advantage of the observation that dnns can be decomposed into a set of fine-grained components to allow distributed ai inference on both the vehicle and edge server sides for inference acceleration. application-wise, the pis plan to design novel dnn models which are optimized for the cooperative ai inference paradigm. testbed-wise, a vehicle edge computing platform with v2x communication and edge computing capability will be developed at kettering university gm mobility research center. the cooperative ai inference system will be implemented, and the research findings will be validated on realistic vehicular edge computing environments thoroughly. the data, software, and educational testbeds developed from this project will be widely disseminated. domain experts in autonomous driving testbed development, intelligent transportation systems, and automotive manufacturing will be engaged in project-related issues to ensure relevant challenges in this project are impactful for real-world applications. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Hominoid origins in a unique paleocommunity

Awardee: Case Western Reserve University

Amount: \$336,384.00

Abstract: this project advances knowledge about a crucial time in primate evolution when the ancestors of apes and humans are thought to have first diverged from other primate lines. a team of experts in paleoanthropology, paleontology and geology are conducting excavations and analyzing

fossils and paleoenvironmental data from a fossil-bearing site in order to better understand the environmental context for primate adaptations and ecological **diversity**. the project offers invaluable research and training opportunities to scientists and students, including individuals from groups underrepresented in stem, and provides opportunities for science outreach about human origins and climate change with local communities and the general public. an extraordinary new fossil primate site provides an opportunity to obtain new data related to the origins of the hominoids during the oligocene. the primary objective of the project is to characterize the species **diversity** and paleoenvironmental context for the site. the central hypothesis is that the earliest stem hominoids arose within unique ecological communities that were very unlike those of the later miocene hominoid radiations. the team of paleoanthropologists, geologists, and paleontologists carry out this work through additional fieldwork and analysis of the hundreds of fossils and geological samples already obtained. the goals are three-fold: (1) characterize the paleobiological disparity between hominoids and cercopithecoids in the mid-oligocene by analyzing functional disparity; (2) build out a robust geologic framework that integrates current and future fossil localities into a well constrained chronology; and (3) characterize the mammalian community **diversity** by contextualizing its taxonomic, functional, and phylogenetic composition. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Hominoid origins in a unique paleocommunity

Awardee: Case Western Reserve University

Amount: \$336,384.00

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Matched Words: diversity

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Title: Effects of experimental warming, disturbances, and species interactions on tropical tree community demography

Awardee: Oklahoma State University

Amount: \$334,985.00

Abstract: tropical forests are the most diverse ecosystems in the world with some forests having hundreds of tree species per hectare. the maintenance of this **diversity** is believed to depend

upon complex interactions among species. however, the relationships and interactions among species can be altered by climate change and disturbances such as hurricanes that disrupt resource conditions that govern seedling and sapling interactions in the forest understory. this project will combine a shade house experiment with novel molecular approaches to study how adult trees influence the interactions among seedlings of species on the forest floor beneath their canopies. in addition to disentangling how disturbances and warming may shift the strength and direction of relationships among species, this project thus investigates how plants can control plant-plant interactions by secreting specific molecules from their root tips. these secretions influence which micro-organisms become common and these micro-organisms in turn influence seedling success (either positively by promoting beneficial microbes, or negatively by promoting pathogenic microbes). specifically, seedlings of canopy trees will be grown in pots at different densities in a shaded greenhouse under a range of growing conditions to simulate global warming and changes in canopy cover (light) that occur with hurricane removal of the adult tree canopy. they will be grown in different combinations of density and with different combinations of the field based micro-organisms that typically associate with the roots of different species of adult trees. the outcome of this work will help us to better predict whether tropical forests will maintain their high level of **\*\*diversity\*\*** as the world's climate continues to change and how changes in light associated with canopy removal during hurricanes or cyclones can change species relationships. in addition to the scientific benefits, this project will offer educational and research opportunities to under-represented students. the study site has an established successful internship program, where recently graduated university students, primarily from puerto rico, are provided the opportunity to participate in research. they will be offered the opportunity for internships with the project and gain research experience from it. the team will also collaborate with a non-profit organization in puerto rico to coordinate field trips for elementary and middle school students to visit the research site and learn about the project. overall, this work will contribute to the scientific and broader community understanding of what tropical forests might look like in the future. the maintenance of tropical forest **\*\*diversity\*\*** is

hypothesized to rely on complex species interactions such as mutualism, predation/pathogen attack, and competition, that regulate seedling dynamics and tree species coexistence. these **\*\*diversity\*\*** maintaining processes could be fundamentally altered under projected changes in climate and disturbance regime, yet we have little understanding of how these factors will act independently or in concert to affect biological **\*\*diversity\*\*** in tropical forests. this project builds and expands upon an existing infrared warming experiment (tropical response to altered climate experiment, trace). based upon preliminary data, the team hypothesizes that the strength and direction of density dependence changes with warming and disturbances because of modifications in species interactions such as associations with mycorrhizal fungi (h1), and that plants can in part control these changes through root exudates (h2). this 2-year project combines a shade house experiment with -omic approaches to evaluate how changes in light, density, microclimate and microbes influence density dependence in different forest species. specifically, seedlings from tree species will be grown in pots subjected to two soil source treatments (e.g. soil from warming versus control plots at the trace site), four microbial treatments (no mycorrhizal fungi, no pathogens, no microbes, control), three densities (low, medium, high), and two light treatments (low and high). broader impacts of the study will fall into three main foci 1) provide research and educational opportunities in science, technology, engineering and math (stem) with an emphasis on **\*\*diversity\*\*** and inclusion, 2) community outreach and education, and 3) generate research that will provide insight into the future of tropical forested ecosystems in a changing world. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Disentangling biological and environmental drivers of diversification in the Andean flora

Awardee: University of Rhode Island

Amount: \$333,083.00

Abstract: the tropical andes of south america is one of the world's richest bio\*\*diversity\*\* hotspots. this \*\*diversity\*\* likely evolved due to the complex environmental and geological history of this region. however, exactly how plant \*\*diversity\*\* arose from the combination of mountain uplift, the development of new habitats, and species interactions is unclear. this research aims to understand how these factors led to plant \*\*diversity\*\* in cloud forests and high-elevation grasslands. the researchers will develop new software to compare plant genomes to understand the ancestry of four groups of flowering plants in the andes. the project will also result in new mathematical models to test the importance of different factors in shaping \*\*diversity\*\* in these plant groups. these new methods will have broad application to studies of bio\*\*diversity\*\* in the andes and beyond. additionally, this project aims to train the next generation of scientists in the study of bio\*\*diversity\*\* through a variety of interrelated activities, including: (1) a course for undergraduates to do guided genomic research; (2) collaborative training for students; and (3) computational training for diverse students. the project will first establish well-supported phylogenetic hypotheses for each of the four focal clades of andean plants using low-coverage and targeted genome sequence data. samples will be collected from colombia as well as museums. this work highlights the importance of natural history collections in cutting-edge biological research, and new fieldwork will add to those collections. a component of the research will be to develop new approaches to address complexities common in plant genomes, including polyploidy and paralogy, that can affect estimates of evolutionary relationships. these methods will be made available through open-source software such that other researchers can easily estimate phylogenies and examine support for phylogenetic hypotheses using sequence data. second, the project will develop new models that jointly infer the roles of dispersal and trait evolution in species diversification. these methods will be applied to phylogenomic, morphological, and distribution data collected for this project. these methods will also be made publicly available for widespread use. finally, by comparing the roles of biogeographic and ecological processes in generating \*\*diversity\*\* in these clades, the research will address the

generality or idiosyncrasy of the processes facilitating rapid radiation in tropical andean plants. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: IGE: Learning the Entire Pipeline: Analyzing and Improving Graduate Engineering Education through Communities of Practice

Awardee: North Carolina State University

Amount: \$332,184.00

Abstract: this national science foundation innovations in graduate education (ige) award to north carolina state university will support groundbreaking research on how graduate students in critical engineering domains learn to put academic knowledge into practice while working in diverse, interdisciplinary teams. in order to prepare students to transfer their classroom experiences to professional practice, engineering education needs to improve students' ability to work in multidisciplinary teams, deal with diverse opinions, ideas, and backgrounds, and broaden their education to understand the impact of engineering solutions in a global context. this project adopts a highly developed theoretical framework called "communities of practice" (cop) and applies, researches, and further extends cop theory in graduate classes across civil engineering, computer science, and electrical engineering. this approach has a strong emphasis on collaboration, teamwork, knowledge as doing, and communication across disciplinary and cultural backgrounds. by applying this approach in three engineering courses from three different engineering departments at north carolina state university, this project will yield insights around student interactions and learning within different team settings: 1) integration into a professional engineering environment, studying how students interact with professionals and how the academic and professional communities learn from their encounters; 2) engagement in interdisciplinary projects in teams that bring together two disciplinary communities; and 3) engagement in interdisciplinary projects with

teams that work on subsystems which need to be integrated into one working whole. this project will focus on how **\*\*diversity\*\*** plays out in cops, examine what factors lead to productive participation by all, what challenges inhibit participation and investigate approaches to structuring academic cops to support equitable learning and contributions by all. through this approach which involves various settings and granularities in three different courses, this project will develop a broader view of how engineering students learn in different team settings. the proposed approach can help to bridge the gap between theory and practice, facilitating the development of a workforce that can work within and across teams, projects, and domains. to help apply the proposed approaches to other disciplines, we will develop and disseminate a set of guidelines in our future publications and presentations. the innovations in graduate education (ige) program is focused on research in graduate education. the goals of ige are to pilot, test, and validate innovative approaches to graduate education and to generate the knowledge required to move these approaches into the broader community. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: RUI: Will climate change lead to system shifts on tropical mountains?: the interplay of epiphyte losses on host tree function, microclimate, and hydrology

Awardee: University of Utah

Amount: \$330,826.00

Abstract: tropical montane cloud forests (tmcfs) are important ecosystems to study and conserve due to their exceedingly high bio**\*\*diversity\*\*** as well as the critical roles these forests play in local and regional water cycling. deforestation in lowland regions and increases in global sea surface temperatures indirectly threaten these forests due to the lifting of the cloud base and an increase in drought conditions. epiphytes, i.e. plants that live on the surfaces of other plants, cover nearly all

tree surfaces in the tmcf and contribute substantially to ecosystem function due to their high capacity to capture and temporarily store water. unfortunately, these plants are the most vulnerable ecosystem components to projected changes in climate. a loss of epiphytes in the tmcf would lead to substantial bio\*\*diversity\*\* loss as well as a destabilization of water resources for human populations. this work aims to fill an important gap in the understanding of feedbacks among epiphytes and forest functions in the tmcf, and will provide important data for land-use and conservation workers as well as natural resource managers and governments in tropical montane regions concerned with long-term water security. a number of local and us-based workers and students will be trained in field and lab-based techniques and regular training events and exchanges will take place amongst all the participants. epiphyte gardens and accompanying curriculum will be created and placed in local schools to increase understanding and awareness of the connectivity between epiphytes and water cycling in the cloud forest.

tropical montane cloud forests (tmcfs) are under threat due to rapid changes in climate and in fact, recent work suggests that this ecosystem is predicted to contract substantially in the coming decades. this proposal addresses the question: how will a loss of the diverse and abundant epiphyte communities in the tmcf impact tree health, energy balance and hydrologic function? the investigators propose to conduct the first large-scale epiphyte removal experiment, in which trees in forest and pasture will be stripped of their entire epiphyte community. changes in crown-level microclimate (air temperature, relative humidity, leaf wetness, wind speed, solar radiation) as well as growth, water relations (water potential, sap flow, stomatal traits, carbon isotopes) and ecohydrological parameters (soil moisture, throughfall, stemflow) will be measured in and under the trees stripped of their epiphytes and compared with paired trees with intact epiphyte communities. direct field-based measurements will be coupled with remotely sensed parameters (ndvi, air temperature, leaf water content) using a high-precision drone outfitted with an integrated multispectral imaging system. a numerical model of epiphyte-host tree water relations will be developed and coupled to a land-surface hydrology model to scale up the field-based measurements and predict the effect of epiphyte loss on regional energy budgets and

canopy water cycling. field work will take place in five locations in the monteverde region of central costa rica. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Collaborative Research: RUI: Will climate change lead to system shifts on tropical mountains?: the interplay of epiphyte losses on host tree function, microclimate, and hydrology

Awardee: Wake Forest University

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Matched Words: diversity  
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Title: Collaborative Research: Genetics and biomechanics of non-Newtonian prey capture adhesives across Panarthropoda

Awardee: University of Maryland Baltimore County

Amount: \$330,483.00

Abstract: several groups of invertebrate species produce prey capture glues that are deposited on

silks, secreted onto limbs, or squirted directly onto prey. these glues are materially unique in their drying times and reaction to humidity, but they are functionally similar in that they vary in viscosity based on applied forces and their rapid adhesion. the researchers will investigate the molecular and physical attributes of prey capture glues from 10 species in three distantly related groups - arachnids (spiders and opilionids), flies (predatory glow worms), and onychophorans (velvet worms). by understanding the differences in glue properties with respect to their molecular bases, a catalog of necessary components can be established for the design of new synthetic adhesives. this research will furthermore enhance participation of underrepresented minorities in field coursework, which research continues to demonstrate to be critically important to individuals choosing careers in ecology, evolution, and environmental sciences. the highlands biological station (hbs) in highlands, north carolina, is an important resource for research in the appalachian region and has hosted the two-week field class, "the biology of spiders," for several decades. this class focuses on field identification, specimen collection, and preservation. with the twin goals of furthering positive public perception and interest in arachnids within the appalachian region, and improving access to fieldwork opportunities for diverse student populations, the researchers will enhance the existing course by supporting student attendance via "diversity"-focused scholarships, new course material, and contributions to the hbs arachnid collection through student participation. unlike materials with homologous origin that diversify under selective pressure, investigating convergently evolved prey capture glues from distantly related organisms offers a unique opportunity to explore the necessary and novel components for constructing these adhesives. this project will examine prey capture glues with the broad goals of understanding the contribution of their molecular components to function, and discovering the commonalities associated with functional, ecological, or morphological similarity. first, targeted transcriptomics, dna sequencing, and glycosylation analyses will be employed to reconstruct the biomolecular organization of the glue from each species. this will be the first study to investigate the importance of glue gene length and repetitiveness for glue function, and the first comparison of posttranslational o-glycosylation modifications in a "diversity"

of bioadhesives. second, force transduction measurements during adhesive manipulation will allow documentation and analysis of the biomechanical properties of each glue. combined with full-length sequences, direct inference will be made about the mechanical potential of glue sequence, including the role of repeat number and unit complexity in contributing to adhesive toughness and extensibility. finally, we will reconstruct gene trees in order to evaluate support for parallel or convergent evolution of prey capture adhesives. similar sequence identity will support the convergent strength of functional selection in the evolution of prey capture glue genes. alternatively, poor sequence identity between glue transcripts indicates that a variety of biochemical mechanisms exist for prey adhesion, providing exciting novel pathways for biomimetic synthesis. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: SWIFT: Cognitive-IoV with Simultaneous Sensing and Communications via Dynamic RF Front End

Awardee: University of California-Los Angeles

Amount: \$329,999.00

Abstract: future transportation is promising safer and more efficient traveling via connected intelligence among vehicles as well as with the transportation infrastructure. at the same time, travelers can also be relieved from tedious driving and use vehicles as offices or entertainment rooms on the move. essential to all these is a reliable and resilient internet of vehicles (ioV). given the unique transportation environment, a satisfactorily functioning ioV is confronted with many challenges. for example, data services for transportation safety/efficiency and/or traveler convenience/comfort are often very sensitive to delays and require large bandwidth. the vehicular environments are also filled with various communication services as well as active sensing devices, which can potentially cause interferences to each other. in addition, the high mobility inherent to

transportation and fluctuation of the transportation information exchange depending on the specific traffic scenario can both lead to fast-changing and possibly unpredictable dynamics. to address these challenges, this project organizes collaborative efforts to enhance spectrum utilization, sharing and management in iov. the project will promote the interactions among multi-disciplinary experts such as electromagnetic waves, electronics, signal processing and wireless communications to create wireless innovations at different network layers. the developed technologies will provide valuable tools for foundational science and engineering research and promote societal embracing of the emergent cognitive iov technologies. the project also has an integrated education plan that aims to prepare the workforce to address future challenges of spectrum utilization and wireless communications, while promoting and embracing **\*\*diversity\*\*** in science and engineering. this project aims to develop a cognitive iov framework with simultaneous sensing and communications via a novel dynamic rf front end. targeting the aforementioned challenges, the proposed iov research has three distinctive features. first, the proposed research is centered at simultaneous communications and sensing. based on a dynamic rf front end that is innovatively designed to facilitate full duplex modes, communications and simultaneous monitoring of multiple spectrum bands with tunable granularity become possible. secondly, the resultant iov framework is cognitive in two counts: i) cognitive in the spectrum environment - the spectrum sensing information from devices equipped with the dynamic rf front end is used to develop algorithms to learn and track the spatiotemporal radio tomography with quantifiable uncertainty; and ii) cognitive in the physical environment - with judiciously designed waveforms that enable simultaneous communications and active physical environment sensing, the acquired information will be leveraged to enhance communications. last but not least, the proposed cognitive iov framework is dynamics-ready via hardware, architecture, and algorithm design: the dynamic rf front end boasts real-time tuning and control capability, the network architecture incorporates unmanned aerial vehicles (uav) to mobilize on-demand support for transportation/traveler data service hotspots, and reinforcement learning algorithms developed to achieve closed-loop control and management of spectrum resources will

remain robust when the dynamics are unknown or unpredictable. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: CNS Core: Small: Adaptive Smart Surfaces for Wireless Channel Morphing to Enable Full Multiplexing and Multi-user Gains

Awardee: University of California-San Diego

Amount: \$329,998.00

Abstract: the connectivity solutions need to scale up massively to support unprecedented exponential growth in data rates and the number of devices. the primary approach to meet the demands has been to upgrade the infrastructure, such as adding base stations with multiple antennas and/or upgrading clients. unfortunately, these approaches have fallen short of their goal as in practice, the channels between users and base stations have limited scattering or richness to enable spatial multiplexing, and users are not sufficiently separated in the spatial domain. this proposal will shape the channel to unlock the full potential of wireless networks without requiring updating the base station or user device at a low cost in terms of power and expense. the proposed research aims to adaptively modify and morph the wireless medium using smart passive reflector surfaces to materialize the spatial multiplexing gains. the underlying idea is to use smart reflectors to create additional channel **\*\*diversity\*\*** to manipulate the received signal before reflecting it to minimize interference at the receivers. the research brings together pis and techniques from communications theory, networked system design, and antenna design to build scalable and low-cost wireless networks. the project also proposes a synergistic educational and outreach plan that leverages the technical work to build exciting demos for undergraduate and k-12 classrooms. for example, a smart surface-based demo, which increases the data rate and coverage of current wi-fi devices, will introduce students to the wonders of engineering in a pragmatic yet compelling



way, with the hope of increasing **diversity** in stem-related education environments. the proposal would develop smart surface designs capable of morphing the channel, and develop the hardware prototype and algorithms to provide coverage and multiplexing gains to support massive numbers of users and the exponential increase in data rates. the designed smart surface with fine-grained control would allow us to morph the wireless channel or environment to increase the **diversity** and multiplexing gains as deemed necessary during optimization. we further establish smart surface placement theory and algorithms and quantify the performance-size trade-offs. we develop low-overhead channel estimation and low-latency optimization algorithms for the base station to support temporal channel changes and improve the data rate and connectivity. the proposed effort would develop the theory and algorithms for multi-user setups to ensure scalability with smart surfaces. the proposed work would enable the first low-cost, practical smart surface and algorithms supporting high-mobility users with significant data-rate improvements. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: CPS: Medium: RUI: Cooperative AI Inference in Vehicular Edge Networks for Advanced Driver-Assistance Systems

Awardee: Rowan University

Amount: \$329,493.00

Abstract: artificial intelligence (ai) has shown superior performance in enhancing driving safety in advanced driver-assistance systems (adas). state-of-the-art deep neural networks (dnns) achieve high accuracy at the expense of increased model complexity, which raises the computation burden of onboard processing units of vehicles for adas inference tasks. the primary goal of this project is to develop innovative collaborative ai inference strategies with the emerging edge computing paradigm. the strategies can adaptively adjust cooperative inference techniques for best utilizing

available computation and communication resources and ultimately enable high-accuracy and real-time inference. the project will inspire greater collaborations between experts in wireless communication, edge computing, computer vision, autonomous driving testbed development, and automotive manufacturing, and facilitate ai applications in a variety of iot systems. the educational testbed developed from this project can be integrated into courses to provide hands-on experiences. this project will benefit undergraduate, master, and ph.d. programs and increase under-represented groups? engagement by leveraging the existing **\*\*diversity\*\***-related outreach efforts. a multi-disciplinary team with complementary expertise from rowan university, temple university, stony brook university, and kettering university is assembled to pursue a coordinated study of collaborative ai inference. the pis explore integrative research to enable deep learning technologies in resource-constrained adas for high-accuracy and real-time inference. theory-wise, the pis plan to take advantage of the observation that dnns can be decomposed into a set of fine-grained components to allow distributed ai inference on both the vehicle and edge server sides for inference acceleration. application-wise, the pis plan to design novel dnn models which are optimized for the cooperative ai inference paradigm. testbed-wise, a vehicle edge computing platform with v2x communication and edge computing capability will be developed at kettering university gm mobility research center. the cooperative ai inference system will be implemented, and the research findings will be validated on realistic vehicular edge computing environments thoroughly. the data, software, and educational testbeds developed from this project will be widely disseminated. domain experts in autonomous driving testbed development, intelligent transportation systems, and automotive manufacturing will be engaged in project-related issues to ensure relevant challenges in this project are impactful for real-world applications. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CSR: Small: Evolution of Computer Vision for Low Power Devices, Breaking its Power Wall and Computational Complexity

Awardee: University of California-Davis

Amount: \$328,084.00

Abstract: the accuracy of computer vision for object recognition and classification has surpassed human capabilities. adoption of brain-inspired convolutional neural network (cnn) models and the ability to train and execute these complex networks by modern graphical processing units (gpus) are the backbone of this progress. however, in terms of computational requirement, memory usage, and power consumption, the cnn solutions are extremely demanding. meanwhile, many interesting applications of computer vision - such as small robotics, a wide range of cyber-physical systems, and many smart devices on the internet of things - are resource constrained. this project aims to substantially lower the computational complexity, the average-case classification power and the latency of cnn-based vision, enabling its deployment to a much wider range of platforms. from a societal viewpoint, this study enhances the research, education, and **\*\*diversity\*\*** at george mason university (gmu) by involving graduate, undergraduate, minority and female students, and enriches several courses that are offered at gmu. the goals of this research project are as follows: (1) reformulating the cnn-based learning model into an iterative convolutional neural network (icnn) learning model that allows early classification and permits early termination via various thresholding mechanisms and developing a framework to use the contextual knowledge that could be extracted from earlier iterations to guide and reduce the computation of future iterations. (2) developing an approximate icnn coprocessor that supports approximation in memory and logic by exploring new approximation opportunities created by icnn, and enhancing the icnn to adjust and learn the approximate hardware behavior in addition to its intended functionality.

Matched Words: diversity

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Matched Words: diversity

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Title: REU Site: Culturally Responsive Research in Developmental Science

Awardee: University of Texas at Dallas

Amount: \$327,848.00

Abstract: this project is funded from the research experiences for undergraduate (reu) sites program in the sbe directorate. it has both scientific and societal benefits in addition to integrating research and education. currently, the majority of developmental research is conducted by and focused on monolingual, white individuals from middle-to-high income households. to address the critical need to expand developmental theories to incorporate underserved and underrepresented populations this project will train students from these understudied populations to become researchers who can provide rich and needed perspectives on developmental science. through participation in the university of texas at dallas's year-long reu, 30 students (10 per year) from historically underrepresented groups will learn the necessary tools to conduct high-quality research with real-world applications with families that are challenging-to-study, vulnerable, and underrepresented in the developmental science literature. thus, the project will advance the field of developmental science by increasing **\*\*diversity\*\*** in both the researchers and the children who are researched. students will be drawn primarily from the dallas/ft worth area, which compared to other similarly large cities in the u.s., has few research intensive 4-year institutions of higher learning, and few opportunities for students to gain high quality, first-hand research experiences. at least 50% of the students will be enrolled at one of dallas college system's 7 community campuses, and the remaining students will be enrolled at the university of texas at dallas . a large number of historically underrepresented college students attend the local community colleges and utd. in the fall, students will acquire skills needed for culturally-responsive research by taking an active role in the play with me program. play with me, a unique and important aspect of this reu's research experience, is a free 12-week parent/child (ages 0-3 years) community-based outreach program created by utd developmental scientists and specialists based on playful-learning research and directed by developmental specialists of utd's center for children and families. with mentorship from utd faculty, students will formulate new theoretically-driven research questions within ongoing data sets influenced by their play with me experience. in the spring, a faculty mentor team will guide students

as they collect and analyze data from families recruited from play with me. in the summer, students will learn to disseminate findings to academic (journals, conferences) and non-academic (newsletters, community outreach) audiences. fellows will also participate in brownbag discussions on professional development, including how to identify and apply to graduate schools, prepare for the gre, and identify academic career options. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: OCE-PRF Biological methane sinks in the deep ocean: Linking genomic diversity and ecophysiology in syntrophic methane-oxidizing consortia

Awardee: California Institute of Technology

Amount: \$327,228.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). microbes are the workhorses behind every biogeochemical cycle, where they control the availability of different nutrients and other compounds. methane seeps in the deep sea are one such system, where methane and other gases seep out from marine sediments, and they account for a significant fraction of the global methane budget. at these seeps, diverse microbial communities thrive and can metabolize the methane released from the seafloor. however, little is known about the specific forces and processes controlling the distribution of these microbes and their ability to perform their important metabolisms. this project investigates the links between microbial **diversity** and the environment in a methane-degrading system, focusing on consortia of anaerobic methanotrophic archaea (anme) and sulfate-reducing bacteria (srb). the results will clarify the fundamental determinants of microbial community composition and improve understanding of marine methane dynamics. the proposed work will engage the broader public in several ways. undergraduate students from backgrounds underrepresented in stem will be mentored over a

summer research project through the caltech wave program. the researcher will also partner with local elementary, high school, and undergraduate-serving programs through the caltech ctl&o office and the center for environmental microbial interactions (cemi) to encourage student participation in research opportunities related to the proposed work. through existing collaborations between the ansep program and the orphan lab, the researcher will participate in the ansep middle school career exploration in marine science program. this project aims to identify 1) how the genomic **\*\*diversity\*\*** of anme/srb partners is structured across scales ranging from individual consortia to environmental gradients and 2) the genes and ecological factors determining ecological outcomes for each partner. samples containing anme/srb consortia have been previously obtained from methane seep sediments with a range of biogeochemical parameters. individual consortia will be sorted and sequenced to produce high-quality metagenome-assembled genomes (mags) for comparative analysis to reveal the strain-level composition of individual consortia and the proportion of each strain across different sediment samples to different methane seeps. functional profiling of mags will then allow comparative genomic approaches to identify the genes most likely to be critical to each population's success in each environment. predictions will be experimentally tested by a range of laboratory experiments including nanoscale secondary ion mass spectroscopy (nanosims), bioorthogonal non-canonical amino acid tagging (boncat), and fluorescence in situ hybridization (fish). the genes and associated ecophysiology identified here will result in greater understanding of the factors controlling methane at seep- and basin-scales, and more broadly, the generalizable principles of how microbes adapt to heterogeneous environments. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RCN: Intermittent River Research Coordination Network (IRRCN): Integrating Intermittent River Ecology and Hydrology

Awardee: Pennsylvania State Univ University Park

Amount: \$326,564.00

Abstract: life is simply different in the absence of water, especially for life in rivers and streams. yet half of the earth's rivers dry or stop flowing each year. these streams or rivers are called "intermittent." intermittent rivers are not well studied or understood by researchers studying river ecology or river hydrology. initial research shows the hydrology and ecology of intermittent rivers are very different from rivers that always flow. the current scientific understanding and concepts of streams and rivers is incomplete as it is biased towards the half of the earth's rivers that continuously flow. the intermittent river research coordination network (ir-rcn) will organize a series of expert workgroups that will synthesize the growing body of research on intermittent river hydrology and ecology. these workgroups will produce generalized frameworks that can explain how intermittent river hydrologic and ecologic systems work. this research is important because intermittent rivers are often overlooked or excluded from water management plans due to uncertainty about their hydrologic and ecological importance. graduate students will receive interdisciplinary training in hydrology and ecology and network with intermittent river ecologists and hydrologists across the globe. funds will be provided by this award to form three workgroups on intermittent river hydrology, ecology, and ecohydrology. the hydrology workgroup will seek to generate new tools to characterize intermittent river flow regimes, develop a hierarchical scale-based framework for predicting spatial intermittence patterns, and compare statistical and process-based models for prediction of intermittent river streamflow metrics. the ecology workgroup will synthesize large scale intermittent river bio\*\*diversity\*\* and ecosystem datasets to better understand the structure and function of intermittent river ecosystems. the ecohydrology workgroup will integrate products from the ecology and hydrology workgroups to identify hydrologic controls on intermittent river ecosystems and integrate these findings into our current river conceptual frameworks designed for rivers that always flow. the ir-rcn will improve the management of intermittent rivers by enhancing communication and networking among academic researchers



and nonacademic stakeholders, including government agencies and ngos. datasets, methods, materials and projects produced by the ir-rcn will be made open access on the ir-rcn web portal and deposited in the dryad digital repository for long-term availability, which will broadly impact the global scientific community. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Engaging K-12 Teachers to Help Build a Cybersecurity Workforce Pipeline

Awardee: Forsyth Technical Community College

Amount: \$326,300.00

Abstract: this project addresses a growing need for cybersecurity professionals in the piedmont triad region of north carolina, an expanse of urban and rural communities anchored by the cities of winston-salem, greensboro and high point. the project will focus on bolstering the academic capacity required to expand the talent pipeline of cybersecurity professionals to serve business and industry needs across the 12-county region. local middle school and high school faculty will be enrolled in a 16 credit-hour program at forsyth technical community college (ftcc) that will prepare them to integrate cybersecurity principles into their classrooms. upon program completion, the teachers will have the knowledge and skills they need to be effective teachers of dual-enrolled high school students, which will result in an increase in the number of students who are prepared and motivated to enroll in a two-year program in cybersecurity. the teachers will also be prepared to earn cybersecurity certifications that will qualify them to serve as adjunct faculty at ftcc and will increase the college's capacity to provide post-secondary and workforce-related instruction in cybersecurity.

three goals guide the project team's efforts. first is to increase the number of cybersecurity professionals in the piedmont triad region. second is to increase the number and knowledge level of cybersecurity faculty at the secondary and post-secondary levels. third is to improve the \*\*diversity\*\*

of the cybersecurity workforce in the piedmont triad region. the project expects to see several outcomes from its efforts. one is to enable ftcc to increase awareness of cybersecurity first principles and practices. another is to develop lasting and effective partnerships for innovative cybersecurity education. additionally, the college envisions keeping the talent pipeline filled with well-educated, multi-skilled, work-ready graduates who will be able to help satisfy a projected national shortage of 1.8 million workers by 2022. the project will leverage options available to north carolina educators to seamlessly link dual-enrollment opportunities for high school students with the automatic transfer of credit awarded by community colleges. through project's collaboration with business and industry leaders, teachers will develop deeper insights into the role of cybersecurity across academic disciplines. this project is funded by the advanced technological education program that focuses on the education of technicians for the advanced-technology fields that drive the nation's economy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: OCE-PRF: Cliff Hangers: Investigating Effects of a Submarine Canyon on the Distribution and Behavior of Midwater Animals and their Predators

Awardee: Monterey Bay Aquarium Research Institute

Amount: \$325,738.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). the deep open ocean waters house the largest animal communities on our planet. these communities remain largely understudied but are known to provide critical services including carbon export from the surface ocean into the deep-sea and feeding economically and socially important fish stocks and marine mammals. these midwater animals are the key link between the base of the marine food web and important predators, which rely on finding and exploiting dense prey aggregations. however, relatively little information currently exists about the oceanic

mechanisms or the ecological drivers that shape the distribution patterns of these important prey. submarine canyons are common features along coastlines that link the deep open ocean with the nearshore ecosystem. they are hotspots of both biological and human activity. this project will examine the role of a submarine canyon on the distribution, density, and **diversity** of the midwater community and subsequent impacts on the abundance and habitat-use of top predators with a combination of acoustic, visual, and biologging techniques. this project will support the training of a post-doctoral researcher and support the recruitment and retention of women in stem by providing resources to further the development of a continuous support network for local female-identifying stem community college students transferring to the local public 4-year university. the results of this project will also be shared with the public through a bilingual digital exhibit at the seymour marine discovery center in santa cruz, ca. the deep midwater (200-5000 m depths) is the largest habitat on our planet and represents over 90% of the entire biosphere, yet it is still one of the least understood and most mysterious ecosystems. deep pelagic communities are now known to provide critical ecosystem services including carbon export from the surface ocean with sequestration in the deep-sea and provisioning predators like economically and socially important fish stocks and marine mammals. however, relatively little information currently exists about the oceanic mechanisms or the ecological drivers that shape the distribution patterns of these important mid-trophic level animals. submarine canyons are common abrupt bathymetric features that bring together normally separated deep oceanic and shallow nearshore communities and have profound influences on coastal ocean dynamics and ecosystems. canyons are often hotspots of both primary production and predator activity. this project will investigate the role of submarine canyon bathymetry on the distribution, density, **diversity**, and composition of the midwater community linking these two trophic levels and the subsequent impacts on the abundance and habitat-use of top predators. this project will compare communities at a canyon wall site and at a midwater time series site, identify the oceanographic drivers and mechanisms driving variability in the near-wall community, and determine the relationships between predator distribution and canyon bathymetry

through a combination of acoustic, visual, and biologging techniques. current knowledge of the linkages between deep midwater and shelf communities remains limited, but increasing anthropogenic stressors like fishing, pollution, and climate change demand ecosystem-based solutions fundamentally based on understanding these interconnections. by investigating the mechanisms and drivers of the relationships between bathymetry, oceanographic conditions, deep water pelagic prey, and their predators, this project will help to address this knowledge gap, and the results will have important implications for the management and conservation of groundfishes and marine mammals. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research:SWIFT:Ultra Wideband Flexible MIMO Radios for Energy Efficient Secure Spectrum Sharing

Awardee: Ohio State University

Amount: \$324,999.00

Abstract: worldwide growth in wireless links, navigation, automation, internet of things (iot), and mobile healthcare has challenged spectrum access. in parallel, we are witnessing rapid advances in augmented reality/virtual reality (ar/vr), autonomous driving and vehicle-to-vehicle communications (v2v). further, increased adaptation of unmanned aerial vehicles (uav) may require large swaths of bandwidth and high data rates. indeed, the **\*\*diversity\*\*** of radio spectrum utilization is quickly growing. however, existing wireless networks may no longer be able to keep pace with these technologies, implying a need for new rhythms and targeted innovations. concurrently, security protocols must be adapted to avoid eavesdropping and man-in-the-middle (mitm) attacks. coexistence of active and passive spectrum utilization is another challenge. to address the aforementioned challenges, and to circumvent radio spectrum scarcity, this research brings forward

innovations and features to significantly advance next generation wireless networks. among them: 1) increased throughput using robust spectrum sensing and slicing of legacy frequency bands by identifying gray and white spaces/gaps across the available electromagnetic spectrum; 2) frequency independent and high isolation antenna feeds and rf cancellers to enable spectrum co-existence; 3) wideband autonomous multiple-input-multiple output (mimo) transceivers using flex radio architectures to maximize overall spectral efficiency; 4) significant hardware reduction via multiplexing; and 5) resilience against man-in-the-middle attacks via artificial intelligence (ai) techniques. this project will also foster workforce development in the rapidly growing area of wireless engineering. curriculum enhancements are proposed to integrate new technologies on spectrum awareness, wireless security, and cross layer rf transceiver architectures. further, new degrees and new curricula in wireless and iot technologies will be leveraged to promote stem outreach programs and coordinate outreach activities. the latter will be aimed at recruiting larger cohorts of undergraduates and k-12 students from the local miami-dade and broward counties to be trained in wireless engineering. examples of outreach programs to be leveraged include engineers on wheels, engineering expo, enlace (engaging latino communities for education), and the miami prep (positive youth preparedness) programs. the proposed research aims to develop next generation flexible and secure wireless networking with adaptive rf front ends and back-end cross-layer algorithms that enable spectrum efficiency and high throughput via novel relay architectures, all with end user protection in mind. namely, a new class of low cost and low power secure mimo transceivers with >100 db transmit/receive isolation are proposed along with flexible radio architectures. the following innovations are proposed: 1) ai-based effective spectrum utilization and/or coexistence, 2) innovative transmitter and receiver technologies through cross-layer design, and 3) improved security by detecting man-in-the-middle attacks and other eavesdroppers. notably, the transformative nature of the proposed research stems from the introduced novelties to overcome challenges in developing low-power and low-cost flexible radio architectures and rf electronics with secure data relays to provide resilience for man-in-the-middle attacks. to accomplish the proposed

goals, a strong background is required in the following areas: rf front/back-end hardware, mathematical network modeling, propagation, optimization, control, queuing, stochastic analysis, and legacy system operation integrated through the following thrusts: 1) rf reconfigurability and spectrum aggregation to support users with decoupled phy/mac protocols, 2) adaptive flexradio wireless networks with increased throughput and protection using high performance phy/mac layer algorithm, 3) rf self-interference cancellation for spectrum co-existence, and 4) ai-based models for security and privacy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: DMREF: Microstructure by Design: Integrating Grain Growth Experiments, Data Analytics, Simulation, and Theory

Awardee: Illinois Institute of Technology

Amount: \$324,817.00

Abstract: most technologically useful materials are polycrystalline microstructures composed of a myriad of small monocrystalline grains delimited by grain boundaries. an understanding of the evolution of grain boundaries and associated grain growth (coarsening) is essential in determining the properties of materials across multiple scales. despite tremendous progress in formulating microstructural models, however, current descriptions do not fully account for various grain growth mechanisms, detailed grain topologies and the effects of different time scales on microstructural evolution. as a result, conventional theories have limited predictive capability. the goal of the project is to develop a predictive theory of grain growth in polycrystalline materials through the construction of novel, closely integrated data-driven numerical simulation and mathematical modeling combined with data analytics, analysis, and a set of critical experiments. this interdisciplinary project, requiring the complementary expertise of applied mathematicians and materials scientists, is firmly aligned

with the materials genome initiative. the new knowledge and tools that will emerge from the project will have a profound impact on the performance and reliability of polycrystalline materials used in many technologically useful systems and structures, thereby expediting advanced materials development and deployment. predictive computational algorithms and data will be made available and accessible to other researchers. for the training of the next-generation materials workforce, in addition to mentoring of graduate and undergraduate students, the pis (from columbia university, illinois institute of technology, lehigh university and university of utah) will participate in outreach activities and will continue to work towards increasing **\*\*diversity\*\*** and broadening participation within stem. grain growth is a very complex process and may be viewed as the anisotropic evolution of a large metastable network. one of the main thrusts of the project will be to uncover possible stochastic processes that define the evolution of various statistical measures of grain growth, discover relations among them, and establish links to materials properties. results from structure-preserving numerical simulations alongside critical sets of experiments and new experimental data will be invaluable in navigating the modeling and analysis. the project will also create and employ specific data analysis techniques for the study of dynamic evolution of grains in experimental and computational systems with the goal of validating and further refining the microstructural models. this component of the project, will lead to a) the development of new materials informatics methods, b) innovative stochastic differential equations/differential equations models of grain growth, c) new mathematical and numerical analysis techniques for coarsening systems, as well as d) improved computational tools. in turn, the results of combined data analytics, modeling and analysis will be used to guide the design of subsequent experiments. experimentally, grain growth will be examined in prototypical metallic thin films (pd, ni, cr, fe). as most elemental metals and many metallic alloys have cubic structures, the proposed studies will have broad applicability. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Elucidating the Nature, Causes and Climate Importance of the Mid-Cenozoic Loess in the Western USA

Awardee: University of Texas at Arlington

Amount: \$323,787.00

Abstract: loess deposits consist of fine-grained, windblown sediments and contain critical information about continental aridification processes that are key to understanding biotic evolution and climate change. this project integrates field data collected from loess deposited ~37-30 million years ago in wyoming, nebraska and montana, laboratory analyses, and paleoclimate simulations to understand the nature, causes, and paleoclimatic importance of these loess deposits. the research will advance stem **\*\*diversity\*\*** by supporting a two-day geocamp for historically underrepresented high-school students from east texas. in addition, this project will promote further development of the high-resolution community earth system model to be used to better understand ancient climate changes. this project will include field sedimentological observation and lab analyses of bulk sediment and quartz grain-size, quartz surface morphology, detrital and high-precision zircon u-pb geochronology to study the ancient loess deposits in wyoming, nebraska and montana, usa. these proxy data will constrain the extent, timing, pattern and characteristics of the loess; and determine sediment provenance and sediment recycling mechanisms. these proxy data will be integrated with a coupled atmosphere-land model to simulate changes of regional climate and vegetation induced by topography changes, global climate cooling, glaciation and shoreline regression to understand the cause and climate significance of the loess. in additional to gaining fundamental understanding of the loess deposits, the project will shed light on 1) the influence of climate change on biotic evolution at the eocene-oligocene transition (~34 million years ago); 2) the validity of different models of surface uplift in the western usa; and 3) the potential positive climate feedback of enhanced mineral dust emissions on global cooling at the transition. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's



intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Examining the Role of Racial Identity and Personal Experiences in Equity-focused Computer Science Learning

Awardee: WestEd

Amount: \$323,305.00

Abstract: this project will explore the significance of race and equity in secondary computer science (cs) education. despite the importance of cs across all aspects of life, there is little racial \*\*diversity\*\* in the field along the pipeline from elementary school to industry. at the secondary level, even students who are highly interested and confident in cs remain underrepresented in the field. to address this problem, researchers have created culturally responsive computing approaches to effectively engage more students in cs. however, progress in implementing these approaches is limited by the low number of experienced cs teachers. this project aims to support secondary teachers in developing both subject matter knowledge and racial equity strategies for teaching cs. the first of three goals is to develop a set of professional learning activities that vary in the ways they address cs subject matter and racial equity topics. the second goal is to examine how well each activity engages teachers in learning and talking about cs content, race, and equity pedagogy. the principal investigator will collaborate with an urban school district to deliver the activities during the district's monthly cs teacher meetings. the third goal is to interview teachers to learn how their racial identity and past experiences in cs and in teaching influence their participation in the activities. the project aims to identify the most effective activities for learning about both racial equity and cs subject matter. the outcomes of this project may support other researchers and teacher educators to train more teachers who are equipped to provide equitable cs learning experiences for all secondary students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: REU Site: Research in Behavior Science at West Virginia

Awardee: West Virginia University Research Corporation

Amount: \$323,027.00

Abstract: this project is funded from the research experiences for undergraduates (reu) sites program in the sbe directorate and the established program to stimulate competitive research (epscor). it has both scientific and societal benefits, and integrates research and education. the reu site for research in behavior science at west virginia university provides high-quality research experience and mentorship to students who aspire to be a part of the next generation of behavior scientists. this project aims to foster interest and participation in experimental psychology and expand the **\*\*diversity\*\*** of skilled researchers in behavior science. recruitment is open to nsf eligible undergraduate students as rising sophomores, juniors, and seniors, and this reu site especially encourages applications from undergraduate psychology majors from primarily undergraduate institutions in the appalachian region and students from underrepresented groups within psychology, including individuals from underrepresented racial and ethnic groups (e.g., black, indigenous, and persons of color), veterans, individuals with disabilities, first-generation college students, and students from socio-economically depressed areas. reu participants conduct laboratory research in behavior science with a focus on ?bench science? in behavioral psychology and the translation of basic research to issues of social significance. participation fosters scientific, communication, and collaboration skills. the research projects address questions relevant to several areas in behavior science, including behavioral pharmacology, prevention of relapse and maladaptive behavior, social behavior, and improving the efficacy of behavioral interventions. the findings of these studies contribute to a more advanced understanding of fundamental behavioral processes and technologies of behavior change. the long-term goal of this project is to foster student interest and participation in experimental psychology and expand the **\*\*diversity\*\*** of skilled researchers in

behavior science. the objectives toward meeting this goal include: 1) provide research opportunities to students from primarily undergraduate-serving institutions and students from underrepresented groups, 2) involve students in laboratory research in psychology with an emphasis on experiences that students may not have the opportunity to gain at their home institutions, including bench and translational research in behavioral psychology, 3) improve students' technical research skills, including idea development, research design, technical laboratory skills, and the dissemination of research, and 4) retain participants in the field of psychology by providing relevant experience, support, and encouragement to pursue graduate studies or other post-baccalaureate opportunities within psychology and related fields. each year, a cohort of 8 reu participants work with faculty research mentors from wvu's behavior analysis program in the department of psychology. during the 10-week experience, reu participants attend a 3-day training, conduct a research project with their mentor, attend research meetings, participate in a weekly seminar and a physical computing workshop, attend multidisciplinary workshops, and present at a research symposium. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: LTREB Renewal: Long-Term Dynamics of Amphibian Populations Following Disease-Driven Declines

Awardee: University of California-Santa Barbara

Amount: \$321,586.00

Abstract: this project will examine the processes of invasion of a novel pathogen into a population for the case of a fungal pathogen that causes the disease chytridiomycosis in frogs and salamanders. outbreaks of emerging infectious diseases are increasingly recognized as major threats, not just to human populations but also to wildlife, and they increasingly threaten global bio\*\*diversity\*\*. the initial invasion of a novel pathogen into a susceptible host population can cause

a disease outbreak resulting in high levels of mortality and declines in population size. when this happens, natural selection can occur for both the host and pathogen populations resulting in evolutionary changes in the host's susceptibility and tolerance to infection by the pathogen and the pathogen's ability to damage the host (virulence). these changes can in turn determine whether the host population can persist and recover from the disease. understanding these evolutionary processes is crucial in development of conservation strategies for threatened species. chytridiomycosis has had catastrophic effects on amphibians worldwide, and has been linked to numerous species extinctions in recent decades and many more species at risk. the researchers will investigate the patterns of evolutionary change in both the pathogen and the host (mountain yellow-legged frogs), following the invasion of the disease into hundreds of high elevation lakes in the california sierra nevada. this project will contribute to the understanding of the role of infectious diseases, such as chytridiomycosis, as agents of evolutionary change in natural populations. it will provide critical information to state and federal agencies, facilitating endangered species recovery and will train and educate undergraduates, graduate students, and the general public. this research builds on data from a long-term study of the population dynamics of mountain yellow-legged frogs (*rana sierrae* and *rana muscosa*) in the complex landscape of the california sierra nevada, and the affects of *batrachochytrium dendrobatidis* (bd) as it has invaded and spread through hundreds of frog populations. in most cases, invasion of bd results in outbreaks of the disease chytridiomycosis, rapid frog population declines, and local extinctions. in some cases, long-term persistence of frog populations occurs with bd in an enzootic state in which the impact of the pathogen is greatly reduced. the research will extend and leverage 25 years of host population and disease data and archived genetic samples from *r. sierrae*/*r. muscosa* and bd. these resources will provide insight into how populations of both host and pathogen change during the transition from pre-pathogen arrival, to disease outbreak, to enzootic disease, to potential recovery of the pre-disease host population abundances. this dataset will be used to investigate the genetic basis for differences in host resistance/tolerance and pathogen virulence. cutting-edge genomic analysis

of existing frog and fungal samples will complement laboratory experiments on bd virulence and frog susceptibility using bd cultures and frog mucosal samples from wild host populations. continued surveys of wild host populations will identify new disease outbreaks and describe the transition from initial outbreak to persistent enzootic state. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Exploring mechanisms of plasticity and tolerance in early stage marine invertebrates in response to marine heatwaves

Awardee: University of California-Santa Barbara

Amount: \$321,379.00

Abstract: marine heatwaves (mhws) ? prolonged periods of unusually warm surface seawater temperatures - have increased in intensity and frequency in us coastal waters. recent mhws on the us west coast have resulted in changes in species distributions, loss of bio\*\*diversity\*\* and closed fisheries due to harmful algal blooms. as the frequency of mhws increase, these events will continue to impact natural marine ecosystems and important resources from the ocean (e.g., fishing and aquaculture). the goal of this project is to better understand how mhws will affect coastal marine communities like kelp forests. a key missing piece of information is how early life-history stages, the stages that disperse and maintain healthy populations of marine organisms, fare in response to these anomalously high ocean temperatures. this project is investigating the response and resilience to mhw stress in embryos and larvae of two key marine invertebrates, the red and purple sea urchins that inhabit the kelp forests of coastal california. the red urchin is a valuable fishery (the roe is sold as uni) and data from this project is contributing to the management of this natural resource. lastly, the project is training early career researchers, undergraduate and graduate students with a focus on broadening participation in the fields of science and technology. the broader impacts are

providing research experiences and mentoring to under-represented undergraduates at uc santa barbara, a hispanic-serving institution since 2015. the project directly supports the phd dissertation research of three women ph.d. graduate students from under-represented groups. this project aims to understand the consequences of anomalously high temperatures during mhw events on reproduction and early development of marine organisms. in the coastal california system, marine invertebrates of the kelp forest ecosystem are reproductive when mhws tend to occur and intensify. the major goal is to examine how maternal and paternal effects, that play out in a mhw context, influence the thermal tolerance of early developmental stages of two sea urchin species from the temperate kelp forest communities of coastal california, the purple (*strongylocentrotus purpuratus*) and red (*mesocentrotus franciscanus*) sea urchins, the latter being an important wild fisheries species. this project is addressing climate-change relevant aspects of larval ecology and is examining how phenotypic plasticity contributes to adaptive capacity of marine organisms. a series of traits are being assessed for each species: (1) fertilization kinetics, (2) successful developmental progression, (3) thermal tolerance (via thermal tolerance trials and biochemical indices of thermal stress), and (4) parental effects. gene expression using rna sequencing is capturing the influence of maternal effects to address whether females that experience mhw temperatures in situ during gametogenesis produce progeny with greater thermal tolerance via changes of the larval transcriptome. this project is jointly funded by the biological oceanography and integrative ecological physiology programs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Audio for Inclusion: Uncovering Marginalized Student Narratives to Provide Insight to Faculty on the Known Unknowns of Inclusion

Awardee: Florida International University

Amount: \$320,642.00

Abstract: this project will bring the experiences of diverse engineering students directly to faculty through edited audio interviews. undergraduate engineering education is a critical juncture in the diversification of the engineering workforce. however, engineering educational culture can marginalize many groups. faculty are key change agents in this culture, and their empathy and understanding for diverse students are critical for enabling and promoting inclusive education. however, faculty may not be aware of diverse student perspectives, and even well-intentioned faculty may fall short of creating inclusive classroom environments. more resources are needed to help develop faculty empathy and understanding for a broad range of student populations in engineering education. qualitative research presents a promising tool for centering the voices and experiences of students, but researchers' typical long form journal publications for disseminating qualitative research are not an accessible and compelling medium. to increase collective impact, more accessible, innovative, and timely dissemination strategies are needed. podcasts and youtube clips can be used to disseminate research findings with more immediacy and personalization than written text. this study will feature these audio formats as media to share diverse student experiences with faculty and to facilitate a broader impact on pedagogy and culture. faculty who listen to the audio will have the potential to gain reflective awareness of student experiences that provoke the creation of more inclusive classrooms. this novel dissemination approach will be sustained through the creation of a widely distributed podcast called audio for inclusion, hosted by the pis. this podcast will include the final versions of edited audio files generated in this study and will be located on the asee \*\*diversity\*\* committee's web and youtube pages, and incorporated into workshops. the project will conduct a nationwide recruitment of students with salient minoritized identities via email distributed through relevant organizations, campus support centers, and snowball recruitment. twenty (20) students will be interviewed twice throughout the duration of the study using a semi-structured protocol that focuses on their experiences in engineering education. interviews will be transcribed, de-identified, edited for conciseness, and re-recorded by student actors. recorded

interviews will be disseminated using a survey distributed to 100 faculty members who represent a range of familiarity with **diversity** and inclusion topics. this survey will prompt faculty participants to listen to embedded student narratives and provide feedback using likert-type and open-ended response questions. survey results will be used to observe the impact of the audio resources on faculty views of **diversity**, equity, and inclusion in engineering. this project will be informed by existing theoretical frameworks such as intersectionality, figured worlds, narrative, and critical theorizing. findings from this work will contribute to the knowledge base on broadening participation in engineering in three ways: (1) by providing insights into the experiences of students belonging to minoritized identity groups; (2) by developing an accessible resource for improving faculty knowledge of and strategies for promoting the inclusion of students? undisclosed identities and experiences in engineering education; 3) by establishing a novel research approach to broaden participation in engineering; (4) by employing innovative dissemination techniques that expand the impact of student participant voices; and (5) by contributing to evidence-based foundations for the future development of faculty-centered support structures related to expanding concepts of **diversity** and inclusion. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Fast and Accurate Statistical Learning and Inference from Large-Scale Data: Theory, Methods, and Algorithms

Awardee: University of Pennsylvania

Amount: \$320,000.00

Abstract: this project will develop statistical methods for analyzing large datasets. such massive datasets are emerging as an important challenge in many areas of science, engineering, and business. the research will pursue a multi-pronged approach to addressing several fundamental



questions in the analysis of such datasets, focusing on three key areas. the first one is sketching and random projections, which is a powerful randomized approach to data analysis used when the data must be analyzed on a single machine. the second area is distributed statistical learning and inference, where datasets are spread across multiple locations, with limited communication among them. the third is model retraining, where statistical or machine learning models must be updated efficiently after data has been added or deleted from the original training set. in addition, the project will have a significant educational component, with the pi developing a new course on statistical machine learning. this project will also train a graduate student. the pi is committed to **diversity** and inclusion, including women and underrepresented minorities in all aspects of the project. the methods developed for the project will be made freely available as software, which will allow others to directly use and benefit from the results. in the area of sketching, the project will leverage powerful tools from asymptotic random matrix theory and free probability to analyze fundamental problems, such as regression and clustering. in the area of distributed learning, the pi plans to develop and analyze statistical methods for distributed learning via gradient based optimization. for model retraining, the pi aims to study the connections between retraining and conformal prediction, with the goal of developing improved and broadly applicable methods for predictive inference. on a technical level, the work will involve advanced tools from probability theory, such as random matrix theory, as well as tools from numerical optimization. by carefully analyzing computational aspects of large-scale statistical analysis, the work will aim to bridge gaps between the statistical and computational perspectives. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Boron in soil carbonates: developing a quantitative soil CO<sub>2</sub> proxy

Awardee: William Marsh Rice University

Amount: \$319,659.00

Abstract: rising atmospheric carbon dioxide (CO<sub>2</sub>) levels pose a global challenge. understanding and preparing for the future impacts of rising CO<sub>2</sub> requires us to look into the past at times periods during earth's history when atmospheric CO<sub>2</sub> levels were higher than they are today. this observational approach is crucial to help test and improve models that are used to project scenarios for the future. this project is aimed at improving the ability to quantify atmospheric CO<sub>2</sub> levels of the past. the proposed improvement involves measurements of boron (B) levels and isotopic abundances in calcium carbonate minerals formed in ancient soils. established theory predicts that B in soil carbonates is sensitive to the abundance of CO<sub>2</sub> belowground in soil pore spaces, which is the most uncertain input into an established and longstanding paleo-CO<sub>2</sub> proxy or indicator. this project will test that theoretical predication with laboratory experiments and studies of natural, modern soils. during the course of the project, undergraduate students from groups underrepresented in the sciences will be mentored through a series of established programs including the research traineeship experience and an NSF research experiences for undergraduates project at UT Austin and Rice University. multiple recruiting efforts will also be initiated to help improve diversity in undergraduate geoscience programs, including cooperation with the OnRamps program at UT Austin and with regional magnet schools that have a high ethnic diversity within the student population and/or high percentage of underprivileged students. the chemistry of fossilized soils, or paleosols, can record quantitative information about ancient climates and ecosystems. in particular, the carbonate minerals that form within some modern and ancient soils have been targeted for analysis as they are thought to record the composition of soil water and gas in ways that permit the determination of ancient atmospheric pCO<sub>2</sub> among other variables. however, critical uncertainties in the "traditional" soil carbonate based proxies (e.g., <sup>13</sup>C/<sup>12</sup>C ratios) fundamentally limit understanding of past environments and motivates the development of new proxies --- such as the work on B isotopic ratios (δ<sup>11</sup>B) proposed here -- that provide complementary, but orthogonal constraints on soil chemistry and, potentially, atmospheric CO<sub>2</sub>. the aqueous speciation of B is pH-dependent

and, all else held constant, the pH of soils is a function of soil  $pCO_2$ . So, the  $\delta^{11}B$  of soil carbonates may record information about soil gas that is independent of C isotopic ratios such that, together, they strongly constrain ancient atmospheric compositions and the ecosystem response to C cycle perturbations. As a proof-of-concept, investigators' new measurements of Eocene paleosol carbonates show a decrease in  $B/CA$  and  $\delta^{11}B$  values during the hyperthermal event ETM2. The directionality of these changes are entirely consistent with an increase in soil (and atmospheric)  $CO_2$ . To advance an accurate and quantitative interpretation of these data, they propose to develop new theory for B cycling in soils as well as validate it using experiments and field observations. Critically, their approach will address alternative (to soil  $pCO_2$ ) controls on soil carbonate  $\delta^{11}B$ , such as weathering and biotic cycling, that might confound interpretations of  $CO_2$  change. The proposed work involves microanalytical imaging and analysis of soil carbonates, development and testing of protocols for B isotopic analysis of soil carbonates, soil sorption experiments, precipitation experiments, and the study of B chemistry across soil  $CO_2$  gradients in nature: vertical within individual soils, horizontal across landscapes (climosequence), and temporal (seasonal variation). They will use surface complexation modeling to help interpret experimental and empirical results. The proposed work also involves development of reactive transport models to investigate the effects of biota and weathering on B chemistry in floodplain soils, including the merging of surface complexation models with existing floodplain landscape evolution models. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: OCE-PRF: Understanding substrate mobility as a disturbance in hard rock marine communities

Awardee: University of Washington

Amount: \$319,295.00

Abstract: this award is funded in whole or in part under the American Rescue Plan Act of 2021 (public

law 117-2). human actions impact marine ecosystems in a variety of ways, including shifting wave and current dynamics through global warming and altering the composition of the ocean floor. these changes, in turn, affect the location and distribution of marine communities. for soft-sediment communities, such as sandy beaches, the interaction between fluid forces and sediment disturbance is well understood. this allows scientists to measure sediment mobility and to create detailed predictions of the impact of human activities on these ecosystems. to date there are no measurements analogous to sediment mobility available for marine hard rock ecosystems. this research will investigate a potential measurement system which connects the forces of waves and currents to the resulting erosion of hard rock substrates and will test and evaluate how these disturbance patterns govern the distribution of communities themselves. by developing and testing this substrate mobility metric, this research will open new avenues of investigation for core ecological hypotheses. in addition, this work will allow managers, conservationists, and engineers to better predict the impact of human-generated change on hard rock marine communities. this project will also support the training and education of groups underrepresented in the geosciences through (1) field and data analysis experience via research experiences for undergraduates summer programs, (2) professional development via mentoring relationships between the fellow and undergraduate trainees, and (3) the expansion of their professional network via cross-institutional coordination. disturbance, including fluid forces via waves on rocky shores, is well understood as a community organizing and structuring force. foundational concepts within ecology, such as connell's intermediate disturbance hypothesis and menge and sutherland's competition/predation/disturbance model, recognize that communities exist within a complex mosaic of physical and biological disturbance. this mosaic presents challenges when measuring disturbance regimes since the scales, causes, and consequences of disturbance vary between systems. however, in the marine environment, substrate mobility represents an explicit measure of disturbance impact present across marine ecosystems. this project will determine how to measure substrate mobility on hard substrates through collaboration with usgs geologists. in addition, this

research will investigate a mechanism for disturbance via substrate mobility on benthic organisms through lab experiments and use field surveys to compare patterns of substrate mobility with the distribution of benthic communities and species functional groups. explicitly quantifying the realized movement of hard substrate in response to fluid forcing integrates hard substrates into the already well understood sediment disturbance paradigm. this results in a universal framework of marine disturbance that is potentially revolutionary as it allows for comparative questions spanning a huge **\*\*diversity\*\*** of marine ecosystems, from coral reefs to the abyssal plain. this mechanistic framework provides a new connection between the disciplines of geomorphology and marine ecology. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Applying Student Knowledge for Success in Cybersecurity and Data Science

Awardee: Union County College

Amount: \$318,925.00

Abstract: this project will contribute to the national need for well-educated scientists, mathematicians, engineers, and technicians by supporting the retention and graduation of high-achieving, low-income students with demonstrated financial need at kean university, the new jersey institute of technology, fairleigh dickinson university, brookdale community college, and union county college. in particular, it responds to areas of national need in cybersecurity and data science by increasing the number of students graduating in computer science (cs) and information technology (it). moreover, the project will build regional workforce strength and contribute to the knowledge base on the role of student competence and belonging in ensuring persistence to degree attainment. over its five-year duration, a total of 256 students will benefit, receiving scholarships to complete cs or it degrees. project components include scholarship support for students, undergraduate research and/or professional experience opportunities prior to graduation, and

generation of new knowledge through research on economic realities for students and impact on career trajectories in cybersecurity and data science. students in this program will be prepared to enter the scientific workforce or graduate school as competent, highly trained individuals with a background in teamwork and research. furthermore, they will contribute to increased professional **\*\*diversity\*\*** in the fields of cs and it, and serve as role models to members of their communities.

the students recruited for this program will participate in workshops, take advantage of cohort experiences, and interact closely with faculty who will provide i) academic advising, ii) guidance for navigating higher education and postgraduate opportunities, and iii) supervision of teamwork, research, and working professional experiences. through undergraduate research opportunities and experiences from participation in faculty research programs and/or existing summer research and internship programs, these individual and cohort experiences will provide a basis for overall intellectual growth and promote increased student confidence, retention, and timely degree completion. these academic outcomes are in turn expected to allow students to successfully navigate common attrition points including financial hardship and professional identity development for post-graduate employment and continued education. the project's academic environment includes student-faculty advising and undergraduate research activities, using the affinity research group (arg) model and peer-mentoring. the use of teamwork, collaboration and student-motivated question and answer sessions will positively support research in the field of computer science and information technology regarding educational impact and retention, particularly for minorities, female, and first-generation students. this project is funded by nsf's scholarships in science, technology, engineering, and mathematics program, which seeks to increase the number of low-income academically talented students with demonstrated financial need who earn degrees in stem fields. it also aims to improve the education of future stem workers, and to generate knowledge about academic success, retention, transfer, graduation, and academic/career pathways of low-income students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review

criteria.

Matched Words: diversity

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Title: GP-UP: RUI: ENHANCING UNDERREPRESENTED MINORITY PARTICIPATION IN STEM AND THE APPLIED GEOSCIENCES THROUGH INTEGRATED EXPERIENTIAL ACTIVITIES

Awardee: University of Wisconsin-Eau Claire

Amount: \$315,000.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). society is facing significant environmental challenges, including climate change, water scarcity and contamination, resource depletion, major changes in global energy production, and the long-term ecological impact of population growth. mitigation of these issues requires a diverse, globally-integrated professional workforce with a strong background in applied geosciences. to meet the need for more geoscientists, the field must broaden its search for future geoscientists by purposefully recruiting individuals from historically excluded groups. the primary objective of this program is to recruit, train and foster career success among individuals from these groups in western wisconsin and minnesota. this program establishes a progressive, multi-phase intentional educational pathway designed to maximize student engagement and retention in the geosciences through high-impact practices, hands-on learning, and dedicated mentorship. the bridge program is a week-long summer institute in applied geoscience based at the university of wisconsin-eau claire that will use inquiry-based activities in the natural setting of the upper midwest to introduce prospective undergraduate students to the relevance of the earth sciences and potential geoscience careers. this program has the potential for long-term, significant enhancement in the \*\*diversity\*\* of the department of geology and the university through the establishment of pipelines between uw-eau claire and regional high schools serving students from historically excluded populations. the proposed pathway entails 1) recruitment of high school juniors into a summer bridge program; 2) matriculation to uw- eau claire; 3) participation in a foundational research experience immediately

prior to their 1st year of college; 4) a college experience characterized by intentional peer and faculty mentoring and high-impact practices, and 5) career development. the project will directly involve at least five department faculty and staff, including an early career female geoscientist, eighteen (18) undergraduate students, and a number of uw-eau claire co-curricular staff over a three-year period. this team will work with ~54 high school students and ~9 high school science teachers from western wisconsin and eastern minnesota during the project. importantly, the strong equity, **\*\*diversity\*\***, and inclusivity framework at uw-eau claire will be leveraged to continue this outreach program beyond the life of the grant. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: GP-UP: Building Opportunities through Networks of Discovery in the Geosciences (GEOBOND)

Awardee: California State University-Fresno Foundation

Amount: \$315,000.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). fresno state and the state center community college district serve the agriculturally-rich, ethnically-diverse, and socio-economically disadvantaged san joaquin valley of california, providing critical educational pathways for geoscience majors and careers. this project will strengthen professional networks and streamline student pathways within the san joaquin valley, which has been affected by severe air pollution, drought and water contamination issues, and climate change impacts, all of which disproportionately impact socio-economically disadvantaged communities. pis plan to implement a student support system, along with community-based problem solving curriculum, and undergraduate research experiences that cross institutions. the project aims to increase the number and **\*\*diversity\*\*** of students entering and graduating from undergraduate



geoscience majors in order to support an innovative and committed geoscience workforce that can tackle environmental justice challenges in the san joaquin valley and beyond. building opportunities through networks of discovery in the geosciences (geobond) is a collaboration between fresno state (four year college) and multiple local two-year colleges to create a novel student support system for undergraduate geoscience students that accommodates the various pathways through which they join the program at fresno state: first-time freshmen, change of major, and transfer students. the project involves three-mutually reinforcing activities:1) developing an undergraduate geoscience learning community cohort program that includes a connected sequence of courses, co-curricular professional development activities, and scaffolded research experiences; 2) forming a professional learning community to collaboratively re-design geoscience courses across partner institutions that incorporate environmental justice themes and evidence-based teaching strategies; and 3) establishing a community-based research program to investigate local environmental issues in collaboration with community organizations and geoscience professionals. the proposed project will advance knowledge about which strategies are most effective for recruiting and retaining undergraduate students and creating inclusive environments in the geosciences that are attractive and supportive to students from groups that have been historically excluded in stem. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: GP-GO: Integrating Spatial Literacy into Geoscience: Bridging the gap between education and workforce in the U.S.

Awardee: Bowling Green State University

Amount: \$314,987.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). by focusing on recruitment and retention of students from historically excluded

communities, the educational-research program spatial literacy - splitgeoscience provides an effective method of increasing **\*\*diversity\*\*** in geoscience, while strengthening obligations to society and broadening intellectual values in stem research. through a combination of workshops, hands-on training, field experience, and internship placement, the program emphasizes partnerships between academia, industry, and multicultural organizations to connect undergraduate and graduate students to future employers and to the scientific community at large. the program integrates geoscience and geospatial literacy with the socioeconomic needs of local communities across the united states, and thus, contributes to understanding geoscience-related challenges across the nation. the geospatial component of the program supports the urgent demand of the u.s. government and industry to prepare the next generation of skilled geoscientists to handle serious problems, such as the effects and mitigation of natural disasters, that are crucial to national welfare and security. this interactive approach attracts students and sparks their research curiosity and critical thinking. the splitgeoscience program is a three-year program proposed by bowling green state university in collaboration with central state university, the university of louisiana at lafayette, idaho state university, and americaview, a consortium of more than 40 universities. the project leverages innovative hands-on learning and field experience using the most sophisticated satellite- and drone-based technologies, plus internship opportunities, to satisfy two goals: 1) encourage and strengthen the geoscience professional development of students from historically excluded communities and facilitate their school-to-work transition using effective recruitment and retention strategies; and 2) elevate the status of career-related pathways of these students by becoming well-rounded and ready-for-job-market professionals. the program consists of two major components: 1) a series of intensive on-site hands-on learning events allowing insights into real-world geoscience problems using the most recent geospatial techniques learned from experts; and 2) a work placement program for university students established with industry, universities, and government. the ability to process and analyze spatial data to confront pressing geoscience and environmental issues is becoming the fundamental form of literacy for experts in geoscience, which

is a fast-growing interest of government, academia, and industry. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Exploring the interplay between form and function: the force-velocity trade-off in the spider predatory strike.

Awardee: University of Maryland, College Park

Amount: \$314,640.00

Abstract: spiders are important predators of insects and other small animals, and the group has nearly 50,000 described species. they are one of the most diverse and numerous groups of animals and occupy a wide variety of habitats; spiders also play an essential role in controlling pest populations. while great advances have been made in understanding how spiders use silk and venom to capture prey, very little is known about the main feeding structures of spiders, the chelicerae. these in some respects function like jaws of vertebrates since they are used to grasp and process prey. this research focuses on how the chelicerae are used during the predatory strike, when the spider grasps the prey and injects it with venom, and how the shape, speed and strength of chelicerae vary in different groups of spiders. the researchers will compare the anatomy and movements of chelicerae in a wide variety of spiders to better understand the evolution of feeding in the group. this work will also examine details of the super-fast predatory strike, found in certain types of spiders, and determine how it evolved. in addition to revealing the function and evolution of spider chelicerae, the project introduces spider biology to the next generation of scientists, with outreach to several groups ranging from high-school students to postdoctoral scholars. results from this research will also be used to engage and educate the public, including school-aged children, through hands-on lessons that will be displayed at the national museum of natural history and used in a summer day camp at the university of maryland. this research focuses on the comparative

functional morphology of spider chelicerae, and tests the hypothesis that a fundamental biomechanical principle, the force-velocity trade-off, explains the diversification of their morphology and predatory strike dynamics. it is widely assumed that lever-based skeletomuscular systems are optimized to produce either high forces or high velocities, but not both simultaneously. predictions of the force-velocity hypothesis will be tested using a broad sample of species from across the spider tree of life, including the "trap-jaw" spiders, some of which have predatory strikes that are the fastest movements known among arachnids. structural details of the exoskeleton and musculature will be quantified through analysis of computed tomography scans and histological sections, and functional performance variables such as strike velocity will be measured through analysis of high-speed videos. a molecular phylogeny will be generated and used to provide the historical framework for examining the evolution of morphology and strike performance. phylogenetically-informed statistical analyses will be used to determine whether the correlations between form and function anticipated by the force-velocity trade-off are consistent with the biomechanical "diversity" observed in spiders. the results will offer insights into the evolution of form and function in skeletomuscular systems and provide a rich source of new information on spider biology. this award is co-funded by two programs in the directorate for biological sciences, the systematics and bio"diversity" science program in the division of environmental biology, and the physiological mechanisms and biomechanics program in the division of integrative organismal systems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: GP-UP: Increasing representation and success of African Americans in the geosciences

Awardee: Jackson State University

Amount: \$314,421.00

Abstract: this project is jointly funded by geo golden and the established program to stimulate

competitive research (epscor). careers in the geosciences are expected to grow by 50% above the average job growth rate in the us over the next 10 years, with some subfields experiencing more than double the average growth rate. at the same time undergraduate enrollment within these fields has remained relatively flat or even slightly decreased in recent years, leading to a shortage of trained geoscientists. furthermore, while recent efforts to increase **\*\*diversity\*\*** within stem have been met with success in some fields, **\*\*diversity\*\*** within the geosciences has lagged behind, with geosciences having the lowest levels of inclusion among groups traditionally underrepresented in stem fields; and, among these groups, african americans remain among the least represented making up less than 1.5% of geoscience doctorates awarded in 2018 (national center for science and engineering statistics, survey of earned doctorates). this project aims to increase recruitment, improve long-term student success and persistence, and enhance post-graduate placement of african american students, through increased exposure to potential geoscience careers, multidisciplinary research experiences, skill-building workshops, networking, and faculty-mediated career planning at jackson state university (jsu), the nation's 10th largest historically black college/university. this project will provide a pathway focused on marine science, environmental science, and earth systems science undergraduate degree programs. it aims to increase enrollment, retention, and persistence of urm in the geosciences by: 1) increasing awareness of potential geoscience careers through a robust seminar series, 2) enhancing preparedness through faculty-mediated career planning and application assistance 3) expanding acquisition of relevant experiences through independent research and skill-building workshops. even with focus on a targeted cohort, most of the activities in this program will be open to all jsu students including: 1) a weekly seminar series that will include invited speakers highlighting potential careers and areas of research in the geosciences, 2) a series of workshops focused on building general research skills (e.g., data analysis and visualization, gis/remote sensing, writing research papers) and the generation of professional documents (e.g., curriculum vitae, resume, personal statement, research statement, cover letter) relevant to career advancement, and 3) seminars focused on identifying and

applying for summer research opportunities or internships, as well as post-graduate programs, in the geosciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Securing the AI Stack in Autonomous CPS under Physical-Layer Attacks: A Systems Perspective

Awardee: University of California-Irvine

Amount: \$312,787.00

Abstract: recent years have witnessed a massive surge in real-world development and deployment of autonomous cyber-physical systems such as autonomous driving cars and delivery drones/robots. to achieve high-level autonomy in complex environments, the artificial intelligence (ai) stack plays a central role, a type of "brain," which makes them highly security-critical. prior works have studied adversarial attacks against ai algorithms used in autonomous cyber-physical systems, but mostly focus on the ai algorithm-level security properties in complete or partial isolation of the physical context. as these algorithms are only components of the entire system, however, it is both more practically meaningful and effective to study and address their security problems from a systems perspective, especially when under the more general and fundamental physical-layer attack model. this project aims to create a suite of systematic methodologies, solution frameworks, and platforms that can achieve system-level security analysis and defense designs for the ai component of autonomous cyber-physical systems under physical-layer attacks. with the growing deployment and commercialization of autonomous cyber-physical systems in the real world, success in this should directly benefit the safety of everyday lives. this project consists of two research thrusts to cover both the attack and defense sides of the proposed system-level security research. first, to enable system-level security analysis, this project will develop novel system-to-ai and ai-to-system mapping methodologies, by overcoming various design challenges such as systematically

maintaining physical realizability and semantic equivalency in physical-layer attack generation, and effectively accommodating the **\*\*diversity\*\*** of real-world system designs and implementations. second, to develop system-level defense designs, this project will systematically identify and leverage novel design opportunities from both individual system and the operation ecosystem perspectives, including new classes of physical invariants, novel attack-resilient sensor fusion designs leveraging system-level properties, and novel designs that leverage other participants in the operation ecosystem and infrastructure support. this project will also develop a simulation-based evaluation platform with uniform and extensible attack and defense development support, which will be used to facilitate both research and education of autonomous cyber-physical system security. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: REU Site: CAS: Research Experiences for Undergraduates in Sustainable Chemistry and Catalysis at Arizona State University

Awardee: Arizona State University

Amount: \$312,000.00

Abstract: this research experiences for undergraduates (reu) site award to arizona state university, located in tempe, arizona, supports 8 students for 10 weeks of research and professional development during the summers of 2022-2024. in this program, supported by the division of chemistry, participants will have the opportunity to design and apply 'green chemistry' transformations in the fields of organic chemistry, inorganic chemistry, materials chemistry, and biochemistry. the participants will be introduced to leading practices in sustainable chemistry and catalysis, take part in professional development workshops to enhance graduate school and industrial career preparedness. reu students at this site will have the opportunity to network with scientists pursuing a variety of career paths. this project aims to broaden stem participation by

encouraging students to consider how chemical research can lead to positive environmental outcomes. in this reu program, students will participate in individual research projects that focus on sustainable chemistry. topics include the development of new base metal catalysts for coupling and c-h functionalization reactions; the computational screening of environmentally friendly solvents; the use of enzymes for hydrogen evolution and halogenation catalysis; and the development of sustainable methods for the preparation of inorganic materials. notably, these projects will be explored within shared laboratory space, allowing for team-based mentoring and collaboration. workshops on sustainable chemistry research, scientific writing, presentation skills, and networking will be offered alongside team-building activities. project mentors will maintain contact with students through virtual meetings and seminars following conclusion of the program. to increase **\*\*diversity\*\*** within the chemistry workforce, this site also aims to recruit underrepresented students from local community colleges and tribal colleges throughout the southwestern united states. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: OCE-PRF: Determining the depth of fluid infiltration in slow and ultra-slow spread oceanic crust

Awardee: University of Wyoming

Amount: \$310,285.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). dr. benjamin urann has been granted an nsf oce prf to work alongside drs. barbara john and j. michael cheadle in the dept of geology & geophysics at the university of wyoming. the goal of this project is to evaluate the depth to which seawater penetrates ocean crust, and whether seawater penetration depth varies with tectonic plate spreading rates across different ocean basins. research products will promote a deeper understanding of earth system processes including



subduction and the interaction between the hydrosphere and deep earth. in addition, this work will help to constrain the habitability of deep ocean crust for microbial life, which relies on delivery of organic and inorganic carbon by circulating hydrothermal fluids. science outreach and education will be a central tenet of the project and involve: (1) outreach with uwyoming office of **\*\*diversity\*\***, equity and inclusion to promote stem and geoscience for underrepresented groups (2) community lectures, both online and in person, including at the wind river indian reservation (3) creation of a uwyoming geological museum exhibit on the generation of ocean crust, hydrothermal vents and the biological **\*\*diversity\*\*** of the seafloor. deep-seated faults expose mantle peridotite and lower crust across broad expanses of seafloor (more than one third of all spreading ridges globally) at slow and ultra-slow spreading ridges. abundant mylonites suggest that these faults must root below regions of earthquake activity, however the depth at which these shear zones initiate remains unknown. these faults act as fluid conduits, yet little is known about the depth to which seawater infiltrates the mantle lithosphere. the pi will investigate the geochemical and textural characteristics of a suite of rock samples from several mid-ocean ridge localities (mid-atlantic, southwest indian, mid-cayman and gakkel ridges) to understand: (1) the depth to which seawater penetrates exposed mantle peridotite along faults, (2) if seawater penetration depth varies with plate spreading rate, (3) the effect of seawater intrusion on global volatile (h<sub>2</sub>o, f, cl, c) cycles and (4) the implications of deep seawater intrusion on the habitability of deep ocean crust. the pi will measure volatile abundances and b isotopes by secondary ion mass spectrometry, in conjunction with petrologic and geochemical thermobarometers and phase equilibria modeling to constrain seawater penetration depths. taken together, this project will provide novel insights into lithosphere-hydrosphere interaction and place some lower bounds on the habitability of the deep lithosphere. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: RI: Medium: Robust Perception through End-User Adaptation

Awardee: Ohio State University

Amount: \$310,000.00

Abstract: for an intelligent system (such as a robot or a self-driving car) to enter end-users' daily lives in a safe and reliable way, the system must generalize beyond the development laboratory to uncontrolled environments where it will be deployed. for instance, a self-driving car may be built and optimized for sunny weather but may be driven by the user in icy or snowy conditions. the state of the art in machine learning and perception cannot generalize or adapt to this sheer **\*\*diversity\*\*** of deployment scenarios. this project seeks to address this challenge by leveraging the fact that people are creatures of habit and tend to use their devices consistently and repeatedly in specific ways (for example, they drive their cars repeatedly over a small set of routes between their home, office, and the marketplace). such repetitive usage provides ample opportunities for the intelligent system to adapt itself to the end-user's specific circumstances, no matter how challenging or different they are. this project builds upon this insight to design robust perceptual systems that will adapt to a diverse array of real-world challenging settings, including self-driving cars in different driving locations and various time and weather conditions. guaranteeing that an intelligent system can operate reliably

across such diverse settings is necessary to unlock the societal benefits that researchers in machine learning, computer vision, and robotics are striving to achieve. beyond the research community, the project will contribute to education by training undergraduate and graduate students and by outreach to high-school students through workshops and summer programs, especially to benefit underrepresented minorities. this research project investigates the design and development of robust perceptual systems through adaptation, by exploiting a specific and well-known property of end-users: humans are creatures of habit and tend to operate devices in specific ways and environments repeatedly and consistently. for example, most people drive their cars primarily along the same routes every day. in particular, the investigators explore three key ideas: (1) adapting the perceptual system by recording sensory input during usage, generating highly reliable pseudo-label annotations that incorporate physical constraints and cross-sensor consistency, and fine-tuning the system while it is offline via dual-task co-adaptation; (2) personalizing the system through repetition, by aligning playbacks over time to leverage deep neural networks' ability to memorize and by augmenting data for diverse settings through label propagation across recordings; (3) verifying adaptation by developing methods to detect and remove noisy labels using learning dynamics and active user verification. these three research aims will be complemented by a comprehensive evaluation plan to include multiple existing self-driving data sets, a newly collected data set by the team of investigators that captures diverse environments along a repeated route, and navigation in home robot scenarios. this research effort towards a much larger, more challenging adaptation problem will open the door to novel solutions in the intersection of computer vision, machine learning, and robotics, including but not limited to reasoning about physics, modeling the relationships between rich perceptual tasks, adapting to changing output distributions, and leveraging patterns in the provenance of the data itself. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Toward lifelike synthetic cells via engineered control of DNA replication

Awardee: Arizona State University

Amount: \$309,665.00

Abstract: the ability of cells to reliably replicate and maintain genomic information is a key facet of life. recapitulating these mechanisms is a critical step towards the development of autonomous synthetic cells that exhibit self-replication and stable propagation of their genetic information. to that end, this project creates a new synthetic mechanism for dna replication control in synthetic cells that will open the door for new applications in biomedicine and biotechnology. this project carries out an integrated social science investigation into the current regulatory framework surrounding engineered synthetic cell technologies. this project also provides educational and technical training aimed at increasing the number and **\*\*diversity\*\*** of undergraduates and graduates pursuing careers in synthetic cell research. public outreach is carried out in conjunction with local partners to increase public awareness of synthetic cell technologies. natural cells have evolved sophisticated mechanisms to control dna replication, to prevent the loss of critical genes while simultaneously preventing runaway replication. analogous replication control mechanisms will be required for synthetic cells. while natural genome replication control systems are complex, plasmids provide a simple yet powerful and modular system for building synthetic replication control systems and modular genomes for synthetic cells. this project addresses the broad challenge of engineering dna replication control mechanisms for synthetic cell systems. rna engineering techniques are used to create modular and programmable synthetic plasmid replication control systems that function in both cells and cell-like systems. this project also studies how dna replication can be utilized for novel biosensing applications. biocontainment applications are investigated through an integrated social science investigation. this award is co-funded by the systems and synthetic biology cluster in the division of molecular and cellular biosciences and the cellular and biochemical engineering program

in the division of chemical, bioengineering, environmental and transport systems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Digitization TCN: Extending Anthophila research through image and trait digitization (Big-Bee)

Awardee: University of Kansas Center for Research Inc

Amount: \$309,216.00

Abstract: declining populations of bees impact plant-pollinator interactions in both natural and agricultural systems. while bees and other insects pollinate most wild plants, and are critical to sustain a large proportion of global food production, they are decreasing in both numbers and **\*\*diversity\*\***. our understanding of the factors driving these declines is limited because we lack sufficient data on the distribution of bee species, and on the behavioral and anatomical traits that may make them either vulnerable or resilient to human-induced environmental changes, such as habitat loss and climate change. fortunately, wild bees have been collected by researchers and deposited in natural history collections for over 100 years, retaining a wealth of associated attributes that can be extracted from specimen images. this project will digitally capture data and images from these historic specimens, develop tools to measure bee traits from these images, and generate a comprehensive bee trait and image dataset to measure changes through time. this will increase our understanding of specific traits that put bee species at risk of decline - a critical need for both sustaining our agricultural economy and the conservation of our natural resources. in addition, the large image datasets created by this project can be used for new artificial intelligence identification tools that will help improve our future pollinator observation and monitoring efforts. the big-bee thematic collection network (big-bee tcn) will create over one million high-resolution 2d and 3d images of bee specimens, representing over 5,000 worldwide bee species, including all of the major

pollinating species of the united states. the big-bee network includes 13 institutions and partnerships with us government agencies. novel mechanisms for sharing image datasets will be developed and datasets of bee traits will be available through an open data portal, the bee library, for research and education. the big-bee project will engage the general public in research through community science via crowdsourcing trait measurements and data transcription from images. in addition, training and professional development for natural history collection staff, researchers, and university students in data science will be provided through the creation and implementation of workshops focusing on bee traits and species identification. all data resulting from this award will be shared with and publicly available through the national digitized biocollections resource, [idigbio.org](http://idigbio.org). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: OPP-PRF: Revealing the Genomic Underpinnings of Polar Bear Physiological Adaptations to the Arctic

Awardee: Washington State University

Amount: \$309,112.00

Abstract: study of the genomic basis and evolution of physiological adaptations can provide valuable insight on the impacts of climate change on arctic species. this research focuses on the polar bear, an iconic symbol of climate change, and its adaptation to high-latitude environments. multiple types of genome data from closely related bear species will be used to identify regions of the polar bear genome that underlie specific physiological adaptations. this information will improve understanding of current and future impacts of climate change on these animals. to broaden participation and **\*\*diversity\*\*** in arctic science, the fellow will conduct public outreach, organize workshops, and mentor students from underrepresented groups. while brown and black bears undergo annual hibernation in response to seasonal prey scarcity, the ability to hibernate has been greatly reduced,

and nearly lost altogether, in the adaptation of polar bears to the arctic. given the complexity of the hibernation phenotype and the short divergence time between polar bears and hibernating bear lineages, evolution of regulatory sequences may have played a particularly important role in evolution. through the integration of functional and population genomics datasets, this project will characterize the landscape of protein coding and regulatory evolution in three bear lineages and test the hypothesis that regulatory evolution facilitated the rapid adaptation of the polar bear lineage to arctic environments. this work will advance understanding of the mechanisms and complexity of polar bear adaptations, the processes by which polar bears adapted to arctic environments, and the vulnerability of this apex predator to climate change. the project will also provide insights into vertebrate genomics and evolution, broadening our understanding of the processes by which complex physiological traits arise and evolve in vertebrates. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Assessing Peer Mentorship as a Scalable Intervention to Promote the Academic Success and Retention of Diverse Undergraduate Biology Majors

Awardee: University of California-Irvine

Amount: \$307,764.00

Abstract: this project aims to serve the national interest by improving undergraduate biology student academic success and retention in the major. at most universities in the united states, roughly 50% of undergraduate biology students leave the major within the first two years of their studies. to address this concern, most institutions put in place a number of first-year student support programs. there are, however, considerable challenges and significantly fewer supports for biology students in

their second year of study when the student retention rate is at its lowest. this project seeks to improve the success of second year biology majors by implementing and characterizing near-peer mentorship programs at two research-intensive, minority serving institutions. upper division biology peer mentors who have themselves overcome common barriers to student success will provide academic insights and supports tailored to their second-year biology major mentees. importantly, this project is intended to shed light on the theoretical mechanisms by which peer mentorship promotes mentee academic success. advancing understanding of how peer mentorship works may enable wide adoption and successful implementation of this strategy at a national level across various post-secondary academic settings. in turn, this should increase the number, quality, and **\*\*diversity\*\*** of students graduating with stem degrees. to assess the impact of peer mentorship, this project will employ a rigorous randomized control research design that will enable the assessment of how peer mentorship influences mentee (1) short-term and longer-term academic performance and retention and (2) sense of belonging, academic self-efficacy, and academic habit complexity. additionally, the project will include a focus on identifying and investigating effective near-peer mentorship practices to assess how these behaviors impact mentee outcomes. to assess whether peer mentorship is a scalable intervention at diverse universities, this project will implement peer mentorship programs at two large, public hispanic-serving institutions where both biology programs share similar academic challenges at the second year level. the mentorship structure will include mentee:mentor cohorts in 6:1 ratios, a seminar course where mentees participate in guided discussions on topics relevant to student success, and weekly mentor check-ins. to characterize these mentorship structures and achieve the previously mentioned goals, data will be collected from a variety of sources. institutional research groups at each project site will provide academic grades, major declaration, and demographic data for mentees, while project-generated survey instruments will capture mentee noncognitive impacts and mentor behaviors linked with these outcomes. combined, these data will advance understanding of how peer mentoring promotes student academic success in challenging stem majors. the nsf iuse: ehr program supports research and

development projects to improve the effectiveness of stem education for all students. through the engaged student learning track, the program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: GP-UP: Kansas City Explores Earth and the Environment (KC E3) ? A program to support early college URM student success through mentoring and community-focused inquiry

Awardee: University of Missouri-Kansas City

Amount: \$307,462.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). urban environmental hazards such as urban flooding and urban heat island disproportionately affect populations of color. the geoscience workforce tackling these challenges lacks the respective **\*\*diversity\*\*** to represent these populations. kansas city explores earth and environment (kc e3) is a ten-month cohort experience for early college students from historically excluded communities. the program aims to increase participation and persistence of these students in the geosciences and support a more diverse workforce prepared to address environmental hazards and the people impacted by them. the kc e3 cohort of 2yr and 4yr college students will work together to develop a research project for a local summer high school community program, kansas city teen summit, to investigate environmental hazards and their impact on urban landscapes. the shared challenge of developing and leading the high school summer program will motivate kc e3 participants to support each other and apply their subject matter expertise to real world challenges in a supportive environment for participants who are transitioning into college. program strengths will be identified to be reinforced in kc e3 and be used as a model for programs in similar locations. kansas city explores earth and environment (kc e3) will recruit early college

students, from historically excluded communities, who are enrolled in 2 yr and 4 yr colleges (2yc, 4yc) to participate in a ten-month cohort program. mentors from stem and student success backgrounds will support participants as they develop and lead an inquiry activity for a local non-profit summer program that supports students of color (kansas city teen summit). the unifying challenge of creating a research activity to help younger students collect and analyze data on a locally relevant environmental hazards (e.g. extreme rainfall, urban flooding, urban heat island, water and air quality) will encourage the kc e3 participants to develop a supportive cohort, and be motivated to leverage subject matter knowledge, while working in a space focused on supporting participants with the transition into college. specifically, kc e3 aims to improve the sense of belonging, self-efficacy, and appreciation of the relevance of geoscience for students early in their college career and to increase the persistence of students from historically excluded communities through geoscience degrees and into the workforce. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: Sustaining The Utqia?vik Aerosol Record of Decades (STUARD)

Awardee: University of Washington

Amount: \$307,203.00

Abstract: the arctic is warming faster than any other place on earth, with sea ice declining rapidly and sources of sea spray and aerosol emissions derived from living organisms (biogenic) are consequently changing. utqiagvik is at the forefront of this change, abutting one of the largest areas of sea ice loss. these atmospheric aerosols could have far-reaching impacts to both the climate, environment and resident community. because this change has happened largely in the last decade, now is an important time to document changes and continue a data record that will allow for a characterization of the new arctic. the longest and most complete record of airborne fine particles (or ?aerosol?) and their properties in the american arctic is that of utqiagvik, where nsf, the national oceanic and atmospheric administration and the department of energy have contributed to making this unique location serve as a regional record of changes in atmospheric aerosol properties. that record has served as the basis for hundreds of publications on questions from atmospheric chemistry to climate science to ecology and bio\*\*diversity\*\* conservation, which clearly demonstrate the broad, cross-disciplinary scientific value of these measurements. this research will extend the baseline measurements of this arctic aerosol record, including a continuation of the 15-year record of submicron inorganic components, re-instituting the 2-year record of organic components collected a decade ago, enhancing the chemical analysis with sulfur isotopes to improve interpretation of emission sources, continuing particle number size distribution measurements, and re-starting cloud condensation nuclei measurements. re-starting sampling for organic components provides a comparison to that of 2008-2010, documenting the myriad of source changes in the last decade. observations for continuing size distribution records and re-starting cloud condensation nuclei measurements provides the link from the chemical record of sources to the physical impacts on climate and the environment. this project will also allow analysis and archiving of the last 7 years of inorganic filters that were collected and the next 5 years, extending the inorganic aerosol composition record to almost 30 years. in addition to making the data widely available for a breadth

of research, a journalist will publish articles in local news media to broaden the awareness of utqiagvik's historic role as an arctic observatory. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: GP-GO: Growing the number and diversity of non-geoscience undergraduates in Cornell's graduate programs in Atmospheric and Geological Sciences with a Geoscience Learning Ecosystem

Awardee: Cornell University

Amount: \$305,506.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). graduate studies in the geosciences require diverse skills and have the potential to attract students from myriad undergraduate majors including chemistry, engineering, computer science, physics, biology, geography, mathematics and the social and behavioral sciences. further, many geoscience graduate programs prepare students for careers in societally relevant fields such as natural hazards, energy, water, and mineral resources, and climate change, that should engage students from these diverse undergraduate majors. however, several studies have shown that student perceptions of careers in the geosciences do not match reality. pis propose to develop a geoscience learning ecosystem that will increase the awareness of geoscience careers in students



from diverse undergraduate majors at the critical juncture between undergraduate and graduate school. We seek to answer the question: which strategies are most effective for increasing the number and **diversity** of non-geoscience undergraduate majors that pursue post-baccalaureate degrees in geoscience? The over-arching goal of the Cornell Geopaths Geoscience Learning Ecosystem (Corggle) program will be to design and test a novel summer bridge program that helps students from non-geoscience fields transition into geoscience graduate programs, specifically giving them exposure to myriad socially relevant careers in the geosciences. The key elements of the project include: (1) engaging diverse undergraduate institutions and students, (2) offering societally relevant summer research projects in geosciences at Cornell, (3) highlighting professional and social development across science, technology, engineering and mathematics fields facilitated by Cornell's award-winning **diversity** programs in engineering, and (4) providing career mentoring. To accomplish the creation of a connected geoscience learning ecosystem, we plan to develop and implement a nine-week summer bridge program, consisting of research and career mentoring for six students per summer from outside the geosciences. A novel aspect of the proposed program is that student research and experiences will span multiple disciplines of high societal relevance, including climate change, natural hazards, and water, energy and mineral resources. By the end of the experience and proposed activities, students will 1) become aware of scientific opportunities in geosciences in areas of high societal relevance, 2) be exposed to multiple career paths, 3) develop a cohort of peers, and 4) will have letters of recommendation from geoscientists that will enhance their chances for successful admission to a graduate program. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: OCE-PRF- Deleterious mutational load in climate driven marine range expansions

Awardee: Northeastern University

Amount: \$304,266.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). species range expansions are occurring across the globe at unprecedented rates as global warming continues to accelerate, and even more so in marine species. in general, range expansions occur by a series of colonization events in waves of a few dispersed individuals at a time. this leads to the establishment of a new population that originates from few individuals, resulting in a small non-random representation of the genetic variation from the original population ? a process known as founder effect. as a result of founder effects, a deleterious mutation that arises at the range edge disperses to a newly expanded habitat and can rapidly increase in frequency within the new population (i.e., expansion load), leading to a loss in fitness. this process is enhanced during range expansion due to the small population sizes and low genetic variation present to select against the new mutation. fishing triggers similar evolutionary dynamics of population declines and lower genetic **diversity**, similarly increasing expansion loads. marine species experience faster range expansions than terrestrial species due to their high dispersal ability and are heavily impacted by fishing pressure, yet, the interaction of both these processes have yet to be elucidated in a marine species. quantifying the load of deleterious mutations is critical for conservation and management, because they can limit a population's adaptability and survival. with climate change expected to continue, more species will experience range-shifts at unprecedented rates, making it imperative to document current genetic **diversity** and understand the genetic basis of populations at the forefront of their expanded range. this project will fund the early career development of an nsf ocean sciences postdoctoral fellow and will support the research, training, mentorship, and professional development of the fellow. to enhance the broader impacts and utility of this work, the fellow will disseminate results to the scientific community, the local fishing community and fishery management officials (e.g., noaa, manomet, atlantic states marine fisheries commission). additionally, this project will increase participation of traditionally underrepresented groups in science through: (1) undergraduate student mentorship, (2) outreach seminars for students in local

community colleges, and (3) outreach with the local community. the rapid accumulation of genetic mutations ? and in particular deleterious mutations in edge populations ? remains largely understudied during range expansions. this study presents a unique opportunity to test the evolutionary theory of the accumulation of deleterious mutations in a rapid climate-driven range expansion and harvested marine fish, black sea bass (*centropristis striata*). using a combination of genome-wide data, fitness tests, and quantitative modeling approaches, the following hypotheses will be tested: h1- (higher load at range edge) *c. striata* will show a greater expansion load in coding regions at the range expansion front compared to the historical range center and edge populations; h2- (decreased fitness at range edge) range expanding populations with a greater expansion load will show evidence of decreased fitness-related traits; h3- (load exacerbated by fishing) overfishing will exacerbate the accumulation of deleterious mutational load in expanding populations. if results support the hypotheses (i.e., higher loads and decreased fitness are found at the expanding-front), as predicted by theory, they will have widespread implications for marine conservation strategies in a rapidly changing climate. however, if these hypotheses are rejected, the data will challenge existing scientific assumptions, suggesting marine systems undergo different processes. this integrative dataset will advance understanding of climate-driven range expansions and the interactive effects of climate change and fishing pressure on marine species, such as black sea bass. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Bees of the World - Phylogenomics, Biogeography, and Evolution of Host-Plant Associations

Awardee: Cornell University

Amount: \$303,954.00

Abstract: bees are vitally important to agriculture, food security, and the preservation of natural

ecosystems due to their pollination services. over 85% of the 325,000 flowering plant species on the planet depend on animal pollination and the vast majority is carried out by bees. in the u.s.a. alone bees are responsible for the commercial production of 130 crop plants, generating over \$11 billion in annual revenue. the value of bees to nature and human well-being is abundantly clear. the partnership between bees and flowering plants formed over 100 million years ago, and since that time, bees have radiated globally into an astounding 20,000+ different species, many of which are specialist pollinators of particular plant species or families. the study of bee bio\*\*diversity\*\* is urgently needed because there is growing evidence that some bee species are in decline and baseline knowledge of bee \*\*diversity\*\*, distribution, and family relationships is incomplete. the bees of the world project has the potential to significantly improve knowledge of bee bio\*\*diversity\*\* and to establish a guide to interpret key traits of bees, such as their host-plant associations. by utilizing recent advances in dna sequencing technology, a comprehensive tree-of-life for bees will be generated for the first time, providing a framework from which to study bee \*\*diversity\*\* and their relationships with plants. to disseminate results and general bee knowledge, the project will engage in multiple outreach efforts with professional and non-professional audiences. activities include creation of a virtual bee course, teaching of a molecular methods workshop, and, in collaboration with the natural history museum of utah, development of exhibits and youth education activities focused on pollinators. the project will use cutting edge molecular and analytical methods and engage a global network of collaborators to assemble a comprehensive phylogenomic dataset for bees. the project aims are to: (1) resolve remaining uncertainties in higher-level bee phylogeny and classification, (2) incorporate fossils to reconstruct the global biogeographic history of bees, revealing the origin and spread of bee \*\*diversity\*\* over time, and (3) analyze patterns of host-plant use across bees and for targeted clades at lower taxonomic levels, revealing how host-plant specialization has evolved and impacted rates of diversification in bees. to resolve the phylogeny of bees with improved confidence, the research team will use next-generation dna sequencing approaches and novel laboratory methods to sequence bee species from across the globe. the

project will generate low coverage genomes for most bee genera and ultraconserved element (uce) data for over 3,000 species, filling in sampling gaps. the resulting bee phylogeny will serve as a framework to study bee classification, biogeography, and host-plant evolution. comprehensive databases of bee fossil, distribution, and host-plant information will be created and made available to other researchers. combining results from each component of the project will provide a comprehensive understanding of how bees have diversified and dispersed over time and how their partnership with plants has shaped their evolutionary trajectory. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Equivariant Approaches to Chromatic Homotopy

Awardee: University of California-Los Angeles

Amount: \$302,773.00

Abstract: the project addresses directly the heart of algebraic topology: computing invariants like numbers, groups, and rings to understand spaces. the goal of algebraic topology is to systematically build a connection between algebraic objects like numbers and geometric objects like spaces. this connection allows a two-way flow of information, with algebraic invariants distinguishing spaces and topological methods informing algebraic problems. starting from foundational work of quillen, algebraic and algebraic geometry data like formal groups gives rise to new invariants for spaces with striking properties. this project combines this classical thread with much more recent developments coming from equivariant algebraic topology. "equivariant algebraic topology" remembers a collection of symmetries inherent in a space as part of the data, systematically grouping spaces with the same symmetries, and the numbers and invariants produced must reflect this. this extra structure provides more nuanced computations, giving more information about how the classically described invariants change under symmetries. equivariant algebraic topology has experienced a renaissance recently due to the solution by the pi, hopkins, and ravenel to the kervaire invariant one problem, one of the oldest outstanding problems in algebraic topology. the solution introduced a host of new constructions and techniques that have striking ramifications in classical and equivariant algebraic topology, and this project focuses on unpacking some of these new constructions, exploring their ramifications in classically studied computations, and describing what they mean for algebraic topology in general. many of the projects focus on **diversity** in stem. building on the pi's prior first year seminar on women in math, the pi will create a **diversity**-driven class, combining mathematical content and pedagogy with discussions of representation and inclusion in mathematics. at the same time, the pi intends to create more opportunities for students who do not see themselves as "math people" to connect with algebra and geometry concepts using ucla's

"maker spaces" to have students design and build concrete models. the pi will continue conference organizing, especially conferences focusing on making space for early career mathematicians and for advanced undergraduates, using these as a way to connect students with the ideas and researchers in stable homotopy. using newly developed tools in equivariant stable homotopy, the pi will study the slice spectral sequences for certain chromatically meaningful quotients of hyperreal spectra. these are closely connected to the classical approaches to studying  $k(n)$ -local phenomena using the hopkins--miller higher real k-theory spectra, and at the prime 2, computations here subsume all previously known higher real k-theory computations. the project focuses mainly on concrete computations (both of chromatically meaningful quotients of hyperreal bordism and of more traditional objects like the dual steenrod algebra), while also studying more abstract questions of what kinds of multiplicative structures we can see. finally, an application of all of this machinery to the classical questions of orientability of vector bundles is explored. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: SHF: Small: Programmable Hierarchical Caches: Design, Programming, and Prototyping

Awardee: University of Rochester

Amount: \$301,689.00

Abstract: as computing technology becomes ever more powerful, memory is larger but more complex, with different materials, configurations, and interconnects having different trade-offs among capacity, speed, and cost. because of this complexity, fully automatic solutions are increasingly sub-optimal and brittle. this project develops new designs of the memory hierarchy that are programmable and therefore can achieve better performance and provide stronger guarantees than conventional solutions used on current computer systems ranging from smartphones to



supercomputers. the new programmability enables optimization in software and hardware in concert. since computer cost and speed depend on memory hierarchy, programmable designs can overcome the current limit in scalability and power efficiency. beyond its technical content, the project advances teaching in the science of computer memory and strives to increase the **\*\*diversity\*\*** among participants in this area of research and development. specifically, the project develops a two-level programmable cache system called the lease cache and designs its programming techniques. it has three parts: automatic programming and optimization of the lease cache; hardware design and prototyping of a risc-v processor with the two-level lease cache on an fpga board; and lease-cache theory especially statistical properties and guarantees of the cache performance. through theories and prototyping, the new designs can retain software portability, ensure matching performance to current automatic solutions by default, and provide precisely defined cache performance properties. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: OPUS: Recovery, resilience and the ecology of change

Awardee: University of Colorado at Boulder

Amount: \$301,542.00

Abstract: a diverse ecological community is composed of many species of organisms, all responding to environmental change as well as interacting with each other. in this complex web of nature, predicting how bio**\*\*diversity\*\*** will change over time is challenging. because changes in one species abundance propagate through interactions in the community to affect other species, it is often not sufficient to understand only how organisms respond directly to environmental conditions. this same challenge affects the utilization of monitoring information by conservation and restoration practitioners. considerable time and resources are devoted to monitoring these complex changes,

and it can be difficult to discern whether changes indicate a healthy self-sustaining system or one that is declining and on the verge of collapse. other disciplines outside ecology also deal with analogous complex processes and have developed metrics and analytical frameworks to describe dynamics of multi-dimensional systems over time. in the proposed work, these metrics will be applied to long-term ecological datasets to inform how managers can utilize monitoring datasets. datasets in the proposed synthesis will also form the foundation for graduate student seminars and exchanges to train across subdisciplines and connect theory to applied work. this project seeks to develop a new perspective on the temporal dynamics of multispecies communities by highlighting, through synthesis, ways to describe how complex ecological systems respond to environmental change and how species organization within a community may cause different dynamics in the propagation of environmental change. the project focuses on several innovative metrics that can describe dynamic stability of multispecies communities, using a series of eight long-term plant community datasets. it then seeks to apply new methods that describe the organization of species interactions to connect dynamics with community organization. the last part of the project seeks to make this understanding more useable to decision-makers through collaborations with managers on analyses of long-term conservation monitoring datasets. partnering with managers and training graduate students, the research will explore new ways to arrive at a better understanding of how to monitor and anticipate dynamic ecological responses to environmental change. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Development of an Asymmetric Electrochemical-NHK Reaction using Multivariate Linear Regression Analyses

Awardee: Hunter, Arianne Chenice

Amount: \$300,000.00

Abstract: arianne hunter is awarded a fy21 mathematical and physical sciences ascending postdoctoral research (nsf mps-ascend) fellowship to conduct a program of research and activities related to broadening participation by groups underrepresented in chemistry at cal tech. the project being performed by arianne hunter, entitled development of an asymmetric electrochemical-nhk reaction using multivariate linear regression analyses, is to be conducted under the guidance of mentoring scientist sarah e. reisman. this project is supported by the office of multidisciplinary activities in the mathematical and physical sciences directorate. this project utilizes multivariate linear regression (mlr) models to guide the identification of a privileged ligand class that will transform the electrochemically driven nozaki-hiyama-kishi reaction (e-nhk) into a highly enantioselective method. the specific aims include screening ligands to identify privileged scaffolds that produce high levels of asymmetry, developing tethered ligands to increase the efficiency and asymmetry of the reaction, and conducting electroanalytical investigations into the formation of heteronuclear complexes. these in-depth studies into the e-nhk using data science-driven mlr models and electroanalytical/spectroelectrochemical mechanistic investigations will contribute a new fundamental understanding of the cr and ni speciation in the e-nhk. dr. hunter will also work to broaden participation through efforts like starting a nobcche chapter, participating in the \*\*diversity\*\* in chemistry initiative at caltech, and working with the caltech center for teaching, learning, and outreach. dr. hunter also plans to use her extensive background in organizing scientific community outreach, gained through her non-profit ?we do science too? and her work with ?girltech? of oklahoma city, to organize outreach activities at pasadena high school. this award reflects nsf's

statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Ferroelectricity Emerging from Antisite Defects in Complex Oxides

Awardee: Massachusetts Institute of Technology

Amount: \$300,000.00

Abstract: nontechnical description: ferroelectric materials can store electric charge, and have applications in energy storage, memory devices, and actuators. this project develops a new class of ferroelectric materials that also have magnetic properties. this combination of properties makes them particularly useful for low power memory and computing devices. it has been a challenge to find materials that possess both magnetic and ferroelectric properties at room temperature, but recent work shows a path to this goal by manipulating the composition of a class of oxides that contain iron and a rare earth metal. the change in composition produces a particular type of defect which is the source of the ferroelectricity. this research project investigates ferroelectricity in material compositions that are predicted to show the strongest effects. broader impacts include student training, activities to promote **\*\*diversity\*\***, public outreach via events and online classes, and technology transfer to industrial groups. public outreach is offered at the nano-observatory, an annual event where attendees visit a nanofabrication and characterization lab at mit for demonstrations of nanotechnology, and through free online classes that contribute to a micro-minor certification. outreach to underserved minorities is carried out through a program that brings undergraduates from minority populations to mit, and through a departmental **\*\*diversity\*\***, equity and inclusion collaborative. technical description: ferroelectrics are useful and interesting materials, with applications in energy storage, memory and actuators. furthermore, when combined with ferro- or antiferromagnetic order, the materials are multiferroic and exhibit additional functionality such as voltage-induced changes in magnetization or magnetic field-induced changes

in polarization. this research project explores the hypothesis that ferroelectricity can be induced in perovskites with generic formula  $ABO_3$  as a result of antisite defects, i.e. the presence of one cation on a site that should contain a different cation. recent work has shown that antisite defects in yttrium orthoferrite  $YFeO_3$  with  $y:fe > 1$  lead to a robust room-temperature ferroelectricity, even though the bulk stoichiometric material is non-ferroelectric, and density functional theory predicts that this mechanism would be even stronger in orthoferrites with smaller rare earth cations such as Lu. this research investigates antisite-defect-mediated ferroelectricity in thin films of rare earth-rich orthoferrites  $LuFeO_3$  and  $YbFeO_3$ , and measures the effect of magnetic field on their ferroelectric response. broader impacts include student training, activities to promote **diversity**, public outreach via events and online classes, and technology transfer to industrial groups. public outreach is offered at the nano-observatory, an annual event where attendees visit a nanofabrication and characterization lab at MIT for demonstrations of nanotechnology, and through free online classes that contribute to a micro-minor certification. outreach to underserved minorities is carried out through a program that brings undergraduates from minority populations to MIT, and through a departmental **diversity**, equity and inclusion collaborative. this award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Observational Studies of Fast Radio Bursts and Technosignatures with the Allen Telescope Array

Awardee: Sheikh, Sofia Zara

Amount: \$300,000.00

Abstract: sofia sheikh is awarded a mathematical and physical sciences ascending postdoctoral research fellowship (mps-ascend) to conduct a program of research and education at the search for extraterrestrial intelligence (seti) institute, mountainview, california. dr. sheikh will improve coherent imaging methods for rejection of radio frequency interference (rfi) and use the improved imaging for characterization of fast radio bursts (frbs). she will work to broaden experience in **\*\*diversity\*\*** and inclusion for underrepresented minority undergraduate students in astronomy. dr. sheikh plans three research activities using the unique qualities of seti's allen telescope array (ata). the first is a hardware and software development project to increase the backend coherent imaging capabilities of the ata. she will use these new capabilities to localize and characterize frbs, which have previously been detected with other radio telescopes. her third goal is searching for signs of extraterrestrial intelligent life by radio observations of the anti-solar point, defining a special space and time on the sky from which a distant observer would see earth in transit of the sun. all three activities rely on implementing novel strategies and pushing into new regions of parameter space (i.e., higher frequencies, new regions of the sky). dr. sheikh seeks to improve the retention rate of



underrepresented scholars in science and engineering fields. her approach is mentoring these students and explicitly teaching the unspoken rules of academic success, helping them build strong professional networks, and provide introductory research experiences. she will enhance existing programs at the seti institute. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: IRES Track I: A U.S.-Ireland Partnership for an International Graduate Research Experience in Biopharmaceutical Processing

Awardee: Thomas Jefferson University

Amount: \$300,000.00

Abstract: the u.s. economy is faced with unprecedented challenges in numerous industry sectors. these challenges underscore a compelling opportunity to prepare the next generation of biopharmaceutical scientists who are specially trained in a field that our world desperately needs. despite the fact that international partnerships between u.s. and non-u.s.-based sites are often challenging to arrange, especially in the area of biomanufacturing, we have a unique opportunity to execute a track 1 international research experience (ires) that capitalizes on our existing collaboration between thomas jefferson university and ireland's national institute for bioprocessing research and training (nibrt), a non-academic research enterprise. the program will provide a unique training and educational research experience in a world class facility, engage underrepresented minorities, and provide assistance to transition the participants to industry or advanced degree programs. thomas jefferson university proposes to engage its international training partner, the national institute for bioprocessing research and training (nibrt) to enable global research in methodologies of bioanalytics and biomonitoring with the following goals: (1) offer a specially selected cohort of students (n=6 each year) the opportunity to develop agile, analytical skills in

biopharmaceutical process engineering with a prominent global leader so that they emerge as distinctively prepared. (2) increase the inclusion of underrepresented minorities (urms) in the life sciences and engineering through participation in biopharmaceutical process engineering and recruitment efforts. (3) train and transition exceptionally prepared, highly competitive students into industry positions or advanced degree programs. our long-term goals are to increase the workforce pipeline for the biopharmaceutical and vaccine industries, and foster u.s. manufacturing competitiveness in an area critically important to human health and national security. the biopharmaceutical industry is highly regulated and research and training opportunities at relevant sites are both difficult and costly. the meaningful relationship already in place between philadelphia/jefferson and nibrt offers a powerful convergence of two thought leaders in establishing a novel and potentially transformative research training experience that capitalizes on our international exchange, existing curriculum, and world-class researchers and capabilities unmatched anywhere else on the globe. furthermore, continued targeted efforts to engage urms are critical to the evolution of the u.s.'s stem workforce as the \*\*diversity\*\* of u.s. populations increase and we attempt to remain competitive in stem fields. finally, we intend to build this nascent international opportunity into a sustainable and long-term exchange in which u.s. and nibrt trainees have global opportunities on either continent. in return, by securing this type of training and experiential learning, we will contribute significantly to a workforce that is desperately needed in the biomanufacturing industry and our findings will bolster the existing literature on the advantages of international stem student training opportunities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Investigating the Impact of Arts on Student Learning by Introducing Glass Science in the Materials Engineering Curriculum

Awardee: South Dakota School of Mines and Technology

Amount: \$300,000.00

Abstract: this project aims to serve the national interest by improving stem learning environments with a focus on engineering education. a key focus of the project is the introduction of creative glass science elements that enable the creation of a steam (stem + arts)-infused engineering curriculum and co-curriculum. this steam-based project will support the recruitment and retention of engineers and deliver quality science and engineering content to a diverse group of students and to the community. the project hypothesizes that positive student outcomes can be achieved through strategic curricular and co-curricular modifications that integrate and embrace development of steam programs. the project builds on prior research that involves highly successful curricular and co-curricular programming integrating arts into an undergraduate engineering degree program. advances that result from the project have potential to inform and enhance steam teaching within programs in undergraduate engineering. the south dakota school of mines and technology proposes to create a degree program that incorporates glass science into an undergraduate materials engineering degree. the project aims to increase the creativity, innovation, collegiality, entrepreneurship, critical thinking, and intellectual \*\*diversity\*\* of students in the program, and possibly also improve its gender \*\*diversity\*\*. specific aspects of the program include new curriculums in glass science and engineering, integration of steam laboratory and design content with inclusion of content from an embedded artist-in-residence, and formation of a campus steam council. the project's research elements address the sustainability of the proposed modifications through: 1) translation of selected programmatic elements to other campus engineering programs, 2) recruitment of students into the revised degree programs, 3) marketing to the campus, local, and state community, 4) involvement of private-sector partners through steam-influenced design projects, and 5) dissemination to targeted professional societies and associated stakeholders, including local art centers. a rigorous external assessment of the research will be conducted that includes use of herrmann brain dominance inventory and the critical thinking assessment test to

determine the effectiveness of program outcomes. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the engaged student learning track, the program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: BPC-DP: Developing Shared Measures Among the BPC Community

Awardee: Computing Research Association

Amount: \$300,000.00

Abstract: the computing community's efforts to broaden participation in computing (bpc) take many different forms but ultimately, these efforts are all working toward the common goals of increasing **\*\*diversity\*\***, equity, and inclusion in the field of computing. measuring the progress of these efforts is critical in improving these activities and assessing their impact. however, such measurement is difficult given the variance of these activities. recognizing the challenges of measuring progress across organizations that engage in a wide variety of activities, this bpc demonstration project will produce common definitions and a framework to enable comparable measurement across the bpc community of practice (including bpc alliances and demonstration projects). these shared frameworks and definitions will facilitate learning across the bpc community about model practices for bpc. development of shared measures is of great interest to all stakeholders, including the bpc alliances and demonstration projects. this project will closely collaborate with the existing bpc alliances to represent the efforts of the bpc community while also maintaining open communication with demonstration projects, new bpc alliances, and others actively working in broadening participation. by providing shared measures for understanding the impact of bpc alliances and other bpc interventions (e.g., demonstration projects), this project will benefit efforts to increase all

underrepresented groups these efforts are intending to support. these include groups identified as underrepresented in computing by nsf (i.e., women, persons with disabilities, blacks and african americans, hispanics, american indians, alaska natives, native hawaiians, and pacific islanders) as well as others who are disadvantaged based on other identities (e.g., sexual orientation) and factors such as socio-economic background. this project will result in a number of tools and resources to help sustain these efforts long-term. the outcomes of this project will add to our knowledge of collective impact measurement in a way that reflects the cumulative experiences of organizations who have been engaged in bpc for more than a decade. this project will enable knowledge exchange and assist in capacity building across bpc alliances by strengthening the connections and collaboration among the alliances and, therefore, expanding their potential for impact. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: ASCEND: Expanding the Multi-Messenger Impact of In-Ice Radio Experiments

Awardee: Muzio, Marco Stein

Amount: \$300,000.00

Abstract: marco muzio is awarded an nsf mathematical and physical sciences ascending postdoctoral research fellowship to conduct a program of research and education at the pennsylvania state university. muzio will use multi-messenger astronomy, combining neutrino, gamma-ray, and particle detection to study the highest energy events. specifically, muzio will use data from the askaryan radio array (ara) to perform new, higher sensitivity studies related to very high-energy (vhe) neutrinos above approximately 10 petaelectronvolts. along with the research, muzio will work with the climate and \*\*diversity\*\* committee and others at the university to broaden the participation of underrepresented minorities at both the postdoctoral and undergraduate levels.

detection of vhe neutrinos will address pressing questions in the study of ultrahigh energy cosmic

rays, including how their sources are distributed, what their composition is, and if accelerators produce a substantial flux at energies at length scales inaccessible through cosmic ray observations. importantly, neutrinos will address these questions in a hadronic interaction model-independent way, sidestepping particle physics uncertainties that plague the interpretation of cosmic ray data. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: BPC-DP: Distributed REsearch Apprenticeships for Master?s (DREAM)

Awardee: Colorado School of Mines

Amount: \$300,000.00

Abstract: people who identify as female, black/african american, hispanic/latino, native american, hawaiian, alaskan, asian pacific islander, and people with disabilities have been traditionally marginalized in the computing and tech fields. to reverse this trend and attract more students from these populations to the field, the 13 universities in the mscs pathways to computing consortium created ?bridge to an ms in computer science? programs for students with non-cs bachelor?s degrees. the primary goal of the distributed research apprenticeships for master?s (dream) project is to increase the number of students pursuing a ph.d. in cs from the groups mentioned previously and, ultimately, increase the **\*\*diversity\*\*** of the computing professoriate. dream is modeled after the computing research association?s committee on widening participation?s (cra-wp) distributed research experiences for undergraduates (dreu) program, which has been very successful at encouraging diverse undergraduate students to enroll in cs graduate programs. dream funds consortium students from diverse backgrounds to participate in a research experience during their m.s. degree program. in this cohort model, students participate in a robust mentoring program, various community building and networking opportunities, guided research, professional

development, and have opportunities to attend technical conferences. at the end of their research experience, students will begin to see themselves as researchers in computing and be inspired to pursue further research through a ph.d. the diverse demographics of the consortium programs provide a unique opportunity to recruit ph.d. students from a previously untapped population of students. beyond the immediate impact on the cohort of participating students, dream creates a pathway to a ph.d. for students traditionally marginalized away from the computing field that can be scaled nationally. the project team is working in close collaboration with cra-wp to ensure a smooth handoff of the program at the conclusion of the pilot implementation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: SEE DATA: Spaces of Empowerment for Equity and Diversity: Advancement Through Access

Awardee: Portland State University

Amount: \$300,000.00

Abstract: the spaces of empowerment for equity and **\*\*diversity\*\***: advancement through access (see-data) project at portland state university (psu) aims to identify, understand, and improve the workplace experiences and retention of faculty in stem fields who have been traditionally minoritized and marginalized based on gender, race/ethnicity, and other intersectional identities (e.g., sexual orientation, disability, socioeconomic status, national origin, immigrant status). the project will collect, analyze, and map data about faculty's experiences at psu to inform programs and policies that seek to foster the retention and flourishing of a faculty that more closely resembles the diverse student body at psu. it is anticipated that the see-data project will significantly contribute to



improving institutional equity. see-data will take an intersectional approach to data collection, management, analysis, visualization, and dissemination by combining qualitative, quantitative, and socio-spatial data, techniques, and mapping tools with the goal of conveying more nuanced understandings of the equity landscape and "ecosystem" for diverse faculty members than has been established to date elsewhere. the scope of the methodology that the project will develop will be applicable to stem departments across the university and to other institutions. the project's strengths-based self-assessment methodologies will contribute to a toolkit for capturing and visualizing the dynamic interplay between the multiple lived identities of stem faculty as they are manifested in the institutional landscape, thus supporting advance goals for expanding intersectional equity strategies and interventions. this project addresses limits in extant sources of data (e.g., numerical counts, climate surveys) on the intersectional factors affecting academic stem recruitment, workplace experiences, retention, and promotion. outcomes will be expected to advance a clearer and deeper understanding of individual empowerment pathways and institutional systemic change levers in advancing faculty equity in stem. knowledge generated will be disseminated via avenues such as a project webpage, public seminars, and conferences geared to professional and general audiences, as well as through networks within psu, at other colleges/universities, with professional organizations nationally, and via the advance resource coordination network (arc) and strategic website. the nsf advance program is designed to foster gender equity through a focus on the identification and elimination of organizational barriers that impede the full participation and advancement of diverse faculty in academic institutions. organizational barriers that inhibit equity may exist in policies, processes, practices, and the organizational culture and climate. advance "catalyst" awards provide support for institutional equity assessments and the development of five-year faculty equity strategic plans at an academic, non-profit institution of higher education. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Probing Undiscovered Reaction Pathways in the Decomposition of Highly Energized Molecules: Isomerization, Roaming, and Proton Coupled Electron Transfer

Awardee: Marquette University

Amount: \$300,000.00

Abstract: with support from the chemical structure, dynamics, and mechanisms-a (csdm-a) program in the division of chemistry, professors scott reid at marquette university and richard loomis at washington university in st. louis, respectively, will explore competing bimolecular reaction pathways of highly-excited molecules. energized reactant molecules can relax via multiple mechanisms, including (i) direct bimolecular reactions, (ii) isomerization (changes in molecular structure and connectivity), (iii) roaming (long-range intermolecular interactions that lead to unexpected, secondary products), and proton-coupled electron transfer (pcet) reactions that occur following the initial transfer of an electron or proton from an excited reactant molecule to the other reactant molecule. the understanding of roaming, isomerization, and pcet processes are still at an elementary stage. reid and loomis hypothesize the pathways that compete with direct bimolecular reactions are central to many fundamental processes, and they are striving to develop a unified understanding of the factors that dictate their efficiencies and how these pathways dictate the properties of the products. thus, the research teams led by professors reid and loomis are using a powerful combination of frequency- and time-resolved experiments, together with theory, to unravel the dynamics of these processes. the experiments will be performed in vacuum, in solvents, and in solid matrices, and the energetics and yields of the products are characterized as a function of how much energy is deposited into the reacting molecules. in this manner, the research teams will characterize how these different pathways and their efficiencies are altered by local environment and excitation. the collaborative nature of the research project offers graduate and undergraduate students training in an array of important skill areas, preparing them for careers in science. the

project also has a focus on broadening the participation of underrepresented groups in science, technology, engineering, and mathematics (stem) through a number of complementary initiatives at marquette and washington university. a notable component of this program is the development of highly practical courses for at-risk students at the onset of their graduate education. the courses build on a principle of enhancing **\*\*diversity\*\*** in stem, especially in academia, by providing promising scientists with the tools they need to succeed at an early stage. the goal of this collaborative research project led by professors scott reid and richard loomis at marquette university and washington university in st. louis, respectively, is the characterization of common features associated with isomerization, roaming, and pcet reactions on ground, excited, and ion radical surfaces. the systems being explored fall into two categories: (i) reaction dynamics of halons including the isomers of di-bromoethane, di-chloroethane, and haloethane and their partially deuterated analogs, and (ii) reactions of ionized complexes of ammonia with halobenzenes. these target systems, the halons, are environmentally important, are expected to demonstrate the full range of reaction pathways listed above, and yet are small enough to be tractable via high-level theoretical methods. the complementary and overlapping skill sets and techniques in the two laboratories enable experiments to be undertaken with high sensitivity, energy resolution, and temporal resolution. specifically, frequency-resolved fluorescence-based spectroscopy, frequency- and time-resolved ion time-of-flight velocity mapped imaging experiments, ultrafast transient absorption spectroscopy, and infrared excitation experiments will be pursued. these reaction systems were chosen, in part, because of the ability to probe the properties of the parent molecules or complexes and all of the product channels with high sensitivity. the selected systems are also being investigated in detail using computational methods, with the experimental results providing stringent tests and milestones for ongoing development of the theory. important challenges in this research effort include state-specific preparation of the reactants and state-resolved detection of the products, challenges that are to be overcome through the combined effort of the two research groups. student training opportunities and an emphasis on broadening participation in stem

education and research further broaden the impacts of the project. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Testing the reduction of aerobic habitat as a common kill mechanism for major mass extinction events

Awardee: University of Chicago

Amount: \$300,000.00

Abstract: the project will study the response of marine animal ecosystems to environmental change using three mass extinction events from the geological record as study systems. specifically, the project will test the hypothesis that a large proportion of extinction during these events can be explained by the stresses that elevated temperatures and reduced oxygen availability place on animal respiration. geochemical data will be used to constrain computer simulations of changing ocean conditions during these mass extinction events. results from laboratory studies on animal respiration will then be paired with fossil data to assess whether differences in extinction intensity in space and across taxonomic groups can be explained by spatial variation in environmental change or differences among taxonomic groups in their ability to withstand environmental change. the project will provide interdisciplinary training to a group of graduate students and post-docs. it will further impact stem education through the creation of a website that will allow access to model results so that students can visualize and explore model output to understand cause-effect relationships between continental configuration, ocean conditions, and biological **\*\*diversity\*\***. the investigators will also offer short-courses on earth system modeling and data interpretation at major conferences that will be recorded for asynchronous use. the project will also involve the development of a podcast series addressing how we reconstruct the ancient earth system and use these reconstructions to better understand the present and predict the future. in this project, the

hypothesis will be tested that the loss of habitat through constraints on aerobic respiration under climate change and ocean deoxygenation can explain the magnitude, taxonomic selectivity, and latitude variation in intensity for the late devonian (frasnian-fammenian), end-permian, and end-triassic mass extinction events. paleoredox and paleoclimate proxy data and geochemical indicators of diagenetic alteration will be used for both global average and local conditions before and after each major event combined with predictions from earth system models and occurrence data from the fossil record of marine animals to separate aspects of extinction that can be explained by physiological stress from those that require other explanations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: IRES Track I: Manifestations of climate change in extreme events

Awardee: Pennsylvania State Univ University Park

Amount: \$300,000.00

Abstract: human-induced changes in the global climate and atmospheric environment are among the most significant scientific challenges to address this century. increasing concentrations of greenhouse gases are the dominant cause of observed warming since the mid-20th century. earth system models are used to both understand these issues as well as project the future state of the

climate and the environment. however, significant uncertainties remain in these models, owing to the lack of high-quality data of key variables, especially from complex terrains that encompass mountains, rainforests, and a variety of land uses. this ires project will provide five u.s. undergraduate students each year the opportunity to spend eight weeks in peru to study the extreme weather manifestations of climate change. peru is on the extreme side of potential impacts that climate change can have, and therefore, the training we will develop in peru could be applied to the united states. students will learn the necessary research skills to apply theories about climate change, impacts, adaptation, and solutions within the peruvian context. students will also work in peru to address challenges associated with climate change. the international experiences will contribute to increasing retention and graduation rates of participating students, improve programs and strategies for sustaining **\*\*diversity\*\*** in science and engineering. the program provides individually challenging experiences in research and well-organized integrative team activities and professional development to undergraduate students. the program aims to provide a high quality, and balanced research activities that positively impact the participants' lifelong career choices in science and engineering research. the students will work with faculty and investigators from peru and united states to integrate weather sensors and mount them on a drone, design experiments, collect and analyze data, and present results to scientific and non-scientific audiences. students will study complex terrain and ecosystems in collaboration with local scientific and engineering experts, and utilize laboratory and local field infrastructure. proposed activities rely on existing and new data sets, social science data collection, and ground-based and remote sensing measurements in collaboration with local partners in peru to study extreme weather events such as severe hailstorms and frost conditions in the peruvian andes, and wildfires in the peruvian amazon. research activities will include data analyses to mitigate el niño phenomena and identify drawdown solutions to combat climate change. students will work within the areas of faculty expertise but choose and define a project of personal interest. each project will have at least two faculty mentors to help the students develop with multidisciplinary approaches to tackle their research activities. this program includes a

robust mentoring component aimed at sharing best practices for future researchers. the involvement of undergraduates in research with exposure to climate change and the social impact on humankind has implications well beyond the technical scope of the individual research projects, and the inclusion of science communication shows how research can directly impact society. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: FET: Medium: Robust Quantum Networks via Efficient Entanglement Distribution

Awardee: CUNY Hunter College

Amount: \$300,000.00

Abstract: quantum computing has the potential, if realized, to significantly alter the computing landscape. however, building large-scale quantum computers is a key challenge. quantum networks (qns) enable the construction of large, robust, and more capable quantum-computing platforms by connecting smaller quantum computers. networked quantum systems have the potential to significantly alter various activities in society by leading to faster development in medicine and engineering; more secure and privacy-preserving communication; and hitherto infeasible optimizations that leverage the immense computational power to identify efficiencies in manufacturing, logistics, finance, etc. this project is also using the potential and attractiveness of qns to design and offer a variety of educational programs, including a flexible post-baccalaureate program in quantum computing and networking to cater to non-traditional students, improve the **\*\*diversity\*\*** of undergraduate and graduate student body, and develop a quantum capable workforce. building qns that support robust communication across nodes requires several fundamental scientific and technological advances, especially since classical techniques cannot be directly used in the quantum regime. qns can be used to build quantum computing systems that are



more capable and more resilient than stand-alone quantum computers. this project is examining the design and implementation of qns from the ground up by developing an infrastructure for efficient communication and management of quantum entanglements in the network. in addition, the project is addressing specific challenges in two key applications of qns: (i) distributed quantum algorithms, and (ii) quantum sensor networks. the project is evaluating the developed techniques using large-scale simulations and over a 6-node qn testbed spread across long island, ny. the testbed is providing a high-fidelity platform to evaluate the effectiveness of our developed techniques. overall, the project has three research thrusts. in the first thrust, the project is developing an infrastructure to facilitate efficient communication and entanglement management. in particular, it is developing optimization techniques for (i) efficient generation of long-distance entanglement using multiple paths, and (ii) efficient distribution of pre-distributed entanglements. in addition, the project is developing efficient entanglement-distillation strategies in practical settings, and protocols for multicast primitives. in the second thrust, the project is addressing challenges in the context of two key qn applications to corroborate and validate the developed techniques. in particular, the project is developing optimization techniques for efficient distributed implementation of centralized quantum circuits; efficient distributed implementations are important for qn's computational success. in the context of quantum sensor networks, it is designing efficient protocols for the estimation of binary parameter functions and investigating the benefit of entanglements in these settings. in the third thrust, the project is evaluating the above techniques using large-scale simulations and a small qn testbed. to evaluate qn performance effectively, the project is formulating novel performance metrics for qns; this requires non-trivial generalization of the classical network metrics. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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collaboration with local partners in peru to study extreme weather events such as severe hailstorms and frost conditions in the peruvian andes, and wildfires in the peruvian amazon. research activities will include data analyses to mitigate el niño phenomena and identify drawdown solutions to combat climate change. students will work within the areas of faculty expertise but choose and define a project of personal interest. each project will have at least two faculty mentors to help the students develop with multidisciplinary approaches to tackle their research activities. this program includes a robust mentoring component aimed at sharing best practices for future researchers. the involvement of undergraduates in research with exposure to climate change and the social impact on humankind has implications well beyond the technical scope of the individual research projects, and the inclusion of science communication shows how research can directly impact society. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Radiation Transport in Strongly Coupled High-Energy-Density Plasmas

Awardee: LeFevre, Heath Joseph

Amount: \$300,000.00

Abstract: heath lefevre is awarded an nsf mathematical and physical sciences ascending postdoctoral research fellowship to conduct a program of research and education at the university of michigan ? ann arbor. lefevre will study high-energy density (hed) plasmas at the omega and omega ep laser facilities at the university of rochester. the project aims to understand and measure coupling between intense electromagnetic radiation and an hed plasma, a plasma with particularly high particle density and temperature. the regime where effects of strong coupling on emission and absorption of radiation in hed plasmas is not well studied and is important to the physics of white dwarf stars and type ia supernova, as well as for inertial confinement fusion plasmas. along with the research, lefevre will conduct outreach, recruiting, and mentoring efforts aimed at increasing the

**\*\*diversity\*\*** of students studying plasma physics. this study explores strongly coupled, radiation flux dominated plasmas, which are relevant to inertial confinement fusion, white dwarf stars, and type ia supernova. this is a physics regime that is difficult to model and therefore the experimental results to be obtained at the university of rochester's high energy laser facilities are of fundamental interest to astrophysics and hed science research. comparing results of these experiments with available radiation hydrodynamics, atomic kinetics, and radiation transport codes will quantify the effects of radiation coupling in these plasmas. this study will be able to eliminate common sources of uncertainty and error in hed physics models due to its use of multiple facilities and experimental conditions. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: DMS-EPSRC Eco-Evolutionary Dynamics of Fluctuating Populations

Awardee: Virginia Polytechnic Institute and State University

Amount: \$300,000.00

Abstract: a fundamental scientific puzzle is understanding the origin of **\*\*diversity\*\*** and the evolution of cooperation, which can be understood through understanding the stability of populations composed of competing species. it directly addresses deep societal concerns, such as the maintenance of endangered ecologies, the effective prevention of the loss of bio**\*\*diversity\*\***, and stemming the rise of antimicrobial resistance. to this end, one must address the coupled eco-evolutionary dynamics of fluctuating populations, namely the interdependence and combined effects of (i) random internal variability in population numbers, composition, and each species' traits and (ii) sudden, gradual, or repetitive external changes in environmental conditions on the evolution of an ecological system. this transdisciplinary research is situated at the interface of biology, mathematics, physics, statistics, and computer science and will combine a set of advanced theoretical and mathematical tools from these fields that so far have rarely been utilized together. it

will be pursued in an international collaboration, funded jointly through national science foundation ? division of mathematical sciences and the u.k. engineering and physical sciences research council, and provide advanced training for a postdoctoral research fellow at the university of leeds and a graduate student at virginia tech. conceptual and technical advances in the basic understanding of complex interacting systems in general, and specifically of spontaneous pattern formation under the combined influence of intrinsic noise and environmental variability, are anticipated, and will be disseminated to the scientific community at tailored workshops to be organized alternatingly at leeds, u.k. and blacksburg, virginia. while population dynamics traditionally ignores fluctuations and considers static and homogeneous environments, demographic noise arising from randomly occurring birth or death events as well as external environmental variations play a crucial role in understanding the eco-evolutionary dynamics of a population in time. the interdependence of external environmental variability and internal demographic noise is poorly understood to date, but it is of eminent importance, for example in microbial communities, which are often subject to sudden and extreme environmental changes. in particular, modelling populations of varying size and composition subject to changing external factors is crucial to gain a full understanding of the evolution of microbial antibiotic resistance. standard theoretical techniques, like mean-field approximations or system-size expansions cannot be straightforwardly used, and new mathematical approaches are needed. a suite of novel theoretical methods, based on and combining evolutionary and nonlinear dynamics, deterministic and stochastic partial differential equations, agent-based computer simulations, and tools from non-equilibrium statistical physics such as dynamical scaling theory, renormalization group approaches to critical phenomena, and mathematical representations of stochastic kinetics in terms of continuum field theories, will be developed. the goal is to design and quantitatively characterize biologically relevant evolutionary models of increasing levels of complexity, which incorporate both switching environmental features and fully account for the underlying stochasticity. these theoretical advances will be utilized to generate directly testable predictions for laboratory experiments to further explore how demographic noise and environmental

variability conjointly influence the emergence of collective features and affect species coexistence and their organization into spatial patterns. this project is jointly funded by the mps division of mathematical sciences (dms) through the mathematical biology program and the ls-biotech venture fund, and the division of materials research (dmr) through the condensed matter and materials theory program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Catalyzing STEM Gender Equity at Drexel: Building a Foundation for Systemic Transformation

Awardee: Drexel University

Amount: \$300,000.00

Abstract: it is fundamentally important to ensure **\*\*diversity\*\*** and equity across the career lifespan of faculty in science, technology, engineering, and mathematics (stem). motivated by this core tenant and priority for drexel university, the long-term goal for this project team is to create a pipeline of outstanding, diverse women leaders at drexel. however, this can only be accomplished through the retention and promotion of women faculty at the institution. drexel has a long history of recruiting talented women faculty at the assistant professor level, who are then promoted to associate professor. however, a recent internal audit identified a consistent and persistent gap in promotion to full. the gap is particularly stark for underrepresented minority women. this study is designed to evaluate the current policies, procedures, and practices at drexel for faculty transitioning from associate to full professor, identify best practices developed through other advance programs, and to use this insight to develop an evidence-based fair and equitable promotion policies, procedures, and practices for use campus-wide. recognizing the need to eliminate systemic gender and race barriers impeding progress across the academic lifespan, this project will focus on the intersections of gender and race/ethnicity, while also paying attention to gender identity and expression, country

of origin, different abilities, family status, and faculty appointment type and rank. Drexel prioritizes **diversity** and equity for university leadership. This project aims to develop a transparent and sustainable professional "roadmap" to professor, which is essential for attaining gender parity and **diversity** at that rank. The three goals of this project are: 1) understand the policies, procedures, and practices that negatively impact or facilitate women's retention and promotion to full professor; 2) identify best-practice strategies developed by other advanced institutions that might be tailored to fit Drexel's context; and 3) utilize findings to create a comprehensive strategic action plan for developing inclusive and diverse leadership at Drexel University. This two-year mixed-method study will prepare Drexel for future data collection and data analyses of faculty equity which can be used by institutional leadership to inform decision-making. The advance "catalyst" work will also prepare the institution to implement evidence-based strategies to enhance retention and promotion for all faculty which will be outlined in a five-year faculty equity strategic plan that will be produced as part of this project. Results will be disseminated via conferences, peer-review publications, industry press, popular media, and shared with other advanced institutions. The NSF Advance program is designed to foster gender equity through a focus on the identification and elimination of organizational barriers that impede the full participation and advancement of diverse faculty in academic institutions. Organizational barriers that inhibit equity may exist in policies, processes, practices, and the organizational culture and climate. Advance "catalyst" awards provide support for institutional equity assessments and the development of five-year faculty equity strategic plans at an academic, non-profit institution of higher education. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Understanding the Role of Undergraduate Research and Mentoring in the Self-Efficacy, Identity, and Success of Engineering Undergraduate Students

Awardee: University of Memphis

Amount: \$299,998.00

Abstract: this project aims to serve the national interest by improving academic success and broadening participation for engineering students at the university of memphis. it has been shown that engineering identity and self-efficacy play a role in student retention and graduation rates. this study will examine the impact of mentoring and undergraduate research on developing students' engineering identity and self-efficacy. an important aspect of the project is understanding how the proposed interventions in research and mentoring can aid college students who may not see themselves as "fitting in" with engineering as a means of broadening participation. this project will increase the use of undergraduate research as part of the curriculum, make research experiences accessible for all students, and promote broadening participation in engineering. the project team will adapt, implement, research, and evaluate a targeted active learning focused undergraduate research experience for which students will receive course credits towards their baccalaureate engineering degree. using peer and faculty mentoring, students who begin research as early as their first year in college will continue in research and mentoring throughout their time as undergraduate students. it is expected that these interventions will help improve academic success and persistence as well as broaden participation in the engineering workforce. the project goals are to improve academic success, retention, **\*\*diversity\*\***, and inclusion in engineering at the university of memphis by integrating educational interventions such as active learning through project-based research opportunities and peer mentoring that involves networking and role modeling. the educational interventions are designed to foster the development of engineering identity and self-efficacy in undergraduate students. project activities that aim to foster an inclusive culture in engineering include research training units, innovation seminars, and mentoring. the successful implementation of this project is expected to increase awareness and interest in engineering majors and provide a new approach to recruiting students to engineering. important outcomes of the project will be: 1) improving retention of all students in engineering; 2) making engineering majors at the university of



memphis more accessible to undecided freshmen, particularly for the purpose of broadening participation; and 3) supporting engineering identity growth, self-efficacy, and a sense of belonging for undergraduate engineering students. though other projects have investigated some of the components addressed in this project, few have looked at them collectively, as this project will do. as such, this project will generate new knowledge in how to recruit, retain, and broaden participation in undergraduate engineering. in addition, memphis area community college students and high school students will engage in research and mentoring through a one-day summer summit. the adapted undergraduate research and mentoring model will be disseminated through an established consortium and to other interested institutions. project results will be disseminated through conference presentations and journal publications as well as through a dedicated website. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the engaged student learning track, the program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: ADAPT: AI Guided Design and Synthesis of Semiconducting Molecules

Awardee: Trustees of Boston University

Amount: \$299,995.00

Abstract: understanding how atoms and molecules combine to form more complex molecules and materials is fundamental to chemistry. yet, there are more ways that atoms can be arranged into molecules than there are actual atoms in the universe. chemists typically rely on experience, literature accounts, and ad hoc criteria for designing and prioritizing molecules for specific applications, often resulting in a monumental effort. furthermore, when considering the synthesis of new molecules using tried or untried reactions, chemists must often speculate, relying on instinct

rather than ground truths. the pis will apply and extend several aspects of artificial intelligence (ai) to develop a general platform that will facilitate data-driven property prediction and synthesis of semiconducting materials, focusing on blue light-emitting materials. as a result, this project will expedite the discovery of novel organic semiconductors that can be synthesized efficiently, with optimized properties for target applications. the inclusion of a diverse team of graduate students in this work from the pis? research groups will broaden participation and help create an ai-aware workforce in the context of chemistry and materials science. the research focus will be on optimizing the design of blue light-emitting materials using ai. to carry out this objective, the project will proceed with two parallel experimental tracks connected by an ai platform. in the first track, data and computational models will be used to train ai machine learning and experimental design modules for molecular-pair inputs. this will provide a workflow that is fully containerized, enabling the design of robust blue light-emitting molecules. in the second track, the focus will be on extending the potential chemical space that can be integrated into the first track design concept. this will dramatically increase the **\*\*diversity\*\*** of semiconducting materials that can be explored and provide a roadmap for how to make new, unexplored molecular frameworks with desired properties. the project will incorporate concepts and techniques from high-dimensional sparse regression, machine learning with graph inputs, and discrete optimization. the resulting dual mode platform (property design/synthesis design) will provide an unprecedented level of prediction, making the design and manufacturing of materials a more efficient and automated process. at the same time, novel statistical machine learning and experimental design algorithms are expected to emerge in addressing chemistry problems involving molecular pairs as inputs. this project also provides new opportunities for undergraduate and graduate student training in materials and computational chemistry. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Testing the Effectiveness of a Digital Tool, Tandem, in Assessing and Supporting Inclusive and Equitable Teamwork in Engineering

Awardee: Regents of the University of Michigan - Ann Arbor

Amount: \$299,983.00

Abstract: this project aims to serve the national interest by improving how teamwork in introductory engineering courses is assessed and supported, with specific focus on equity and inclusion. learning how to work effectively in a team is clearly an important goal for preparing undergraduate engineering students. however, supporting inclusive teamwork remains challenging. marginalization on teams has been linked to aspects of students' social identity, such as identifying as a woman or person of color. it can take a variety of forms, including ideas going unheard or being pushed into more menial tasks. particularly in introductory courses and at large colleges and universities, engineering instructors face the additional hurdle of having many students and student teams. with these compounding factors, it is difficult for instructors, and even students themselves, to be aware in real-time when inequitable behaviors are occurring on their teams, and to know how to address them. the consequences of inequitable teams are serious, leading to inequities in mastery experiences and ultimately contributing to students leaving engineering degree programs. to address this problem, this project introduces a digital pedagogical tool, called tandem. tandem holds promise for disrupting inequitable team behaviors. developed at the university of michigan, tandem is a multi-faceted tool for course teams that delivers tailored lessons to students about effective teamwork. the tool provides feedback to students and instructors about how teams are doing. the objective of this project is to study the effectiveness of tandem in assessing and supporting inclusive and equitable teamwork in engineering. this project seeks to improve the **\*\*diversity\*\*** of students that participate in engineering as well as improve novel educational tools. further, the project will address two components of the research agenda outlined in the national research council's discipline-based education research report. this includes conducting research that: 1) seeks to understand similarities and differences between student groups that differ by, for example, gender

and race/ethnicity; and 2) goes beyond assessing gains in conceptual understanding by focusing on outcomes associated with affective dimensions of learning. using mixed method study designs, this project will address the overall objective through the following research questions: 1) in what ways can tandem be used to observe inclusive and equitable teamwork in engineering? and 2) in what ways can tandem be used to support more inclusive and equitable teamwork in engineering? while tandem is currently being used across a range of courses at the university of michigan, the scope of the project will be limited to engineering 100, the cornerstone first-year engineering design course. engineering 100 is a useful context in part because small differences in teamwork experiences early in a student's college coursework can be magnified in subsequent team project experiences and because the first and second years in college are considered the most impactful in terms of retention and persistence of stem majors. key data sources include data from student surveys and responses to lessons collected throughout the term in tandem, student interviews, and observations of engineering student teams during class meetings. the expected outcomes from this work include 1) generalizable knowledge about an approach to measuring teamwork competency that emphasizes inclusion and equity and fosters instructor and student awareness of inequitable team behavior, 2) improvements to survey and lesson features within tandem that will support the ability of teams to behave inclusively, and 3) improved pedagogical practice in this engineering course context. the positive impacts of this project will be further propagated through the use of tandem in other team-based courses at the university of michigan as well as at other institutions. this project has transformative potential in the tailored support that tandem can provide to instructors and students in recognizing and addressing inequitable behavior in teams and promoting conditions in which all can be successful. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the engaged student learning track, the program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts

review criteria.

Matched Words: diversity

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Title: Collaborative Research: FET: Medium: Neuroplane: Scalable Deep Learning through Gate-tunable MoS<sub>2</sub> Crossbars

Awardee: Purdue University

Amount: \$299,742.00

Abstract: the increasing complexity of deep-learning systems has pushed conventional computing technologies to their limits. while the memristor is one of the prevailing technologies for deep-learning acceleration, it is only suited for classical learning layers where two operands, namely weights and inputs, are processed at a time. meanwhile, to improve the computational efficiency of deep learning for emerging applications, a variety of non-traditional layers, requiring concurrent higher-order processing of many operands, are becoming popular. for example, hypernetworks improve their predictive robustness by simultaneously processing weights and inputs against the application context. two-electrode memristor grids cannot natively support such operations of emerging layers. addressing the unmet need, this research will develop neuroplane -- a novel deep-learning accelerator of gated memtransistor crossbars. exploiting crossbars' gate controllability, multiple operands can be processed within the same crossbar unit in neuroplane. many advanced inference architectures that can generalize beyond a typical passive crossbar will thus be possible. overall, the ultra-low-power, higher-order processing of neuroplane will harness high robustness and efficiency of emerging deep-learning layers within area/power-constrained devices such as mobile, sensor, and embedded systems. the investigators will develop fabrication methods for nanometer node gate-tunable dual-gated crossbars of mos<sub>2</sub> memtransistors. a self-aligned fabrication method with defect passivation and process variability compensation will be created. exploiting the gate-tunability of mos<sub>2</sub> memtransistors, a new generation of crossbar platforms with many runtime control knobs will be developed, rendering the design a high elasticity

and agile computing space. for example, computing methods will be created for the gated crossbars to utilize crossbar elements for product-sum digitization, thereby preventing the critical overheads in current crossbar technologies. similarly, control-flow methods will be developed for gated crossbars to adapt their inference paths depending on the input characteristics by dynamically deactivating input/output neurons to conserve processing energy. a coherent collection of software and hardware-based correction techniques is proposed to minimize the impact of process variability. unlike the current schemes, by following the train-once-deploy-anywhere tenet, the proposed crossbar correction methods can scale to millions of deployments without considerable overhead. an annual workshop will be conducted at local high schools with substantial ethnic and gender **\*\*diversity\*\*** to mentor underrepresented students. undergraduate research projects will be sponsored using paid summer internships and university-level programs such as summer undergraduate fellowship. an inter-university senior-design mentoring program will be created for students among participating institutions. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: IRES Track 1: The long-term impacts of extreme climate events on the behavioral ecology, fitness and population viability in wild bottlenose dolphins, Australia

Awardee: Georgetown University

Amount: \$299,599.00

Abstract: this international research experience for students program will support at least three u.s. undergraduate and two u.s. graduate students each year (15 students in total) to collaborate with researchers in australia to investigate the long-term impacts of an extreme marine heat wave on a population of indo-pacific bottlenose dolphins (*tursiops aduncus*) that has been studied since 1984. students will conduct field work in shark bay, western australia (a unesco world heritage site with the

highest vulnerability rating according to the climate change vulnerability index), and then wet-lab work at the university of the sunshine coast (queensland, australia). students will use behavioral and genetic data to answer three questions regarding the dolphin population: 1) how does individual dolphin behavior change when their habitat is disrupted? 2) how does the individual's social environment and foraging strategies affect their ability to respond to environmental change? and 3) how does habitat fragmentation affect genetic and social connectivity throughout the population? students will gain computational, field and wet-lab skills from addressing these research topics, as well as policy skills and broad socio-cultural and biological perspectives on wildlife management from their collaborations with local stakeholders and government researchers. in this program students will be afforded a unique opportunity to study genotype-environment interactions in the wild, and bring back tools to apply to local conservation issues and wildlife management in the us.

in this program students will be afforded a unique opportunity to study genotype-environment interactions among wild dolphins, studied since 1984, and their responses to an extreme climatic event in a global bio\*\*diversity\*\* hotspot. in 2011, the most extreme marine heat wave on record devastated the shark bay ecosystem, leading to a 90% reduction in foundational seagrass coverage, the collapse of local fisheries, and significant changes to the abundance and distribution of marine megafauna, including bottlenose dolphins. shark bay dolphins exhibit a diverse behavioral repertoire including tool use, multiple foraging tactics, highly differentiated social bonds, and distinct social and ecological phenotypes. this behavioral heterogeneity allows us to investigate the adaptive value of such traits in the decade before and after exposure to an extreme climate event. student-led research will investigate the widespread impacts on the dolphin population, focusing on three areas of inquiry including fine-scale population structure, individual social and foraging behavior, and individual variation in reproductive success after the heatwave. our long-term 37+ year database of behavioral, ecological, genetic, and demographic data will allow students to analyze baseline population dynamics, parameterize simulations, and develop hypotheses. next, while in the field, undergraduate and graduate students will work together to collect data continuing

a decade-plus assessment of the behavioral and fitness consequences of environmental disturbance. participants will be trained by expert Australian collaborators in genetic data analysis and the study of genotype-environment interactions. students will analyze population changes in the context of their impact on inbreeding potential, resource competition, social networks, and ultimate fitness consequences. the proposed integration of animal behavior and landscape genetics will advance our understanding of ecological and evolutionary principles by leveraging a natural experiment in rapid environmental change. this program affords a diverse group of students from the DC-Metro area international research experience in meeting some of the biggest environmental challenges we currently face. by contrasting local systems with international systems facing different environmental conditions, managed by different governments, with distinct regional complexity, students will gain extensive insight into pressing conservation problems. this award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: StEM: Stimulate, Engage and Motivate student research by enhancing the research capacity (CISE-MSI: RCBP-ED: IIS ? III)

Awardee: SUNY College at Old Westbury

Amount: \$299,498.00

Abstract: this award is funded in whole or in part under the American Rescue Plan Act of 2021 (Public Law 117-2). exposure to research is one of the best predictors of degree completion and success in postgraduate education among students pursuing degrees/careers in STEM fields. however, only a small percentage of undergraduate students are engaged in research. this lack of participation has been attributed to factors such as interest in more applied experience, lack of awareness about research opportunities and their benefits, lack of time, lack of interest, perceived barriers to interactions with the faculty, and personal and financial barriers. the problem further aggravates with



little participation from underrepresented minority groups. additionally, biases in several sectors of computer science are evident due to the historical underrepresentation of researchers. significant evidence shows that engaging undergraduate students in research builds confidence and efficacy, motivates them to pursue advanced graduate level stem courses, increases retention in majors having high attrition rates, and acclimates them to the demands of a research environment. in addition, underrepresented minority groups students? participation in research is beneficial to the field as it enhances **diversity** in the stem workforce. the goal of this project is to stimulate, engage, and motivate graduate and undergraduate stem students, including from underrepresented minority groups to conduct data research in different domains, while supporting expansion and enhancement of research capacity to provide more research opportunities to the diverse student population and the faculty. this goal will be achieved by following a three-pronged approach to 1) enhance and expand the technological infrastructure by acquiring new equipment to facilitate computational processing and big data analyses; 2) embed research within the curriculum for existing courses via cure and introduce new research-focused programs and courses; and 3) motivate and engage students in research activities and provide hands-on experience via research projects, training, seminars, and workshops through guidance and mentoring by academia and industry experts. the award will improve the academic and professional skills of stem students, in particular female and other underrepresented minority students, provide an opportunity to work with experienced research mentors and present/publish their work, create educational materials for long-term enhancement of academic curricula, and foster knowledge and promote the developmental skills to prepare students for data science and big data careers. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: IRES Track I: Engaging students in management oriented research to conserve rainforest

primates in Uganda

Awardee: CUNY Hunter College

Amount: \$299,439.00

Abstract: to successfully conserve rainforest primates, the current challenges affecting their survival in the wild need to be identified and addressed. this type of research requires interaction among scientists and wildlife managers to solve conservation problems. through this ires funded project, u.s. undergraduates and first year graduate students from hunter college of the city university of new york will conduct integrative management-oriented research that is aimed towards addressing primate conservation in uganda. during 8-week summer experiences over three years, eighteen students will conduct collaborative research with park wardens of the uganda wildlife authority in kibale national park, uganda, a tropical rainforest national park that hosts high densities of primates. students will tackle problems related to three pressing conservation themes: 1) global change and primate nutrition; 2) ecotourism of wild apes; 3) invasive plant species in primate habitats. by undertaking this research, students will be involved in an immersive experience in uganda where they will gain field experience and learn about ugandan culture at makerere university's biological field station. they will develop their scientific skills by writing a research proposal that addresses primate conservation, constructing testable hypotheses and conducting fieldwork. students will then analyze, report and discuss their results in several forums in uganda and the usa. they will learn how to communicate their results through the media in uganda by working alongside journalists and public relations professionals. hunter college is a minority serving institution and at least 50% of the students selected for this experience will be underrepresented minorities in the sciences. global change has pressing outcomes for tropical forests and their inhabitants even when they are protected in national parks. this is particularly true for monkeys and apes, because they grow more slowly, have longer lives and modest reproductive rates compared to most other mammals. to successfully conserve primates, empirical research needs to be combined with effective management. twelve undergraduates and six master's students will conduct research for eight

weeks in three summer cohorts in Kibale National Park, Uganda, a tropical rainforest in western Uganda that hosts a high **diversity** and density of primates. Students will investigate management-oriented research questions that will promote primate conservation under the guidance of Uganda Wildlife Authority professionals. They will engage in research foci under three themes: (1) students will investigate primate feeding ecology, nutritional chemistry of tree leaves, food availability and food density, and compare current patterns with long term datasets; (2) students will examine different parameters of ecotourism in relation to how it might affect chimpanzee ecology and behavior; (3) students will explore the ways that invasive and exotic shrubs affect plant community **diversity** and the primate food supply. At least half of all the student researchers will be underrepresented minority undergraduates and graduate students in STEM. Students will participate in conservation efforts and integrate their research into conservation plans. They will learn how to prepare media briefs and communicate their research findings to the Ugandan public. Students will also present their research within several forums in New York City, at Hunter College and in Uganda. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Dynamics of Seasonal Forecast Uncertainty: Cross-Basin Ocean-Atmosphere Interactions

Awardee: University of Texas at Austin

Amount: \$299,130.00

Abstract: Every few years the Pacific Ocean warms dramatically in a narrow strip along the equator extending roughly from the South American coast to the dateline. This warming is called an El Niño event, and El Niños and their cold La Niña opposites are referred to collectively as El Niño/Southern Oscillation (ENSO) events. While ENSO events are broadly similar there are important differences, in

particular they differ in whether the sea surface temperature (sst) change is greatest in the eastern or central pacific. they also differ in their magnitude, and el nino events are often stronger than la nina events. the consequences of enso are felt worldwide, from changes in the indian monsoon to the severity of winters in canada, and these impacts vary according to the pattern and magnitude of the event. the dynamical mechanisms that cause **\*\*diversity\*\*** in behavior among enso events and their global impacts are thus an important practical problem as well as a topic of scientific interest.

this project examines the idea that much of the **\*\*diversity\*\*** of enso events occurs because of interactions between the developing enso event and a variety of less prominent climate variability modes occurring over the global oceans. for example the pacific meridional mode (pmm) is a variability pattern in which fluctuations of the aleutian low over the north pacific generate warm ssts (or cold, in the opposite phase) which propagate slowly toward the equatorial pacific through air-sea interactions. the overlap between the domains of the pmm and enso makes the pmm a likely suspect in diversifying enso events. likewise, the episodic warming of the indian ocean in the indian ocean dipole (iod) mode affects the trade winds in the western pacific, with potential consequences for enso given the central role of trade wind fluctuations in enso evolution. to examine the effect of secondary modes on enso **\*\*diversity\*\*** the principal investigators (pis) of this award take advantage of the ensemble method used to predict enso events. ensemble prediction means using a climate model to predict enso based on observed initial conditions (the state of the atmosphere and ocean at a given time) but performing several forecast simulations instead of one, and starting each forecast simulation with slightly different initial conditions. the resulting perturbed initial condition ensemble (pice) gives a best estimate of the evolution of enso and also estimates the uncertainty in the prediction. the idea of this project is that the individual forecast simulations in a pice contain different secondary modes, and the interactions between secondary modes and enso can be assessed by examining differences in enso evolution among the simulations. an advantage of this method is that a large database of pice simulations has been created by the earth system prediction (esp) working group of the community earth system model (cesm). the pice dataset provides a

much larger sample size than the observational record, thus statistically robust results can be obtained. the work is of societal importance given its direct connection to enso prediction. in addition to its examination of enso evolution in prediction simulations the research uses the pice simulations to understand how differences among enso events lead to differences in the impacts of enso in populous parts of the world. the project also supports two graduate students and provides internship opportunities for undergraduates. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Supporting Diversity to Increase Innovation: Building New Mexico's Computer Information Systems Technician Workforce through Equity and Inclusion

Awardee: Central New Mexico Community College

Amount: \$298,757.00

Abstract: the department of labor estimates that more than a million computing-related job openings will be available in the u.s. by 2024. it also estimates that more than two thirds of these jobs could go unfilled due to an insufficient pool of qualified applicants. addressing the underrepresentation of women and other minoritized groups in the computing workforce will help to close this predicted employment gap. evidence suggests that the resulting increased **\*\*diversity\*\*** of the workforce can also lead to increased productivity and better problem solving in the workplace. this project will investigate how to recruit, retain, and prepare women and minoritized students to pursue careers in computer information systems (cis). project goals include: 1) providing cis faculty at central new mexico community college with resources to support and retain traditionally underrepresented groups in cis technician majors; 2) introducing high school students to careers in cis, with a focus on girls and students from other minoritized groups; 3) preparing these students for success in postsecondary cis pathways; and 4) strengthening high school teachers' knowledge and understanding of cis careers. project efforts will focus on the entire pipeline, from high school teachers and students to college faculty and students in the cis program. the project intends to broaden participation in cis by recruiting high school students from minoritized groups, including women, into cis career pathways and supporting their success within the pathway. the project will leverage multiple approaches including providing high school students with cis skills workshops, paid internships, and courses that provide dual enrollment credit. it will also train college faculty to better support the educational journeys of all their students using customized curriculum. quantitative instruments will be developed to monitor the impact of activities on high school students.

descriptive statistics will be used to determine the baseline perceptions of cis and confidence in ability to learn cis skills. the student cohort will be surveyed over time to measure changes in attitude and behavior, as well as changes in their intention to pursue cis education after high school. this project is funded by the advanced technological education program that focuses on the education of technicians for the advanced-technology fields that drive the nation's economy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Unconventional High Surge Impedance Loading Transmission Line

Awardee: Virginia Polytechnic Institute and State University

Amount: \$298,507.00

Abstract: to achieve net-zero emission in america by 2050, high voltage transmission capacity must expand ~60% by 2030 and triple by 2050 to connect further wind and solar facilities to demand. this expansion requires a capital investment in transmission capacity of \$360 billion by 2030 and \$2.4 trillion by 2050. we will fail to achieve a net-zero america by 2050 unless high-capacity overhead lines are developed. to tackle this problem, we will (i) develop a revolutionary and flexible design for transmission lines by shifting phase configurations and sub-conductors into unconventional arrangements that are geometrically optimized within the space, enabling a given high surge

impedance loading (hsil) design, and (ii) create and introduce a novel transmission expansion planning (tep) framework, where, given the possibility provided in (i), line parameters that do not play a role in traditional tep will now play key roles as variables in this new framework. this will lead to cost-effective planning scenarios and huge savings that cannot be achieved through conventional transmission lines. by combining (i) and (ii), this research plan introduces a new concept that we call smart tep-based unconventional hsil line designs that will revolutionize power delivery. the integrated education plan train the next generation of power engineers needed to maintain the competitive vitality of the u.s. workforce. we also collaborate with the center for the enhancement of engineering **\*\*diversity\*\*** at virginia tech on k-12 outreach activities designed to attract women and ethnic minorities to the field of electrical engineering. the proposed research pioneers power transmission loadability enhancement at the nexus of tep and unconventional hsil line design. the original and potentially transformative idea of engaging unconventional hsil line designs that address tep requirements is the cornerstone of this project. where conventional transmission lines fail due to insufficiencies in their self-reactive power compensation, unconventional hsil designs can (1) significantly increase power transmission loadability, (2) be creatively used for extra-high voltage, high voltage, and medium voltage levels for both transmission and distribution networks, and (3) decrease the need for lumped reactive power compensators. on the line design side, a very complex optimization problem will be solved to determine the optimal size, number, and location of sub-conductors in the space. another aspect is that tep itself has always been a complex optimization problem. in this research plan, we will complicate it further by making the line parameters that were fixed and predetermined in traditional tep now be variables. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Non-Profit and HBCU Collaboration to Establish a Plant Phenotyping Data Science

## Course-Based Undergraduate Research Experience

Awardee: Donald Danforth Plant Science Center

Amount: \$298,206.00

Abstract: this project aims to serve the national interest by increasing the **diversity** of students in the stem pipeline through the provision of opportunities for undergraduates at a historically black university to collaborate with plant and data science researchers via a course-based undergraduate research experience (cure). a vibrant and diverse stem pipeline is critical to the nation's economy, innovation capability, and economic prosperity. in the united states, this stem pipeline relies on diverse backgrounds, viewpoints, and experiences to improve innovation and outcomes, yet the participation of minority ethnic groups like african americans in the pipeline remains lower than their representation within the population as a whole. recommendations for building and sustaining a diverse and robust pipeline in stem call for increasing the number of mutually beneficial collaborations between faculty at historically black colleges and universities (hbcus) and scientists in traditionally white academic institutions. expansion of such collaborations would enable the numbers and types of authentic research experiences available to undergraduate students at hbcus to increase. current efforts to improve undergraduate stem education include the adoption of cures that can successfully engage large numbers of undergraduate students in authentic scientific research. cures in diverse disciplines including biology, biochemistry and chemistry are gaining prominence in undergraduate institutions as a successful strategy for growing the stem pipeline, but they are not prominent at hbcus. through this project, the donald danforth plant science center (ddpsc), a non-academic, non-profit plant science research facility, and harris-stowe state university (hssu), a hbcu, are collaborating to develop and offer a plant and data science cure. the overall goal is to increase the number of minoritized students in the stem pipeline. the american association for the advancement of science (aaas)'s 2011 report, vision and change, recommended that the biology education community prioritize providing opportunities for students to practice science through active engagement in research rather than just reading about it. experiences in research for

undergraduate students are known to greatly contribute to academic achievement, future career interests, and increased self-efficacy. despite such benefits, these research experiences have historically not been readily available to entire classrooms of students at minority-serving institutions. this project will enhance the scientific research skills of underrepresented racialized minority students through a cure which will train student in cutting-edge skills in image analysis and data science techniques, using image datasets from current scientific research studies. by major and by course (biology vs math) we will analyze various student learning outcomes, including self-efficacy, attitudes towards data science, position on a knowledge acquisition curve, and laboratory course assessment survey (lcas) scores. we will include in our model variables that might impact knowledge acquisition and self-efficacy using a generalized linear model (glm) that includes attitude, gender identity, race/ethnicity, educational background, major, and scores for collaboration, discovery/research, and iteration. to determine how collaborating with data scientists impacts students? perceptions of their role in research, we will use a mixed methods approach of analyzing the lcas results which will quantify student?s perceptions of their engagement in collaboration, discovery/research, and iteration. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the engaged student learning track, the program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: Tracking the movement and strength of the Northern Hemisphere westerlies over the last glacial cycle.

Awardee: Columbia University

Amount: \$297,771.00

Abstract: the westerly wind belts are a key part of the climate system. knowing the strength and position of the westerlies during different climate states and across abrupt shifts in climate would provide insight into the mechanisms of climate variability. studying the westerlies during past warm

intervals is particularly important because modern observations of weather patterns suggest that the westerly winds are moving poleward in response to global warming. the proposed study will document the strength and position of the northern hemisphere westerlies using sediment records of dust accumulation and upper ocean biological productivity. sediment cores from sites in the north pacific ocean will cover the last 150,000 years. they will include the most recent global warm interval roughly 130,000 to 115,000 years ago. the broader impacts of the proposed study include support for a postdoctoral fellow. the study also will provide opportunities for including high school students in hands-on research through the lamont high school intern program. that program builds on existing partnerships with new york city and rockland county high schools to recruit students from groups underrepresented in the earth sciences.

this proposed study will produce five ~150 kyr dust, productivity, and grain size records from the north pacific ocean to characterize the westerly winds during various mean climate states (peak interglacials of mis 5e and the holocene as well as peak glacials of mis 6 and the last glacial maximum), and how they respond to abrupt climate changes during terminations i and ii. these records will use samples from five marine sediment cores from a recent rv sonne research cruise to the north pacific (so264) that encompass ~15° latitude. these data will fill a gap in the current picture of a key region in the northern hemisphere and will serve as benchmarks for modeling studies. these datasets will be useful to both the paleoclimate and modern/future climate modeling fields, as they will provide constraints on the natural variability of the westerlies to changes in potential driving mechanisms such as ice volume and atmospheric temperature gradients, thus aiding essential modeling of future changes in the westerly winds. finally, the results of this work could serve as the impetus to perform similar studies in other regions of the world, such as the southern hemisphere, allowing questions related to hemispheric synchronicity of atmospheric circulation across various climate regimes to be addressed. the pi is the co-chair of the new lamont ldei task force and is deeply involved in implementing **\*\*diversity\*\*** programs on all levels, including active recruitment of underrepresented minorities in the geosciences. interpretations and conclusions drawn from this work will be brought to the public via

non-technical settings such as the annual lamont-doherty open house. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CISE-MSI: RCBPP-RF: SHF: Towards Efficient, Reliable, and Secure Chaotic Communications in Wearable Devices

Awardee: California State University-Long Beach Foundation

Amount: \$297,448.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). wearable and portable sensors are finding their way into everyday life, not only as tracking devices but as diagnostic and treatment devices. wearable wireless devices require efficient secure communication solutions that meet the resource-limited requirements of such devices. to facilitate secure communications for low-power, implantable, portable, or wearable sensors, the encryption process must be integrated directly with the sensor's underlying hardware. chaotic circuits can be used to secure communication of resource-limited devices. chaotic systems are highly complex, unpredictable, and sensitive to their initial condition. however, they can be used to generate predictable responses if certain requirements are met. chaos can be utilized to hide data under noise, thus providing data confidentiality if used in wireless communication. on the other hand, applications of chaos in secure wireless communication have been limited to laboratory research. lack of solutions that maintain both ends of communication (transmitter and receiver) synchronized in real-world applications has limited the use of chaotic communication to research laboratories. to eliminate these issues and provide an efficient, reliable, and secure on-chip chaotic ciphering transmitter and receiver, this research aims to accomplish the following objectives. phase 1: delivering a chaotic low-power transmitter and receiver capable of real-time ciphering of sensory signals. phase 2: securing the underlying hardware of chaotic communication against piracy



and duplication by adopting a provably secure logic locking framework specifically designed for such systems. phase 3: developing efficient smart and machine learning algorithms to provide a dynamic matching of the transmitted and received signal. phase 4: ic prototyping and implementing the design in the physical form to ensure the functionality of the design. this research brings researchers from the department of electrical engineering and department of computer engineering and computer science in california state university long beach to provide a logic locked transmitter and receiver that can code and decode the signal using chaos in an efficient and reliable manner. the financial burden of healthcare has been preventing many, most among minorities and underrepresented groups from monitoring their medical condition and seeking treatment. wearable technology has seen an unprecedented increase in adoption in the last decade and can reduce the cost of healthcare. it can provide accessible care if security is implemented on devices at the design. if such devices are designed with efficient security, the public confidence, and subsequently their adoption, will increase. california state university, long beach is a minority serving institute ranked number four for **\*\*diversity\*\*** among united states colleges. by engaging diverse students in designing, implementing, and testing secure solutions for wearable health devices, this project aims to expand participation in computing and communication research. furthermore, secure wearable devices can enhance trust and adoption of such health-monitoring devices and increase access to affordable healthcare and improve health equity. the general progress of the projects, results, and datasets will be shared publicly through the website and git repository. the obtained results from this research will be disseminated in the form of publications, technical presentations, design reports, educational materials, dataset, and source code, and will be hosted publicly for the length of this project and beyond, on the investigator's website and git repository. the project git repository: [https://github.com/ahedaya/csulb\\_nsf\\_cise\\_msi](https://github.com/ahedaya/csulb_nsf_cise_msi) the project website: <https://avahedayatipour.com/research/hardwaresecurity> this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Geoheritage and Two-Eyed Seeing - Advances in Interdisciplinary Earth Science Research, Learning, and Inclusion through Shared Ways of Knowing

Awardee: Michigan Technological University

Amount: \$296,686.00

Abstract: geoheritage and two-eyed seeing (gts) is an exploratory place-based project that combines indigenous knowledge with geoscience education and research. a project team that crosses disciplines, generations and cultures will study dynamic and interconnected geologic and human stories about the landscape's past, present, and future. the project will employ equitable knowledge exchange and other ways of knowing to understand the foundations of earth processes. gts aligns with the pressing societal need to expand and support **\*\*diversity\*\*** in the geoscience community. the project engages innovative interdisciplinary perspectives and new expertise, which challenges conventional ways of thinking about the earth. the project aims to broaden considerations of the relationships between people, landscapes, and earth systems processes. the work is expected to contribute to the evolving field of geoheritage in the united states. results will demonstrate how braided knowledge system approaches nurture and complement deeper understanding of diverse perspectives and increase awareness of indigenous histories, language, and knowledge of geologic landscapes among the broader public. the diverse team will also cultivate social consciousness through shared dialogue on critical issues related to belonging, access, justice, equity, **\*\*diversity\*\***, and inclusion (bajedi) through amplifying currently underrepresented knowledge sets in the geoscience community. the project will result in the creation of a geoatlas that includes geologic, geographic and cultural data, which will be available to a range of stakeholders in the great lakes region. the project also engages tribal and non-tribal youth in digital storytelling and geoheritage research. in this project setting, the keweenaw region of michigan's upper peninsula on lake superior, gts explores relationships with the earth through the

lens of both anishinaabe-gikendaasowin (anishinaabe knowledge) and western science with two objectives: 1) the creation of a geoatlas ? a publicly accessible, exploratory geoheritage database that combines physical, cultural, and geographic datasets that will serve the scientific community, educators, local tourist entities, land use planners, and the broader public; and 2) cultivate youth leaders by fostering cultural competency in tandem with other essential skills for career paths in the geosciences. to achieve these goals an interdisciplinary team of great lakes indigenous knowledge holders, geoscience/geospatial researchers, and two cohorts of tribal and non-tribal youth will braid knowledge sets documenting the way that nibi (water), mishomis grandfathers (rocks), miskwaabik (copper), and geologic processes have guided and continue to mold culture and life. these qualitative data will be integrated as innovative geoheritage data layers in the geoatlas expressing these relationships in a holistic way offering potentially transformative impacts for the development of digital storytelling and long-term geoheritage research and increased cultural competency among the broader public. further contributions of this work include: a) cultivating a diverse geoscience community by introducing youth to geoscience career pathways through multi- disciplinary, -cultural, and ?directional learning about earth systems processes; b) creating foundations for transformative place-based, inclusive, and culturally-appropriate k-12 earth science and higher education geoheritage curriculum, both informed by gts project deliverables; and c) fostering a more diverse and equitable geoscience community through elevating currently underrepresented indigenous knowledge sets in the geosciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: CPS: Medium: RUI: Cooperative AI Inferencein Vehicular Edge Networks for Advanced Driver-Assistance Systems

Awardee: SUNY at Stony Brook

Amount: \$295,386.00

Abstract: artificial intelligence (ai) has shown superior performance in enhancing driving safety in advanced driver-assistance systems (adas). state-of-the-art deep neural networks (dnns) achieve high accuracy at the expense of increased model complexity, which raises the computation burden of onboard processing units of vehicles for adas inference tasks. the primary goal of this project is to develop innovative collaborative ai inference strategies with the emerging edge computing paradigm. the strategies can adaptively adjust cooperative inference techniques for best utilizing available computation and communication resources and ultimately enable high-accuracy and real-time inference. the project will inspire greater collaborations between experts in wireless communication, edge computing, computer vision, autonomous driving testbed development, and automotive manufacturing, and facilitate ai applications in a variety of iot systems. the educational testbed developed from this project can be integrated into courses to provide hands-on experiences. this project will benefit undergraduate, master, and ph.d. programs and increase under-represented groups' engagement by leveraging the existing \*\*diversity\*\*-related outreach efforts. a multi-disciplinary team with complementary expertise from rowan university, temple university, stony brook university, and kettering university is assembled to pursue a coordinated study of collaborative ai inference. the pis explore integrative research to enable deep learning technologies in resource-constrained adas for high-accuracy and real-time inference. theory-wise, the pis plan to take advantage of the observation that dnns can be decomposed into a set of fine-grained components to allow distributed ai inference on both the vehicle and edge server sides for inference acceleration. application-wise, the pis plan to design novel dnn models which are optimized for the cooperative ai inference paradigm. testbed-wise, a vehicle edge computing platform with v2x communication and edge computing capability will be developed at kettering university gm mobility research center. the cooperative ai inference system will be implemented, and the research findings will be validated on realistic vehicular edge computing environments thoroughly. the data, software, and educational testbeds developed from this project will be widely disseminated. domain experts in

autonomous driving testbed development, intelligent transportation systems, and automotive manufacturing will be engaged in project-related issues to ensure relevant challenges in this project are impactful for real-world applications. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Spectral Theory and Quantum Dynamics

Awardee: William Marsh Rice University

Amount: \$294,000.00

Abstract: this project aims to improve understanding of how the amount of disorder present in an environment can promote or suppress transport in a system. this issue is studied in the context of quantum mechanics at the atomic level. applications of new insights about quantum systems include the development of quantum computing devices and quantum algorithms. the project supports education and **\*\*diversity\*\*** through graduate student training, the supervision of undergraduate research, and the writing and publication of an introductory textbook on ordinary differential equations aimed at introducing undergraduate students to a rigorous treatment of this field. this project addresses the spectral analysis of schrödinger operators and unitary analogues of jacobi operators. these operators are relevant in many areas, primarily in quantum mechanics and approximation theory. the objective is to develop new approaches for the spectral analysis of these operators, and the methods employed range from functional analysis via harmonic analysis to dynamical systems and ergodic theory. the project also investigates the schrödinger time evolution in terms of transport and dispersion phenomena. the investigator seeks a complete spectral analysis of schrödinger operators with potentials generated by hyperbolic transformations, a proof of several conjectures in the context of orthogonal polynomials on the unit circle, an approach to proving zero-measure spectrum for multi-frequency schrödinger operators, and a study of quantum

dynamics from the perspective of transport exponents and dispersive estimates. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Effects of Mentoring Relationship Heterogeneity on Student Outcomes among NSF Research Experiences for Undergraduates (REU) Program Participants

Awardee: University of Utah

Amount: \$293,423.00

Abstract: understanding mentoring relationships is critical to increasing **\*\*diversity\*\*** in stem fields. researchers at the university of texas at el paso and the university of utah propose to study the effects of mentor relationship mismatch on student outcomes during nsf research experiences for undergraduates (reu) programs. this project aims to employ a novel approach to studying mentoring by examining multilevel mentoring and demographics of students and the mentor team. the project aims to collect data from participating students and mentors from across the country at the end of the summer research program and during the next year to gauge outcomes related to stem interest and persistence and intent to follow a stem career pathway. this project aligns with the ehr core research program's goal of addressing challenges in stem interest, learning, and participation.

the project aims to address three interrelated research questions, including how mentoring relationship heterogeneity impacts short-term and mid-term student outcomes, if these effects can be moderated by interactional dynamics between mentors and mentees, and how mentoring relationship heterogeneity impacts educational, research, and career goals immediately after the reu experience and after one year. mentoring relationship heterogeneity in context provides a conceptual framework focusing on how student mentees match with multiple mentors, including graduate students and post-doctoral researchers. the concept of programmatic heterogeneity will be used to measure the dissimilarity between students' demographic background and the

demographic composition of their reu program. post-reu surveys collected from the center for the improvement of mentored experiences in research (cimer) data will be used along with a matrix analysis of semi-structure individual interview responses. short-and mid-term student outcomes consist of immediate gains in working like a scientist, comfort with science skills, science identity, sense of clarity about career path, research productivity, persistence in stem major, and intent to pursue graduate school. the project seeks to advance knowledge about mentoring relationships and aims to produce mentor and mentee workshops to positively impact undergraduate research students from underrepresented groups. the project is funded by the ehr core research program that supports fundamental research focused on stem learning and learning environments, broadening participation in stem, and stem professional workforce development. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: BPC-DP: Building Ecosystems of Belonging for Neurodiverse Computer Science Students

Awardee: SUNY at Buffalo

Amount: \$293,110.00



Abstract: the university at buffalo's open education lab is designing and testing neuro\*\*diversity\*\* micro-credentials to create an ecosystem of belonging in undergraduate computer science programs. micro-credentials, similar to digital badges, are tools that can deliver bite-size curriculum and then both assess and verify learning for a given audience. in this case, students are the audience; this training is designed to increase instructor preparedness for teaching neurodiverse computer science students in undergraduate programs while presenting students with information about their instructors' training through digital badges. neuro\*\*diversity\*\* refers to differences in cognition and brain development common to conditions such as autism spectrum disorder and attention-deficit/hyperactivity disorder (adhd). these students are often attracted to stem career paths and possess traits that would make them valuable members of the united states' computing workforce, but drop out before graduation when they encounter misaligned teaching practices or instructors who discourage accommodations and supports for students with invisible disabilities. these micro-credentials are designed to give instructors the training they need to be able to transform their practice for neurodiverse undergraduate computer science students, as well as providing students with opportunities to identify trained instructors. in a process guided by the universal design for learning framework, which is used to create educational interventions that will meet the needs of as many students as possible, the project consists of two major components. the curriculum for the training is comprised of prior, piloted adhd training course for teachers and additional evidence-based strategies for improving educational success among diverse computer science students. the digital badges (micro-credentials) are co-designed with students and faculty to design a system of delivering curriculum to instructors and displaying instructor training to students. as instructors complete courses, badges display instructor preparation and willingness to learn about student needs directly to students. this allows students to identify instructors who will be safe to talk to about their needs and trained to support them, whether choosing mentors or making class selections. micro-credentials are evaluated at multiple stages of the co-design and implementation process to iterate on the design. the micro-credentials and curriculum will be published on the open

education lab's website at the completion of the project to allow other schools to access and update the tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: OCE-PRF: Variability in connectivity and receptivity of highly dynamic coastal ecosystems: implications for community structure and function in a recipient soft-sediment ecosystem

Awardee: University of California-Los Angeles

Amount: \$292,243.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). coastal ecosystems face pressures from both the land and the sea, including development and sea level rise. it is important to better understand how coastal ecosystems function so that predictions can be made about how they may change under future conditions and to better manage these environments now and in the future. this project will use long-term data, observational studies, and experiments to learn more about the relationship between kelp forests and sandy beaches. specifically, this project will explore how waves, tides, and sea level control the amount of kelp wrack that washes ashore, how the condition of kelp forests impacts the ecology of sandy beaches, and how beach wrack provides habitat and food for animals that live or find food on

beaches. this project will develop new research methods using drones and start new, long-term monitoring datasets that will contribute to the conservation of these important coastal ecosystems. additionally, this project will support the next generation of marine scientists and increase **\*\*diversity\*\*** in the field by providing research opportunities and mentoring to under-represented minorities at the undergraduate and high school levels. this project will also increase community awareness of coastal ecosystems and conservation issues through earth day participation, guest lecturing at public high schools, and public biology days at the university.

cross-ecosystem connectivity is a critical feature of many ecosystems and has important implications for food webs, bio**\*\*diversity\*\***, and ecosystem functioning. sandy beach ecosystems provide a unique study system for the role of ecosystem subsidies because of strong natural gradients in the type and amount of marine wrack inputs and the dependence of multiple trophic levels on wrack for food and habitat. the proposed research will use a combination of observations, experiments, and theory to explore how environmental attributes, including ecosystem connectivity, food web subsidies, and natural variation work across scales to affect multiple levels of biological organization and ecosystem functioning. this study will utilize nearshore rocky reefs and sandy beaches to understand the fate of subsidies under varying environmental conditions, determine how variability and stability in a donor ecosystem affects the structure and function of the recipient ecosystem, and to explore how variability in the type and supply rate of subsidies affects its colonization and remineralization. this project will also initiate and contribute to long-term monitoring datasets and utilize unoccupied aerial vehicle-based methodology and analyses to quantify ecosystem subsidy dynamics and fate across spatial and temporal scales. using a natural gradient in kelp forest persistence and a manipulative field experiment varying subsidy inputs, it will explore how subsidy variability impacts the bio**\*\*diversity\*\*** of multiple sandy beach trophic groups. field experiments will be utilized to better constrain the dynamics and fate of subsidies over time and across a range of oceanographic and beach conditions. this research will expand understanding of the coupling between kelp forests and beaches and the fate of detrital kelp export. results from field surveys and

experiments will also further elucidate the importance of ecosystem connectivity for critical ecosystem functions from promoting and maintaining bio\*\*diversity\*\* to secondary productivity and other aspects of this detrital food web. this study will have implications for management and conservation of coastal ecosystems in the face of reduced connectivity, increased variability, and loss of food resources and habitat associated with global climate change and other direct anthropogenic pressures. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: OCE-PRF: Variability in connectivity and receptivity of highly dynamic coastal ecosystems: implications for community structure and function in a recipient soft-sediment ecosystem

Awardee: University of California-Los Angeles

Amount: \$292,243.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). coastal ecosystems face pressures from both the land and the sea, including development and sea level rise. it is important to better understand how coastal ecosystems function so that predictions can be made about how they may change under future conditions and to better manage these environments now and in the future. this project will use long-term data, observational studies, and experiments to learn more about the relationship between kelp forests and sandy beaches. specifically, this project will explore how waves, tides, and sea level control the amount of kelp wrack that washes ashore, how the condition of kelp forests impacts the ecology of sandy beaches, and how beach wrack provides habitat and food for animals that live or find food on beaches. this project will develop new research methods using drones and start new, long-term monitoring datasets that will contribute to the conservation of these important coastal ecosystems. additionally, this project will support the next generation of marine scientists and increase

**\*\*diversity\*\*** in the field by providing research opportunities and mentoring to under-represented minorities at the undergraduate and high school levels. this project will also increase community awareness of coastal ecosystems and conservation issues through earth day participation, guest lecturing at public high schools, and public biology days at the university. cross-ecosystem connectivity is a critical feature of many ecosystems and has important implications for food webs, **bio\*\*diversity\*\***, and ecosystem functioning. sandy beach ecosystems provide a unique study system for the role of ecosystem subsidies because of strong natural gradients in the type and amount of marine wrack inputs and the dependence of multiple trophic levels on wrack for food and habitat. the proposed research will use a combination of observations, experiments, and theory to explore how environmental attributes, including ecosystem connectivity, food web subsidies, and natural variation work across scales to affect multiple levels of biological organization and ecosystem functioning. this study will utilize nearshore rocky reefs and sandy beaches to understand the fate of subsidies under varying environmental conditions, determine how variability and stability in a donor ecosystem affects the structure and function of the recipient ecosystem, and to explore how variability in the type and supply rate of subsidies affects its colonization and remineralization. this project will also initiate and contribute to long-term monitoring datasets and utilize unoccupied aerial vehicle-based methodology and analyses to quantify ecosystem subsidy dynamics and fate across spatial and temporal scales. using a natural gradient in kelp forest persistence and a manipulative field experiment varying subsidy inputs, it will explore how subsidy variability impacts the **bio\*\*diversity\*\*** of multiple sandy beach trophic groups. field experiments will be utilized to better constrain the dynamics and fate of subsidies over time and across a range of oceanographic and beach conditions. this research will expand understanding of the coupling between kelp forests and beaches and the fate of detrital kelp export. results from field surveys and experiments will also further elucidate the importance of ecosystem connectivity for critical ecosystem functions from promoting and maintaining **bio\*\*diversity\*\*** to secondary productivity and other aspects of this detrital food web. this study will have implications for management and

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Matched Words: diversity

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Title: Assessing Peer Mentorship as a Scalable Intervention to Promote the Academic Success and Retention of Diverse Undergraduate Biology Majors

Awardee: University of California-Santa Barbara

Amount: \$292,236.00

Abstract: this project aims to serve the national interest by improving undergraduate biology student academic success and retention in the major. at most universities in the united states, roughly 50% of undergraduate biology students leave the major within the first two years of their studies. to address this concern, most institutions put in place a number of first-year student support programs. there are, however, considerable challenges and significantly fewer supports for biology students in their second year of study when the student retention rate is at its lowest. this project seeks to improve the success of second year biology majors by implementing and characterizing near-peer mentorship programs at two research-intensive, minority serving institutions. upper division biology peer mentors who have themselves overcome common barriers to student success will provide academic insights and supports tailored to their second-year biology major mentees. importantly, this project is intended to shed light on the theoretical mechanisms by which peer mentorship promotes mentee academic success. advancing understanding of how peer mentorship works may enable wide adoption and successful implementation of this strategy at a national level across various post-secondary academic settings. in turn, this should increase the number, quality, and **\*\*diversity\*\*** of students graduating with stem degrees. to assess the impact of peer mentorship,

this project will employ a rigorous randomized control research design that will enable the assessment of how peer mentorship influences mentee (1) short-term and longer-term academic performance and retention and (2) sense of belonging, academic self-efficacy, and academic habit complexity. additionally, the project will include a focus on identifying and investigating effective near-peer mentorship practices to assess how these behaviors impact mentee outcomes. to assess whether peer mentorship is a scalable intervention at diverse universities, this project will implement peer mentorship programs at two large, public hispanic-serving institutions where both biology programs share similar academic challenges at the second year level. the mentorship structure will include mentee:mentor cohorts in 6:1 ratios, a seminar course where mentees participate in guided discussions on topics relevant to student success, and weekly mentor check-ins. to characterize these mentorship structures and achieve the previously mentioned goals, data will be collected from a variety of sources. institutional research groups at each project site will provide academic grades, major declaration, and demographic data for mentees, while project-generated survey instruments will capture mentee noncognitive impacts and mentor behaviors linked with these outcomes. combined, these data will advance understanding of how peer mentoring promotes student academic success in challenging stem majors. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the engaged student learning track, the program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Explaining Differential Success in Biodiversity Knowledge Commons

Awardee: Arizona State University

Amount: \$292,095.00



Abstract: scientists increasingly rely on community-governed digital portals to store and access open data. while these digital portals have improved access to data and other scientific products, portals are expensive to implement, challenging to maintain, and often fail to have uptake among key stakeholders. like those working in other areas of the digital economy, scientists have increasingly adopted platforms to implement and tailor portals to particular communities and needs, a model that lowers infrastructure costs and enables benefits of scale across networked portals. yet portals built from the same platform nonetheless show a large variation in their outcomes. participation in any particular portal is often short-lived and the impacts of data portals on the scientific process are challenging to evaluate; portal usage typically fails to map onto traditional measures of research productivity such as publications and citation counts. this project is the first to systematically investigate scientific data portals built from a common platform in order to understand portal communities and outcomes. the research design, which compares bio\*\*diversity\*\* data portals, will inform studies of other platforms and digital knowledge commons, such as open source software and peer-production communities. specific findings and recommendations will be shared with bio\*\*diversity\*\* portal stakeholders regarding the effective design and use of these portals in order to improve uptake and access to these important species data and facilitate science and decision making around environmental change. this project uses fuzzy set qualitative comparative analysis (fsqca) to analyze open data portals as a kind of knowledge commons that impose minimal restrictions on access or reuse. the study sample comprises the 37 active and 4 inactive bio\*\*diversity\*\* data portals built from the symbiota platform, one of the largest and earliest scientific data platforms still under continual development, with hundreds of participating bio\*\*diversity\*\* collections and several dozen individually managed portals. in 2020, symbiota portals collectively provided access to over 60 million bio\*\*diversity\*\* data records and accounted for 90% of web traffic accessing specimens digitized through the nsf's advanced digitization of bio\*\*diversity\*\* collections (adbc) program, which has invested over \$50 million in this area to date. the project synthesizes across multiple types and sources of quantitative and qualitative data to identify why

some of these portals achieve sustained growth and others do not. to do so, the project collects and analyzes up to ten years of analytics and other information from the portals, including tracked usage data, community building activities, features of portal governance, and resource inputs, as well as observation data collected during portal site visits and interviews with a stratified sample of portal managers. the fsqca approach enables comparative inferences about those portal features most likely to foster productive and sustained outcomes, including collective benefit and building inclusive scientific communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Humanistic STEM: Blending Humanities and STEM to Increase Undergraduate Student

## Engagement, Knowledge, and Skills

Awardee: Embry-Riddle Aeronautical University

Amount: \$291,873.00

Abstract: this project aims to serve the national interest by improving undergraduate stem education.

to do so, it will develop, distribute, and research a transferable humanistic stem (h-stem) undergraduate curriculum model that blends humanities and stem. h-stem is defined as "a blending of the study of science, technology, engineering, and mathematics with interest in, and concern for, human affairs, welfare, values, or culture." h-stem highlights connections between humanities and stem, while reinforcing the relevance of each. the project will support different levels of h-stem curriculum development, from individual modules for implementation within a course to full h-stem courses, as well as an h-stem undergraduate minor. project goals also include the development of the humanistic stem center to facilitate integration of the humanities and stem disciplines at other universities. employers in stem fields have stressed the need for students to develop skills such as creative problem solving, critical thinking, ethical reasoning, and communication. these are skills are often best developed in humanities courses. the institutions participating in this project will work to implement h-stem at a variety of institutional types to create a better prepared stem workforce.

h-stem is a targeted response to two main concerns: (1) a false dichotomization of ways of knowing and skills as either humanities- or stem-focused, a situation exacerbated by institutional silos; and (2) the devaluing of skills associated with the humanities as less important, or even irrelevant, to stem students. the most significant product resulting from this project will be a model for blending humanities and stem content in ways that result in students achieving a deeper realization of the connections between these meta-disciplines. h-stem can also lead to more profound student understanding of the wide applicability of the skills and competencies they acquire in their courses. project leadership will develop an assessment framework that will use direct empirical data to measure project impact and inform future action. evidence from a pilot shows that h-stem students can apply interdisciplinary knowledge, concepts, skills, and methods of inquiry attained in academic

settings to produce creative responses to complex problems and situations. these skills allow the students to blend their technical competence with the creative and critical thinking skills that are increasingly essential for continued success in any stem field in the united states. the anticipated result of broad implementation of h-stem will be stem-focused graduates who are more closely aligned with the expectations of industry leaders, possess the requisite technical skills, and have increased capacity for empathy, refined communication skills, and rich exposure to cultural **\*\*diversity\*\***. these outcomes will have full utility in areas of student lives beyond their jobs, regardless of discipline, learner level or workforce sector. through a dissemination plan that targets a variety of academic audiences, and the formation of a consortium comprising multiple institutional types, this framework has the potential to significantly impact multiple student populations. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the engaged student learning track, the program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: REU Site: Tiling Theory, Knot Theory, Optimization, Matrix Analysis, and Image Reconstruction

Awardee: University of Washington

Amount: \$291,792.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). this reu site program will host nine undergraduate students for eight weeks in summers 2022, 2023, and 2024 at the university of washington bothell (uwb) for research experiences. students will provide their research preferences and work closely with a faculty mentor in groups of three. the research projects to be pursued at this reu site are chosen to be of interest to the greater

mathematical research community while being accessible to students with minimal background preparation required. the research groups will be strongly encouraged to publish their results in journals and present them at professional meetings. this reu site will prepare its student participants for research careers and graduate training, contribute to increasing **\*\*diversity\*\*** in the mathematical sciences, and encourage and prepare its participants to pursue graduate school. the research experience will be complemented by several outings and social activities to build team cohesiveness and networking. this reu site will focus on research problems in the areas of knot theory, tiling theory, matrix analysis, optimization, and image reconstruction. in the tiling theory group, the participants will experiment with known infinite families of tiles and use basic combinatorial methods to analyze patterns. they will also perform computer-aided explorations of potential minimal aperiodic protosets to determine aperiodicity and potential structure of associated markov partitions. in the non-smooth optimization group, students will work to improve the numerical performance of the emerging non-smooth spectral gradient methods. this project will also help develop students' scientific computing skills using matlab. in the knot theory group, students will explore various open questions, for example, identifying types of knots that arise as components of hexagonal mosaic links created from saturated diagrams and understanding splittable links from specific sizes of saturated hexagonal or parallelogram diagrams. in the medical imaging and optimization group, students will study the algorithmic framework, generate simulated data, and modify existing code to train the deep-learning-based prior and incorporate it into the reconstruction algorithm. this project will offer students the opportunity to gain exposure to cutting-edge concepts in imaging science and machine learning and develop mathematical programming skills. the matrix analysis group will explore open questions on nonnegative matrices, the field of values, the geometry of polynomials, discrete geometry, and number theory. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Enhancing Undergraduate Education in Botany through Teaching, Research, Representation, and Experience

Awardee: Old Dominion University Research Foundation

Amount: \$291,099.00

Abstract: this project aims to serve the national interest by increasing plant awareness and professional preparedness among undergraduate students for future careers in botanical sciences. a strong knowledge foundation in plant biology is needed to confront numerous issues of national and global significance (e.g., food security, habitat conservation, climate change mitigation, the bio\*\*diversity\*\* crisis, and human mental health and well-being). despite the overwhelming applicability of plant biology, professional and educational training in botany has been in decline since the mid-20th century. this project intends to reinvigorate plant biology at old dominion university (odu), a minority serving institution. the project will enhance course offerings, increase student involvement and representation, and prepare students for individualized futures through tailored mentorship, professional development, and research experiences. through these actions, this project aims to make significant advances in student recruitment to plant biology courses, research experiences, and professional careers post-graduation. additionally, this project has potential to increase \*\*diversity\*\* in odu's plant biology courses. in this project, an integrated approach will be implemented for undergraduate plant biology training within a biology department. the approach will emphasize experiential learning opportunities across all academic levels. this project builds on traditional curriculum reform through the formation of an impact learning community focused on plant biology, provision of professional development opportunities, and mentoring of students. regular assessments of the program and student surveys will aid in determining the effectiveness of experiential learning activities for promoting positive student outcomes in plant biology. the ultimate goal of this project is to increase student opportunities, involvement, and representation in plant biology courses and research experiences at old dominion university, thus

bolstering knowledge, skills, and confidence in tomorrow's plant professionals. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the engaged student learning track, the program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Towards room-temperature quantum simulators enabled by halide perovskites

Awardee: University of Nebraska-Lincoln

Amount: \$291,039.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). non-technical description quantum effects are any phenomena that typically happen at small scales and cannot be explained by classical mechanics. there are many important research problems involving quantum effects that classical computers cannot fully solve. for example, the rational design of complex materials can require understanding the collective behavior of many atomic components and their quantum interactions. a quantum simulator is a device that can actively consider the complex interactions (quantum effects) to model these real-world complex systems in a programmable fashion. however, traditionally, these quantum simulators have to work at ultralow temperatures, making them expensive to prepare and operate. this career project aims to transform the field of quantum simulators through a combined research and education program focused on novel optical materials and their integration approaches for realizing quantum simulators at room temperature. specifically, the pi will synthesize novel new optical materials, integrate them with photonic structures, demonstrate functional room-temperature quantum simulators, and use them to study the rich exotic materials properties that are previously challenging to fully understand. an integrated education program will also expand quantum science and technology accessibility in



nebraska by working with teachers via workshops and labs to provide them with a scientific frontier perspective. additionally, this program will engage undergraduate and high school students in workshops and internships, with a particular focus on first-generation college students and students from traditionally underrepresented groups. these efforts aim to increasing the **\*\*diversity\*\*** and competitiveness of the future scientific workforce. technical description: the goals of this project are to reveal quantum phenomena previously observed only at low-temperature at room temperature (rt) with excitonic halide perovskites materials in the optical cavities and build a competitive quantum optics education program at the university of nebraska-lincoln. strong coupling between excitons and photons in high-quality optical cavities produces a new hybrid half-matter, half-light quasiparticle called exciton-polariton that exhibits ultras-small effective mass inherited from the photon and significant nonlinearity inherited from the exciton. these qualities allow exciton-polaritons to undergo a transition to bose-einstein condensation at rt, potentially enabling a broad range of applications, such as optical analog quantum simulators and low threshold polariton lasers. the project will significantly expand our understanding of how excitons interact at rt and form stable polariton quantum liquid in these new perovskite material systems. it also provides a fantastic photonic platform for exploring the macroscopic quantum phenomenon at rt without requiring complicated and expensive ultracold atoms, cryostats, or molecular beam epitaxy growth vacuum chambers. lastly, the tunable mode splitting in perovskite microcavities behaves as an effective magnetic field on photon spin, enabling studies on synthetic non-abelian gauge fields and topological physics at rt. this research, which will utilize nanofabrication, materials synthesis, and optical spectroscopy methods to study halide perovskite materials, promises to transform the field of rt polaritonics and quantum simulators. it will also undergird an integrated education program focusing on quantum photonics. a graduate course, various outreach pathways, and a k-12 teacher workshop, all featuring research frontiers in quantum photonics, will be developed with the ultimate goal of building a diverse, globally competitive workforce pipeline on quantum science, a critical knowledge frontier for the nation. this award reflects nsf's statutory mission and has been deemed

worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: CNS Core: Medium: Systems Support for Federated Learning

Awardee: University of Wisconsin-Madison

Amount: \$290,320.00

Abstract: traditional approaches toward applying machine learning techniques to end-user data often require copying all data to the cloud. this is not only expensive but faces data privacy risks as well. by analyzing data on the device where it is generated, federated learning aims to mitigate both cost and privacy concerns of centralized machine learning without sacrificing its benefits. this collaborative project brings together investigators from two institutions to develop building blocks for practical federated learning by addressing challenges arising from the **\*\*diversity\*\*** of user devices and the heterogeneity of data distributions in those devices. the project takes a three-pronged approach: (1) enable performance improvements for machine learning developers (e.g., judicious participant selection instead of randomly selecting participants); (2) provide efficiency improvements for service providers (e.g., redundancy elimination for data transfers); (3) enable end-users to control their data privacy (e.g., akin to app permissions in android) without sacrificing device usability. two core principles underpin these solutions: multi-tenancy both in the cloud and on individual devices; and maintaining theoretical correctness, convergence characteristics, and privacy/security guarantees of federated learning algorithms. widespread adoption of practical federated learning can fundamentally change how we gather insights from end-user data and how users value data privacy, because users may not have to sacrifice privacy for convenience in many cases. this, in turn, can force large corporations to rethink their data collection and usage practices, and influence policy makers to consider stricter privacy regulations. all software from this project will be open source. through outreach and new educational materials, this project will pioneer the

training of privacy-aware systems builders. this collaborative project will produce software artifacts, experimental harnesses, benchmarks, and results of running those benchmarks and artifacts. these materials will be available for public use under permissive open-source licenses at multiple locations, including <https://github.com/symbioticlab>. they will be retained for at least three years after the completion of the project. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: OCE-PRF Ecological consequences of seawater chemistry modification by ecosystem engineers

Awardee: University of Washington

Amount: \$290,149.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). this project will determine how ecosystem engineers shape communities by altering local chemistry. ecosystem engineers modify the physical properties of a habitat often via the dense aggregation of individuals (e.g. mussel beds, kelp canopies, etc.)and can harbor extensive bio\*\*diversity\*\* compared to unmodified habitats. such habitats can control resident communities through a variety of mechanisms including altering local chemistry. through laboratory and field experiments, this project will compare how the altered chemical environments within diverse assemblages of habitat-forming species can shape long-and short-term community resilience to chemical stress. results of this study will directly inform aquaculture, conservation, and restoration by revealing mechanisms available to prepare communities for more stressful oceans in the future. this project will additionally broaden participation in science by groups typically underrepresented in ecology by partnering with existing stem recruitment programs and allocating funds to compensate participants. in collaboration with local shellfish aquaculture and community education programs,

this project will also serve as the basis for education and outreach materials that are used to increase peoples? connection to the environment while educating them on topics related to environmental stewardship and scientific research in an academia-industry-community collaboration.

small scale alterations of seawater chemistry within biogenic habitats can be dominated by biological processes like respiration, photosynthesis, calcification, dissolution, and their combinations (e.g. macroalgal canopies vs coralline algal canopies vs mussel beds). each of these processes has different consequences for the seawater carbonate system in that they can, for example, either decrease or increase carbon dioxide concentrations (photosynthesis and respiration, respectively) or either decrease or increase alkalinity (calcification and dissolution, respectively). these processes additionally occur against a backdrop of further perturbations to carbonate chemistry by larger scale processes like ocean acidification or riverine discharge. this project will examine the ability of different habitat-forming ecosystem engineers to ameliorate diverse chemical stresses within the habitat they create and the time scales over which that amelioration occurs. short-term amelioration potential will be assessed by determining whether habitat preference of mobile or settling taxa differs under acute chemical stress conditions. by measuring growth rates of residents within diverse types of biogenic habitat this project will reveal amelioration potential during a resident organism?s lifetime. lastly, the ability of these habitats to drive resident adaption to chemical stress will be determined by tracking how strains of a locally adapted clam originating from different types of habitats perform in the face of chemical stress events. overall, this project, aims to reveal the chemical contexts under which various types of chemical modification by foundation species can either facilitate or inhibit the members of associated invertebrate communities across several time scales this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: The Impact of Relevance, Belonging, and Growth Mindset on Persistence in Economics

Awardee: St. Catherine University

Amount: \$289,083.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). this project aims to strengthen capacity in economics at msis through research on the impact of institutional setting on underrepresented racial/ethnic minority students and women in economics. the project will investigate to what extent the past findings on relevance, belonging, and growth mindset generalize beyond a single institution and how the university context interacts with students' development of an identity as an economist. lower relevance, belonging and growth mindset are

linked to worse grades and lower persistence in economics majors. this project proposes an important addition to our understanding of relevance, belonging, growth mindset, and persistence in economics by increasing the institutional and demographic breadth of research. broader representation in economics will lead to more inclusive businesses and policy and accelerate economic growth. this project will increase understanding of the roles that relevance, belonging and growth mindset play as potential barriers or levers for change across diverse settings. the project will use longitudinal surveys of students and faculty at 18 universities stratified by educational type to examine if relevance, belonging and growth mindset develop differently in economics classes at men's and women's colleges than at non-men's and co-educational institutions. collecting data on relevance, belonging, and growth mindset and persistence from approximately 1,800 students at different points in their educational trajectory at different points in time (a year apart) will facilitate distinguishing selection into institutions from the impact of experiences in those institutions. understanding the role of men's and women's colleges in promoting relevance, belonging, and growth mindset and persistence in economics will indicate important directions for interventions to promote **diversity** in economics. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Power of Us: Increasing Female Enrollment and Retention in Career and Technical Education Programs

Awardee: Durham Technical Community College

Amount: \$288,951.00

Abstract: the low participation of women in technical fields has been a matter of concern for many years. workforce-**diversity** data, from several major technology companies, show a significant underrepresentation of women in technical jobs. industry points to the narrow pipeline of women

pursuing degrees in technical fields as the primary cause of this issue. this project aims to address this issue by implementing measures to increase female enrollment and retention in durham technical community college's most male-dominated career and technical education programs of study. the average percentage of females enrolled in the targeted areas is only 13.5%, meaning that females, who represent 53% of the overall student population, are vastly underrepresented in the pursuit of such degrees. the project will use both proven and novel strategies and activities, as well as equitable and inclusive practices that other institutions can use to increase female enrollment and retention in traditionally male-dominated programs of study. this project will leverage durham technical community college's new makerspace to hold events and provide a place where students can gather to work, study, and socialize. making the "power of us" brand visible in the makerspace will contribute to the college's efforts to create a makerspace that is rooted in equity and inclusion, where all voices are welcome. this project will offer engaging, female-led, female-focused learning opportunities; provide support services that are tailored to the needs of female students; and otherwise, create an environment where female students can thrive in the targeted programs. through its commitment to this project the college seeks to root the makerspace in the ideals of equity and inclusion, making it a welcoming space for all. this inclusive makerspace model will be one that other colleges and organizations, both inside and outside north carolina, can utilize to create makerspaces that are welcoming to all. this project is funded by the advanced technological education program that focuses on the education of technicians for the advanced-technology fields that drive the nation's economy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Sustainable ABI: Arctos Sustainability

Awardee: University of Texas at Austin



Amount: \$287,248.00

Abstract: an award is made to three partner institutions ? the museum of vertebrate zoology (univ. california berkeley), museum of southwestern biology (univ. new mexico albuquerque), and the texas advanced computer center (univ. texas austin) ? to perform critical technical and infrastructure work that will establish a sustainable framework for arctos, a database and collection management system. the arctos community is a group of museum-based professionals representing natural and cultural history collections at over 40 institutions that share in the governance, design, maintenance, and development of arctos. a primary objective of the arctos community is to make high quality data on bio\*\*diversity\*\* and cultural collections openly accessible and richly networked for multidisciplinary research and public understanding. this is accomplished through the arctos online platform, which serves primary species and cultural data to national and international users. these data are used to advance knowledge in a \*\*diversity\*\* of disciplines and serve as an archival record for future generations. additionally, the arctos platform is used as an educational tool where students access raw data to design original inquiries. the arctos community is dedicated to rigorous management of collections and their data, as well as mentoring and training the next generation of curators, collection managers, and scientists. arctos views collections comprehensively and promotes linkages across biological, earth science, art, archival, and ethnographic collections to add value and relevance for education and research. for example, cultural and archival records often contribute temporal, ecological, and behavioral dimensions to bio\*\*diversity\*\* data from identifiable species components or observations. many museums curate more than one type of collection, and arctos provides a comprehensive management solution integrating diverse disciplines. for the last 20 years, arctos has practiced the concept of the ?extended specimen network?. the richly annotated data in arctos creates a web of knowledge with deep comprehensive relationships between cataloged records and all of their derived and associated data, and by using reliable published resources for globally shared information such as taxonomy, people names, and geography. to sustain this community-driven infrastructure and resource, the arctos database

platform will complete migration to open-source technologies removing the need for costly software. other benefits include stabilizing web services, query responses and delivery, spatial functionality, among other core features. the arctos model of community engagement and development is attractive for collections of any size, including small institutions such as field stations that may lack it infrastructure, because of its ease of cloud-based access, community mentorship, and enterprise-level platform at scaled pricing. project activities and results will be accessible on the arctos websites (arctos.database.museum and arctosdb.org). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Cultivating Innovative Thinking Skills in STEM Education

Awardee: Pennsylvania State Univ University Park

Amount: \$286,185.00

Abstract: this project aims to serve the national interest by enhancing innovative thinking skills in stem education, which is important for sustaining the nation's global leadership in science and engineering. student innovation competitions and challenges (iccs) play an important role in motivating, educating, and providing training grounds for the next generation of innovators. given the growth of iccs in higher education entrepreneurship and innovation ecosystems, this project will help advance the theoretical basis for explaining how these experiential opportunities build students' competence and self-confidence in innovation and help them discover their limitations and capabilities. specifically, the proposed work will validate a theoretical research model based on transformative learning theory with the overarching goal of helping stem students become more open to new ideas, different identities, social attitudes, and values while also enabling them with decision-making tools to evaluate alternative viewpoints. by advancing the stem education community's understanding of the roles and processes of iccs in cultivating an innovation mindset,

the project outcomes will lead to better integration of iccs within existing stem curricula, thereby helping more students to develop an innovative mindset. finally, a systematic investigation of strategies to attract a diverse group of students to iccs will facilitate broadening participation in entrepreneurial and innovation ecosystems. the project postulates that participating in iccs is a transformative experience for students as they gain deeper self-awareness of their capabilities in innovation and become more open and critically minded. to answer research questions related to this main hypothesis, the project puts forward a research model that synthesizes the transformative learning theory and kern entrepreneurial engineering network's 3cs (curiosity, connections, creating value) framework. the project's research activities are organized in five interconnected research thrusts: (i) capturing students' experiences in iccs through interviews; (ii) developing the transformative learning scale for the innovation mindset (tlsim) to assess transformations in students' mindset toward innovation; (iii) validating tlsim in various iccs and other experiential learning settings including internships and capstone courses; (iv) investigating the relationships among attributes of iccs, student backgrounds, transformative learning processes, and student outcomes; and (v) studying the factors that motivate diverse groups of students to participate in iccs. the project outcomes will generate new knowledge about how different aspects of iccs can facilitate transformations in students' mindsets toward innovation, thereby laying the groundwork to improve iccs' potential for building student agency and self-efficacy. in addition, the project outcomes will help to increase **diversity** and inclusion in stem fields in two ways. first, the research model's underlying hypothesis, which posits that transformative experiences lead to mindset changes, can stimulate new research on the effectiveness of stem-related activities in attracting more diverse students. second, by emphasizing open-mindedness as a key outcome of iccs, the project outcomes will support enhancing **diversity**, equity, and inclusion in entrepreneurial ecosystems. project results will be disseminated to the stem education community through technical conferences, engineering education journals, and academic social networks. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students.

through the engaged student learning track, the program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: GP-IN: Pathways to tribal geosciences careers through cultural connections to iconic landscapes

Awardee: Idaho State University

Amount: \$284,964.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). this project focuses on recruiting and retaining native american students into the geosciences through three strategies that engage with participants at multiple points of contact from junior high to undergraduate levels. people of native american descent make about ~4% of bannock county's population (home to isu), however they only represent about ~1% of isu's student population and less than 1% of isu geoscience majors. initially, pis plan to work with shoshone bannock jr./sr. high school teachers and tribal elders to develop geoscience curriculum and field-based activities that tie tribal culture to iconic landscapes of idaho and wyoming. secondly, a project mentor will focus on early-undergraduate and transfer student geoscience internship opportunities to facilitate career pathways. geoscience faculty and the mentor will connect students to campus resources such as native american student services, counseling and testing and the career path internship program for educational and career pathway support. lastly, pis will work with the isu bengal bridge program which is a transition program between high school and college to develop best practices for recruiting through field visits. this program will focus on recruiting native americans into the geosciences at idaho state university (isu) in collaboration with six educational and non-profit partners. the overarching goal is to increase the number and **\*\*diversity\*\*** of

geoscientists attaining undergraduate degrees in eastern idaho. to achieve this, the pis offer a three-pronged effort that will blend informal and formal geoscience learning ecosystem strategies with multiple points of contact across a continuum of education levels. the three levels of engagement for the participants include 1) building a sense of identity by offering summer professional skill building through a youth employment program and related activities, 2) accessing trained mentors who will engage in both professional and geoscience development elements and 3) providing access to a bridge transition program that will ready students to enter undergraduate programs. the activities in this collaborative network of partnerships are based on established community of practice and self-efficacy models that can effectively support diverse recruitment and retention. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Testing the timing and direction of mantle exhumation at the Iberia-Newfoundland margins with low-temperature thermochronology

Awardee: University of Southern California

Amount: \$284,753.00

Abstract: the change from continents to seafloor is an important tectonic process that leads to the formation of oceanic basins. continental breakup results in extreme thinning of continental crust and exposure of mantle lithosphere to the seafloor before the start of seafloor spreading. the best-studied margin is the iberia-newfoundland margin in the north atlantic. previous work on the iberia-newfoundland margin provides the foundation for our understanding of the structure of these basins. however, multiple models have been proposed, each with slight differences. the timing, direction, and number of faults have direct implications on the evolution of these margins, as well as subsequent seawater alteration, which affects the habitability of the seafloor. this study will address questions on timing and structure of faulting that leads to separation of continents. this study will use

the minerals apatite and zircon to evaluate the timing and direction of faulting, as well as when the margin cooled enough to allow key chemical reactions to occur. these key reactions are believed to be critical to understanding the evolution of life on earth. the project will engage with a usc communications phd student to produce a podcast mini-series that explores the scientific research in this proposal and scientific communication practices for diverse audiences. in addition, a graduate student in the pis lab will initiate the first **\*\*diversity\*\***, equity, and inclusion (dei) poster session for graduate and undergraduate students from the department of earth sciences and department of marine and environmental biology at usc. the complex interactions between faulting, magmatism, and serpentinization at hyper-extended margins have fueled geophysical, geochemical, and numerical modeling investigations for decades. however, there is still debate over first order questions about timing and mechanics of the transition from continental breakup to mantle exhumation and seafloor spreading. these include the temporal relationship of faults that accommodate mantle exhumation, the number and directionality of faults in the exhumed mantle section, and the thermal history of the lithosphere during mantle exhumation and seafloor alteration. this project is the first comprehensive low temperature thermochronology study to constrain the cooling history of the rocks exposed within and adjacent to the exhumed mantle section of the iberia-newfoundland margins, the only hyper-extended margin that has been systemically sampled. the project will use zircon and apatite recovered from igneous intrusions, syn-rift sediments, and exhumed continental crust from nine drill cores that make up a horizontal transect across the exhumed mantle section. these data will be used to track lithospheric cooling below ~200c (zircon (u-th)/he) and ~80c (apatite (u-th)/he), within the thermal window of serpentinization and ophicalcite formation, respectively. the results will be used to test proposed exhumation models and address three overarching research questions: 1) what is the temporal relationship between the faulting that accommodates mantle exhumation and seafloor spreading? 2) was the mantle exhumed along one major detachment or multiple faults? 3) how does the timing of mantle exhumation faulting relate to other tectonic and petrologic processes, including the onset of seafloor spreading, serpentinization,

and magmatism? these data will be used to evaluate whether faulting, serpentinization, and/or magmatism occurred over progressive exhumation from east to west or occurred in several locations simultaneously, with key implications for the transition from continental breakup to seafloor spreading and the relationship between magmatism, lithospheric extension, and mid-ocean ridge development. the rates and extents of serpentinization and opicalcite formation will also have implications for understanding the development of conditions suitable for life on earth. the project will engage with a usc communications phd student to produce a podcast mini-series that explores the scientific research in this proposal and scientific communication practices for diverse audiences. in addition, a graduate student in the pis lab will initiate the first **\*\*diversity\*\***, equity, and inclusion (dei) poster session for graduate and undergraduate students from the department of earth sciences and department of marine and environmental biology at usc. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Old Dominion University Research Foundation

Amount: \$281,667.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award

reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: The Role of Marketplaces in the Development of Complex Society

Awardee: Howard University

Amount: \$281,040.00

Abstract: this multidisciplinary pilot project identifies prehispanic marketplaces and establishes a set of marketplace indicators that can be applied elsewhere in the world. in the process, the project works with students to train a new generation of archaeologists currently underrepresented in the field. the objectives address a research gap that impedes archaeology's contributions to economic theory. pre-modern markets offer particular promise for adding **\*\*diversity\*\*** to economic ideas. isolated from global capitalist forces, these markets allow researchers to re-examine foundational concepts ? such as money, credit, debt, and investment ? in non-western contexts, expanding understanding of how culture influences economic behavior. for both theoretical and methodological reasons, however, archaeologists have only recently begun to establish the undisputed existence of pre-modern markets. previously prevailing western theories created a false dichotomy between past and present economies and suggested that market exchange ? the transfer of alienable goods and services between strangers ? could not exist outside of capitalism. while recent research has challenged these theories, archaeologists still lack sound methods for investigating the physical manifestations of markets, market systems and marketplaces, which are often ephemeral, barely leaving a material imprint. few archaeological projects worldwide have even tried to identify marketplaces, and their locations remain an important missing component in pre-modern market research. to help fill this gap, eight independent research programs are cooperatively investigating a possible prehispanic regional market system by identifying marketplace locations. economic investigations in the region have lagged due to several factors, including a historical



mischaracterization of the past society which had been conceived as less complex than those of other neighboring groups. researchers now however have begun to search for marketplaces as a sign of economic complexity. while marketplace investigations across archaeological sites have already had some success, varying metrics have hindered the research. additionally, the dense vegetation covering sites makes it difficult to employ conventional approaches such as examining item distributions, which rely on surface collections. to ensure comparable results, collaborators on this project are examining marketplace indicators by using a cross-cultural set of marketplace indicators that depend on a combination of approaches from archaeology, botany, soil science, and physics. researchers are analyzing both old and new data according to common protocols to produce joint results that address the central research hypothesis: an integrated system of large and small markets existed in the region, allowing access to similar goods for households within it. these results will further establish precedents for future research in terms of both methodology and cross-program cooperation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: The geological and paleoecological contexts of early Miocene hominoid evolution

Awardee: University of Minnesota-Twin Cities

Amount: \$280,789.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). this project examines the roles of time and environment in the adaptive evolution of early apes by advancing knowledge about the chronology, paleoecology, and species **\*\*diversity\*\*** for a set of geographically restricted fossil localities. the research design includes a series of fossil excavations to uncover new evidence of early apes and their habitats, combined with laboratory

analyses designed to aid in synthesizing and interpreting these discoveries. the scientific importance of this project lies in documenting early ape adaptive **\*\*diversity\*\*** within specific, highly-resolved chronological and ecological contexts, with major downstream implications for interpreting the origin and diversification of later apes, including hominins. more broadly, this project expands participation in research through training opportunities targeted to underrepresented groups, enhances scientific infrastructure by digitizing invaluable but currently inaccessible field records, and increases public engagement with science through outreach activities aimed at museums and public schools. fossil and molecular evidence indicate that the major lineages of humans and apes diverged during the early miocene (ca. 23-16 ma). the **\*\*diversity\*\*** of ape species and adaptations during that time greatly exceeds modern variation in this group making it difficult to interpret the evolutionary sequence and ecological contexts in which the suite of features shared by living apes and humans appeared. this project is organized around the central question: are differences among early apes tied to differences in paleoenvironments, ages, or both? to clarify these relationships, researchers pursue three specific aims: (1) establishing a rigorous chronology of early ape fossil sites; (2) generating high-resolution paleoecological reconstructions for undersampled ape localities; and (3) documenting the **\*\*diversity\*\*** of ape species during the early miocene. fossil excavations are conducted at a series of outcrops to better document ape **\*\*diversity\*\***, geological contexts, and habitat parameters. the project employs radiometric and magnetostratigraphy at correlated stratigraphic sections (aim 1); sedimentological, isotopic, and paleontological analyses (aim 2); and comparative, morphometric, and phylogenetic analyses of new fossil ape specimens (aim 3). integration of these study results can enable the researchers to contextualize the timing and ecological parameters associated with the emergence of key characteristics in the ape and human lineage, and to subsequently interpret how these early miocene primate communities contributed to the distribution of primates across broad regions. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: SHF: Small: Programmable Hierarchical Caches: Design, Programming, and Prototyping

Awardee: Rochester Institute of Tech

Amount: \$280,097.00

Abstract: as computing technology becomes ever more powerful, memory is larger but more complex, with different materials, configurations, and interconnects having different trade-offs among capacity, speed, and cost. because of this complexity, fully automatic solutions are increasingly sub-optimal and brittle. this project develops new designs of the memory hierarchy that are programmable and therefore can achieve better performance and provide stronger guarantees than conventional solutions used on current computer systems ranging from smartphones to supercomputers. the new programmability enables optimization in software and hardware in concert. since computer cost and speed depend on memory hierarchy, programmable designs can overcome the current limit in scalability and power efficiency. beyond its technical content, the

project advances teaching in the science of computer memory and strives to increase the **\*\*diversity\*\*** among participants in this area of research and development. specifically, the project develops a two-level programmable cache system called the lease cache and designs its programming techniques. it has three parts: automatic programming and optimization of the lease cache; hardware design and prototyping of a risc-v processor with the two-level lease cache on an fpga board; and lease-cache theory especially statistical properties and guarantees of the cache performance. through theories and prototyping, the new designs can retain software portability, ensure matching performance to current automatic solutions by default, and provide precisely defined cache performance properties. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: Collaborative Research: Mass transport in Jupiter's magnetosphere -- driven by internal or external processes?

Awardee: Planetary Science Institute

Amount: \$279,536.00

Abstract: the sun emits a stream of particles called the solar wind. the solar system presents a wide variety of obstacles to the solar wind in the form of planetary magnetospheres. magnetospheres arise from the internal magnetic field of a planet and serve to deflect the solar wind from the surface of the planet. mass from the solar wind hits the magnetosphere and is diffused toward the poles and then carried out behind the planet in a structure called the magnetotail. io is a moon of jupiter that also provides particles to its magnetosphere from within, and so it can be used to trace the flow of particles from within the magnetosphere. this project will use observations of sulfur and sodium ions to trace out the diffusion of particles from within jupiter's magnetosphere to better understand the process of diffusion in magnetospheres. the project will use a dedicated telescope for their

observations. the project will also create a children's book, "the misfit telescope" with a companion website and social media stream that use the benefits of "diversity" in scientific instrumentation as a parable to illustrate the benefits of racial and cultural inclusivity. the proposed project will study the io plasma torus (ipt) around jupiter in order to gain insight into the jovian magnetic field. the project will use the io input/output observatory to make time domain observations of s ii and na lines in the ipt to determine the nature of diffusion of material. ioio is a small-aperture robotic coronagraph that operates nightly, contemporaneously recording narrow-band images of the ipt ins s ii. combined with a model of the ipt, the observations will show whether diffusion is driven by mass loading from io or by activity in the middle jovian magnetic field. the project's children's book will show the value of both being in the minority and havingg a different point of view and of being in the majority and accepting and respecting the minority point of view. the book will be produced by the planetary science institute's award winning public outreach team. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity  
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Title: State-Imposed Local Fiscal Rules and the Fiscal Health of City Governments in the US

Awardee: Georgia State University Research Foundation, Inc.

Amount: \$278,000.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). city governments across the united states provide public services that people rely on in their everyday lives. the ability of a city governments to provide a consistent level of services to their residents depend on the budget choices of the officials in state governments. in order to mitigate detrimental budget decisions such as patronage hiring, risky investments, incurring massive debt, and under-funding of pension and other post-employment benefits, state governments impose fiscal rules on their city governments. these fiscal rules are aimed to improve local fiscal discipline by

preventing the unsustainable growth of local spending, revenues, and debt, as well as ensuring that local budgets are balanced. state-imposed local fiscal rules include balanced budget requirements (bbr), debt limits (dl), and tax and expenditure limits (tel). this project will identify different provisions of these fiscal rules and examine if such rules actually shape the fiscal health of city governments. fiscal health refers to the ability of governments to meet their service responsibilities and other financial obligations. to achieve this goal, the project will collect data on state-imposed fiscal rules using a combination of legal research and surveys of state and city government officials. the literature on political economy suggests that one mechanism to improve government fiscal discipline is constitutional constraints. the prohibitive costs of gathering information about budget policies to monitor official's budget choices, and agency problems in setting budget agendas lead to the notion that it may be more effective to bind the actions of government officials through fiscal rules. bbrs, dls, and tels function as ex-ante constitutional constraints that limit government's budgetary choices. bbrs require governments to match their expenditures with revenues. tels control the extent to which governments can increase revenues, spending, or both. dls control the type and amount of debt that a government is authorized to incur. even though there are these fiscal rules, there is inadequate knowledge on whether these rules work as intended. while there are rich data on state-level fiscal rules, data on state-imposed local dls, bbrs, and tels are outdated or limited. the majority of research focuses on state governments as the unit of analysis, and the evidence on the effectiveness of fiscal rules is mixed. this research will take advantage of the **\*\*diversity\*\*** of fiscal institutional arrangements across the fifty states to examine the design of local fiscal rules. the project will use multi-year detailed data from comprehensive annual financial reports collected from cities to measure the different dimensions of fiscal health. the econometric analyses will involve different approaches to address a critical issue in the study of institutions, which is the potential endogeneity of fiscal rules. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.



Matched Words: diversity

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Title: EAGER: Predicting the impact of microplastics on the microbiota and viral transmission by mosquitoes

Awardee: Texas Tech University

Amount: \$277,146.00

Abstract: plastic pollution has become one of the most pressing environmental issues. while larger plastic pollution cause concerns when ingested by animals, little is known about the effects of much smaller microplastics, which can be formed by the degradation of larger pieces of plastic. microplastics of a few microns in size are common, are difficult to remove from the environment, and are easily ingested by animals particularly invertebrates, yet their biological effects are unclear. this project will investigate the effects of microplastics on the microbiota of mosquitoes and examine if any alterations of the microbiota will affect the ability of the mosquito to transmit disease causing viruses. this project will also have broader impacts by developing discovery kits and classroom learning exercises targeting underrepresented students in local high schools in lubbock, tx to help educate the next generation of microbiologists and entomologists, and inform society about the risks of microplastic pollution. additional broad impacts and societal benefits will include scientific training of undergraduate students and graduate students to be the next scientific leaders. this research project will use interdisciplinary approaches and the combined expertise of the pi and co-pi in their respective areas of microbiology and entomology, and effects of nanomaterials, to determine the impact of microplastics on the microbiomes, immune response, fitness, and pathogen transmission in mosquitoes. in this project, aedes mosquitoes will be used as a model to investigate interactions between microbial communities, microplastic pollution, insect immunology, and arbovirus infection. this project will use novel metagenomic sequencing approaches and advanced microscopy. with the proposed creative, high-risk approaches to test how microplastics may change microbiome **\*\*diversity\*\*** at the microscale, this project may result in fundamental changes of our understanding

of microplastic pollution impacts on insect microbiomes and the ecology of pathogen transmission.

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Integrative ecological perspectives on extinction processes - a multi-proxy case study of Hispaniolan subfossil and extant rodents

Awardee: Johns Hopkins University

Amount: \$276,219.00

Abstract: this project brings together researchers and educators specializing in genetics, anatomy, and ecology to explore the factors that led to the recent extinction of endemic rodents on hispaniola. hispaniolan rodents provide an exceptional case study for examining the triggers and timeline of island extinction events. bio\*\*diversity\*\* loss is a global concern, and over 70% of mammalian extinctions in the last 500 years have occurred on islands. the caribbean has suffered the greatest species loss of any region in the world. fossil data generated from this project have the potential to contribute to conservation policy by clarifying which factors most contributed to extinction events, and will be helpful for understanding the disappearance of species on other islands. this project will contribute to education by providing mentorship to young scientists at multiple levels, including caribbean and caribbean-american undergraduates and by developing teaching modules for k-12 students. finally, a database of extinct hispaniolan mammals will provide better public access to scientific information both in haiti and the usa. this project will use morphometrics, stable isotope ecology, and ancient dna to (1) identify the ecological relationships among hispaniola's extinct endemic rodents, (2) determine the timing of species loss, (3) resolve phylogenetic relationships among extinct taxa, and (4) clarify extinction triggers. the research team will rely on previously collected fossil material from three paleontologically-rich caves on the tiburon peninsula in southwestern haiti. the data generated will allow a more nuanced understanding of the roles that

human behavior, climate, and individual species characteristics (e.g., body size, habitat, genetic **diversity**) have played in extinctions on hispaniola. the data generated can be leveraged by conservation biologists to inform conservation policy aimed at preserving the remaining biological **diversity** on hispaniola and in island systems more generally. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SBIR Phase I: Key 360 Species Survival Database (K3SS)

Awardee: GODWIT KEY COMPANY

Amount: \$276,000.00

Abstract: the broader impact of this sbir phase 1 project is to create a more collaborative and efficient way for scientists to combat species loss. the project proposes to create the a centralized database for a complete view of all of the issues affecting species survival which can be tracked in real-time. this project will allow scientists to expedite their research while offering the public more transparency about environmental data. the company aims to provide a high level of transparency about what factors are directly and indirectly affecting species survival and provide actionable steps that businesses, organizations, governments, and individuals can take to make a difference that they can see in real-time, and model well into the future. they seek to democratize conservation and bring new skills, people, and funding streams to the science and practice of conservation. this sbir phase 1 project consists of the development of a comprehensive database, which exists in the cloud, that encapsulates all of the factors that affect bio**diversity**. the project will result in a robust data system that can host and pull environmental data from all over the world, track the populations of the world's species, and measure conservation support and influence from the general public. the project will also allow users to query data in the cloud and use artificial intelligence (ai) capabilities to further their research. the project will track both scientific data and data about support

efforts from conservation organizations and the general public. the tracking of these factors will inform decision-making bodies on what methods are most effective in preserving bio\*\*diversity\*\*. the core technical risk to be addressed through phase i research and development is standardizing diverse qualitative and quantitative data so that they can be used together. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSFGEO-NERC:Collaborative Research: Chemistry and Biology under Low Flow Hydrologic Conditions Beneath the Greenland Ice Sheet Revealed through Naturally Emerging Subglacial Water

Awardee: University of Minnesota-Twin Cities

Amount: \$274,887.00

Abstract: this project is jointly funded by the national science foundation's directorate of geosciences (nsf/geo) and the national environment research council (ukri/nerc) of the united kingdom (uk) via the nsf/geo-nerc lead agency agreement. this agreement allows a single joint us/uk proposal to be submitted and peer-reviewed by the agency whose investigator has the largest proportion of the budget. upon successful joint determination of an award, each agency funds the proportion of the budget and the investigators associated with its own component of the work.

weathering is an important process that releases nutrients that are essential for life from rocks and minerals in the earth's surface. this project seeks to understand the effect of large glaciers on weathering processes beneath the greenland ice sheet and the consequences for life. during summer, nutrients and other products are flushed out of the greenland ice sheet with water from melting ice. while these products have been sampled in spring and summer, it is not known how weathering processes are different during winter. in this project, researchers will sample the seasonal ice that forms in front of two of greenland's glacial outlets, isunnguata sermia and leverett

glacier, during the freezing months to assess the chemistry and microbiology processes that reflect wintertime conditions beneath the ice sheet ? periods when input of fresh meltwater is minimal. these samples will increase knowledge of winter conditions under the greenland ice sheet and help better understand the interior portions of the ice sheet which are largely inaccessible. such information will help in assessing past conditions, when colder atmospheric conditions resulted in minimal meltwater input through the ice sheet and to the glacial bed. these analyses will inform understanding of the role of glaciers on earth's nutrient cycles presently, under past ice age conditions, and in a future deglaciating world. the greenland ice sheet is a major exporter of biologically important elements to the world's oceans. however, most of our knowledge of chemical and biological fluxes from the ice sheet comes from the summer outflux of outlet glaciers whose channelized waters contact only a limited portion of the glacier bed. the majority of the glacier-bed interface contains slow-flowing, distributed waters not representative of this flux. the project will test the hypothesis that overwinter chemical and biological processes under outlets of the greenland ice sheet differ substantially from summer outflow and represent a window into widespread, but typically inaccessible, distributed flow. the principal sample collection method will be early spring coring of naled ice that forms at glacial termini from wintertime subglacial flow. chemical, mineralogical, and biological constituents of this flow will be compared to material emerging from the initial, peak, and terminal phases of the melt season. elsewhere in the arctic, the chemistry of frozen overwinter subglacial material shows significant limitation in oxygen or sediment supply compared with even the first spring melt, supporting the idea that naled ice reveals a unique overwinter system. the naled ice and outflow of isunnguata sermia and leverett glacier will be sampled over two years. these west greenland outlets differ by more than an order of magnitude in the size of the catchments they drain, thereby testing the effect of scale on biogeochemistry. naled ice structure will be characterized by ground penetrating radar and ice borehole temperature profiles. the aqueous geochemistry, stable isotopes of carbonate and sulphate, and mineralogy of the suspended sediment of ice and water will be assessed. these analyses will document changes in the mineral flux and supply of atmospheric

gases at the glacial bed between winter low flow conditions and peak summer melt. microbial abundance, **\*\*diversity\*\***, metagenomics, and stable isotopes of biomass will also be measured to understand the concomitant relationship between geochemical conditions and biological communities. researchers will incorporate findings into a number of outreach efforts including developing a new curriculum module for the center for earth and environmental sciences, providing research opportunities for underrepresented students as part of the bridge to research program and preparing hands-on activities for the market science program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: OCE-PRF A transferable modeling approach to predict species distributions under changing conditions across multiple life stages

Awardee: Florida State University

Amount: \$273,561.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). understanding the distributions of species is fundamental to ecology, especially within the marine environment where biotic and abiotic variables are often dynamic over space and time. ecological models have been used to make inferences on species-environment relationships in addition to predicting past and future patterns of species distributions. however, these models are typically developed for a single location, time period, spatial scale, or species life stage, resulting in poor predictive accuracy beyond the study domain. this project will provide a new transferable modeling approach that is applicable to a wide range of species, which will be used to test predictions of current and future distributions of green turtles (*chelonina mydas*) in the gulf of mexico, brazil, and qatar. since there is a lack of information on how marine turtles in general will respond to climate change impacts, these results will provide a crucial evaluation of projected range shifts that

could be used by both conservationists and decision makers. this project will foster the integration of research and education through mentoring undergraduate students that identify as underrepresented minorities, teaching marine ecology and conservation at florida state university, hosting workshops on the analysis of animal movement data, as well as hosting public outreach events. these efforts to disseminate knowledge and results beyond traditional means within the scientific community will be used to engage future scientists and the general public on pressing ecological topics. the overall aim of this project is to develop a transferable modeling approach that can provide accurate and precise estimates of species distributions under changing conditions. this study addresses some of the challenges of model transferability through three hypotheses: 1) a model informed by biological processes and physiological constraints will exhibit greater transferability than those that do not; 2) the analysis of environmental variables at the scale of species perception will result in greater model transferability; 3) a model that accounts for differences among life stages will result in greater model transferability. these hypotheses will be tested using a large dataset of green turtle occurrences at three distant locations (gulf of mexico, brazil, qatar) with a flexible bayesian species distribution model. the use of independent datasets (from brazil and qatar) to validate the species distribution model (developed on data from the gulf of mexico) provides a unique opportunity to critically evaluate the spatial transferability of the model. the findings from this proposed work will provide a roadmap for the further development of transferable ecological models to predict bio\*\*diversity\*\*, disease outbreaks, and risks of biological invasions across global regions and possibly under future climate change impacts. elucidating the importance of biological mechanisms, scale, and life stage differences to ecological modeling is transformative because these factors have been largely untested with regard to model transferability. since predictions remain a major frontier in ecology, products of this work will be of broad interest to a diverse group of scientists, such as marine ecologists, biological oceanographers, fisheries scientists, and conservationists. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's

intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: Collaborative Research: EAGER: Using allies to expand your network: Implementing a psychological methodology to attract and retain underrepresented (UR) students in geoscience

Awardee: Texas Tech University

Amount: \$273,404.00

Abstract: geoscience maintains a base-rate problem with respect to \*\*diversity\*\*: ethnic minorities

and people with disabilities are highly underrepresented. this has been traced to a variety of barriers for underrepresented (ur) ethnic scholars including: a lack of geoscience majors at hbcus and primarily hispanic-serving institutions, a lack of experience with, and time spent in, nature (e.g., < 3% of visitors to u.s. national parks are black and hispanic), and negative attitudes about career prospects. for people with disabilities, the main challenge is accessibility and the provision of appropriate accommodations. ur individuals may self-select out of geoscience programs due to these perceptions and barriers. this project will test the idea that allies, or members of dominant social identities, are best situated to positively influence these statistics. academic allies, whether faculty or graduate student teaching assistants, have tremendous impact on their students? academic engagement and can serve as linchpins for improving the future trajectories of ur students. pis will train individuals in effective allyship behaviors, and incentivize them to recruit ur students into their academic field trips. the pis plan to target allies who engage in field research and education, as geoscience is a unique stem field insofar as much of the data collection and skill development are practiced out in nature at locations around the world. the pis propose testing a strategy to overcome barriers in this context for ur students, as positive (or negative) experiences in field settings have profound impacts on recruitment and retention. this project will facilitate training and assessment of approximately 80 academic allies and measure the effect of that training on allies as well as hundreds of majority and ur students. the expectation is that the training will produce a secondary effect: academic allies role model effective behaviors to all of their students and faculty networks, creating a ?train-the-trainer? ripple effect. the pis will use academic field trips as a vehicle for measurement, including multisource ratings, applying 360-degree-type ratings typically collected in performance appraisals to this setting. deliverables include an experimental, longitudinal (over time), and multisource analysis of the allyship program and its improvement of allyship-related attitudes and behaviors, as well as its impact on the performance of ur students. these results will inform research efforts regarding the effectiveness of implemented strategies, and the materials and procedure will be made open-source for maximum replicability. a capstone

conference will be used to disseminate findings to all participating allies and ur students, inform about methodologies that improve attraction and retention of ur groups in the geosciences, and expand ur networks. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Two-photon absorption engineering in laser diodes for ultrafast pulse generation

Awardee: University of Colorado at Boulder

Amount: \$273,362.00

Abstract: semiconductor lasers are one of the most impactful photonic technologies on the market, with applications ranging from communications to medicine. however, the amount of power that can be obtained from short pulses of light remains low, despite decades of research. the problem is due to physical constraints, which the project will address through an interdisciplinary effort combining emerging materials synthesis with advanced optical physics to create short pulses with power well beyond the current state of the art. this will enable significant advances in both scientific understanding and practical performance, and will yield sources ideal for applications ranging from laser radar for autonomous vehicle navigation to advanced microscopy. the project will further benefit society by integrating research results with education through courses, and into an online course that was launched as part of the university of colorado boulder's master of science in electrical engineering (an online master's degree). additional dissemination and engagement will occur through avenues ranging from undergraduate research opportunities, a **\*\*diversity\*\***, equity, and inclusion seminar series, ecee connects at the university of colorado boulder, as well as science events at the texas school for the deaf. nonlinearities like two-photon absorption limit semiconductor lasers in both the high power cw and ultrashort pulse arenas, constraining the

available peak powers, pulse widths, and pulse energies. for pulsed sources, dispersion compensation provides some improvement; however, less-compact alternatives, such as fiber and solid-state lasers currently offer vastly superior performance. this project will combine recent advances in crystal growth and optical laser pulse shaping techniques to solve these issues and dramatically advance the performance of semiconductor ultrafast sources. specifically. high-bandgap semiconductor cladding layers can now be epitaxially integrated with longer-wavelength gain media to reduce two-photon absorption by orders of magnitude. when coupled with a new pulse shaping mechanism and pulse stacking, it is anticipated that this approach will enable kw peak powers and femtosecond pulses on a chip-scale semiconductor platform. the impact of the project will be further enhanced through a number of engagements and outreach activities and undergraduate research opportunities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: ADVANCE - Catalyst: AGREE: Self-Assessment of Gender, Racial, and Ethnic Equity in STEM Faculty at Bucknell

Awardee: Bucknell University

Amount: \$271,594.00

Abstract: the advance- catalyst: agree project will support a two-year self-study at bucknell university, a primarily undergraduate institution in rural pennsylvania, to identify any existence of systemic inequities and advancement barriers related to gender, race and ethnicity in stem faculty through an intersectional approach. informed by quantitative and qualitative data, the project aims to develop and implement a plan to remove such barriers, solidify evidence-based best practices that support faculty success, establish a review mechanism that allows frequent reflection and improvements in institutional policies, build a supportive community where all members of bucknell

enjoy equitable resources and opportunities, thus extending the advance network, and produce generalizable strategies to extend the impact from this project to all faculty on bucknell campus and those at institutions similar to bucknell. this project will bring significant insights into issues facing women and underrepresented minority (urm) faculty that are unique to stem disciplines and in a primarily undergraduate institution that strives to enhance **\*\*diversity\*\*** in students, faculty and staff.

the advance- catalyst: agree project aims to uncover systemic inequities centered around recruitment, retention, and promotion processes facing women and faculty members underrepresented in stem disciplines. the project adopts an intersectional approach to collect quantitative and qualitative data from faculty through questionnaires and focused small group interviews followed by comprehensive analysis. the project will investigate factors that are unique at different career stages such as pre-hiring recruitment, tenure-review, and promotion and advancement to track the career progression of faculty of different genders and racial/ethnic backgrounds. the comprehensive self-study is expected to bring insights into addressing the historical and emerging barriers to equity and inclusion facing women and faculty who are underrepresented minorities in stem. the outcomes of the self-study will enable the institution to improve strategies to support and retain more women and underrepresented minorities in all disciplines. the implementation of these strategies will also provide generalizable practices to liberal arts institutions. the nsf advance program is designed to foster gender equity through a focus on the identification and elimination of organizational barriers that impede the full participation and advancement of diverse faculty in academic institutions. organizational barriers that inhibit equity may exist in policies, processes, practices, and the organizational culture and climate. advance "catalyst" awards provide support for institutional equity assessments and the development of five-year faculty equity strategic plans at an academic, non-profit institution of higher education. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: STEPP-NET: Steppe Parasite Networks

Awardee: University of North Carolina Greensboro

Amount: \$271,399.00

Abstract: this project focuses on collecting and describing mammals and their tapeworm and flea parasites from the grasslands of central asia. these parasites are highly diverse and ecologically important groups, and many are sensitive indicators of ecosystem quality; further, the parasitic infections they cause can have major negative impacts on wildlife. they also can play an important role in transmitting diseases from wild to domesticated species, and also to humans. however, knowledge of the **diversity** of parasite species, their geographic distributions, and the precise hosts they occur on and in remains highly fragmentary for much of the world. central asian mammals and their associated parasites are particularly highly imperiled but also little studied. this project will collect new material and study how tapeworm and flea parasites from the region evolve in conjunction with their mammalian hosts; it will also consider how the hosts and parasites have responded to various ecological changes across the region. this work is extremely time-sensitive, with many central asian ecosystems on the cusp of major land use change as economies shift and major construction occurs in the region. numerous specimens will be collected, and these will serve as a repository of parasite **diversity** useful for assessing how future global change influences the distribution of parasites and their hosts. this may ultimately improve public health outcomes. the work will also involve training the next generation of early-career stem researchers for careers in bio**diversity** science. the stepp-net project will rapidly advance discovery and description of species **diversity**, host associations, and community assembly, in two mammal-associated macroparasite clades - fleas and cestodes - across the vast grasslands of central asia. this region is a prototype for exploring host-parasite dynamics and spillover in response to human activity; historically, as a conduit for ancient silk road trade routes, and, currently, from intensifying land use changes and construction. stepp-net leverages existing museum specimens, new expeditionary

collections in mongolia and kazakhstan, and genomic analyses of hosts and parasites to advance knowledge of species boundaries, environmental and host niche breadth, and the exploration of novel host interfaces by focal parasite clades in response to global change pressures. a key outcome of stepp-net will be an extended specimen network for central asia, in which mammal and parasite specimens are durably linked to derived data and immediately useful in global bio\*\*diversity\*\* studies and public health initiatives. the project also creates opportunities for stem graduate and undergraduate students to participate across the spectrum of modern bio\*\*diversity\*\* science, from international fieldwork to specimen curation and digitization, genomics, and integrative taxonomy. it will build out this community of early-career stem researchers even further by developing undergraduate and graduate educational modules that are implemented across our institutions and hosted online for broader bio\*\*diversity\*\* literacy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Trace Elements in Pyrite?Validation and Calibration of a Novel  
Paleoenvironmental Proxy

Awardee: University of California-Riverside

Amount: \$267,389.00

Abstract: life in the oceans is often limited by the availability of nutrients, such as nitrogen and phosphorus. other elements occurring in far lower abundances are also bioessential and potentially limiting?particularly trace metals such as iron and molybdenum. these metals are co-factors in many biological processes, and their distributions through time and space are strongly coupled to oxygen levels in the oceans; weathering of the continents; evolving atmospheric composition; and biological evolution. all of these factors tie intimately to climate change as a critical driver and consequence of metal cycling on land and in the oceans. yet, despite extensive study of metals in modern and

ancient oceans, basic gaps remain in our knowledge because of inadequate testing of certain chemical methods, particularly in the modern oceans. these methods, once refined, would allow for more confident exploration of a vast array of past conditions at earth's surface?far beyond those seen today. from that reinforced vantage, researchers can begin to imagine more rigorously and comprehensively what may lie in our future. one of the most promising methods for "time travel" through earth's evolving oceans is elemental analysis of pyrite, an iron sulfide mineral common today and in the past that may provide easily accessible and highly preservable historical archives. surprisingly, despite the advantages that may lie with this approach and hints of success already, no previous effort has attempted to validate and calibrate the pyrite tracer in modern oceans where present environmental conditions, local and global, can be tied directly to the composition of the mineral. this study is the first comprehensive investigation of these relationships in modern systems, strengthened by targeted experiments and novel analytical techniques. the principal expected outcome is an improved understanding of the controls and consequences of change at earth's surface as expressed in evolving ocean chemistry?past, present, and future?and the cause-and-effect relationships with co-evolving life. many studies are now using a technique called laser ablation-inductively coupled plasma-mass spectrometry (la-icp-ms) to measure trace metal contents of pyrite as a tracer for past marine conditions, and the initial results are encouraging. that said, there is still little mechanistic understanding of how and when trace elements are incorporated into pyrite and how these patterns and controls vary across environmental gradients. these uncertainties weaken their utility. the relationships among local controls and the capture of potentially global signals remain largely unknown. thus motivated, this study is designed around a two-pronged approach: (1) sampling in five classic, well-studied modern marine environments with a well characterized **\*\*diversity\*\*** of primary environmental conditions and (2) complementary, carefully conceived laboratory simulations designed to provide unprecedented insight into the mechanisms of trace metal uptake by iron sulfide minerals and their sensitivity to environmental backdrops. the ultimate goal is to expose the strengths and weaknesses of the proxy and best practices while



revealing new opportunities, such as the possibility of tracking the availability of bioessential trace metals in the ancient deep biosphere. plans include analyzing pore waters and sediments from diverse settings in modern oceans and interpreting those data within the framework of experimental results to reveal how trace metal content scales with conditions in the surrounding environment. the utility of the approach will be explored further using novel, highly sophisticated analytical methods applied at high resolution to characterize experimental and natural samples. this will be the first systematic study that correlates pyrite metal contents with metal availability in surrounding fluids and relates such data more generally to the wide range of environmental parameters and proxies often included in studies of earth's ancient biosphere. the impacts of this study will extend broadly through outreach opportunities targeting middle and high school students and ucr undergraduates placed in the lyons lab, while championing **\*\*diversity\*\*** and inclusion at all levels. that community footprint will be expanded through a recurring public lecture series and an on-campus science festival presented entirely in spanish, among other already tested community-directed efforts. at cmu, plans include a geochemical study at two middle schools in flint (mi) emphasizing water quality and use of those data to construct a new, much-needed community-driven water quality database for flint. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Elevating and empowering Hispanic/Latinx voices through video: Reducing barriers in academia and building an ecosystem for success in the Earth system sciences

Awardee: University Corporation For Atmospheric Res

Amount: \$266,162.00

Abstract: this nsf gold-en eager project aims to create a culture of belonging, equity, access, **\*\*diversity\*\*** and inclusion in the earth system sciences by building a network of support for minoritized groups that spans from their families to the university community to professional

societies. as our society is tasked to work on increasingly complex and urgent earth system challenges, geoscience and related fields are as important as ever. yet, the geosciences are one of the least diverse stem fields and there has been little improvement over the last 40 years. furthermore, the geoscience careers are less visible in some communities compared to other stem professions, resulting in careers in the geosciences being not well known or not perceived as viable careers. to solve current socio-environmental issues, marginalized voices must be brought in and elevated in equitable and culturally appropriate ways. this is particularly true for the hispanic/latinx community, the fastest growing minoritized group in the united states. this project will work with hispanic/latinx students and scientists in the earth system sciences to develop a foundation for engaging their families, strengthen a network for hispanic/latinx students and scientists in earth system sciences, and build a sustainable network of academic institution leaders to co-create an inclusive environment for hispanic/latinx students, scientists, and families. this project will foster a framework that will be expanded in the future for culturally appropriate engagement of other underrepresented communities and their families in the geosciences. three techniques will be employed to elevate the voices of hispanic/latinx communities, to increase the knowledge of careers in the geosciences, and to empower conversations between the latinx/hispanic community and the university system: 1) storytelling through film to strengthen and build upon existing culturally relevant science communication and storytelling skills of hispanic/latinx participants; 2) highlighting the experiences of hispanic/latinx students, scientists, and their respective families to increase knowledge of geoscience career opportunities; and 3) conversations between hispanic/latinx participants with university community leaders to elevate the understanding of challenges faced by hispanic/latinx students and scientists as they pursue geoscience careers. through the use of narrative storytelling and listening sessions, the project goals are: 1) to build an ecosystem for hispanic/latinx students to pursue geoscience careers with the support of their families, 2) to feel a sense of inclusion of hispanic/latinx people in academia in their pursuit of geoscience education and careers, 3) and increase retention through a sense of belonging in these fields with the support of

the university community leaders. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: OCE-PRF: Effects of increasing temperature and ultraviolet radiation on copepod mitochondria along a latitudinal gradient

Awardee: Auburn University

Amount: \$263,705.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). our understanding of the mechanisms by which organisms respond to climate change is incomplete. as temperature and ultraviolet (uv) radiation increase, the ability of organisms to survive and reproduce depends on their ability to adapt to changes in the environment. the ability of mitochondria to produce energy in animals is influenced by the movements (i.e., behavior) and structure of these organelles. the ability of mitochondria to produce energy directly impacts animal performance, including survival and reproduction. in turn, the behavior and structure of mitochondria are influenced by the environment. this work aims to: 1) determine if uv radiation influences mitochondrial behavior and structure in natural populations of a marine organism, copepods, in the same manner observed in a laboratory setting, 2) determine if temperature affects mitochondrial behavior and structure in natural populations of copepods, and 3) determine how much the behavior and structure of mitochondria change in the short-term versus the long-term in response to changing environmental conditions. the results of this study will transform our understanding of how environmentally important organisms such as copepods may respond to climate change. in collaboration with the auburn university college of science and mathematics, this work will advance the education and science literacy of students in the state of alabama. the pi will develop several outreach programs to fit the pre-existing infrastructure at auburn university to increase the science

involvement and literacy for 1st ? 6th and 11th ? 12th grade students and interact with the community to discuss the importance and relevance of the research for the general public. these outreach initiatives will involve hands-on participation of students in learning about the scientific process, mitochondria, copepods, and the use of microscopes in scientific research. the general public will gain insight into the importance of the research in understanding the impact of climate change on one of our world's most abundant aquatic organisms. the goal of this work is to integrate observational fieldwork and experimental lab work to further understand the impact of environmental stressors on the physiological ecology of copepods along the west coast of north america. this work aims to fundamentally change our understanding of the mechanisms by which pervasive zooplankton such as copepods can potentially respond to climate change. the pi will collect data on copepods from populations in san diego, ca, battle rock, or, and friday harbor, wa. he will measure their metabolic rate at the point of highest uv exposure and temperature during the day and lowest uv exposure and temperature at night. after measuring metabolic rate, the same copepods will be fixed for transmission electron microscopy (tem) to quantify mitochondrial behavior and morphology, including density of the inner mitochondrial membrane, proportion of inter-mitochondrial junctions, mitochondrial density, and mitochondrial area and aspect ratio. additional copepods from these populations will be shipped to auburn university to establish lab populations under the same temperatures and uv radiation as measured in the field. mitochondrial phenotypes quantified via tem and metabolic rate will be measured following reciprocal transplant experiments in the lab to determine the extent that differences in mitochondrial phenotype are due to environmental variation versus evolved, genetic differences in response to temperature and uv radiation. in collaboration with oregon state university, transcriptomics will be completed under the transplant experiments to identify the up/downregulation of genes that may be associated with mitochondrial behavior and morphology to maintain metabolic rate differently between the three populations. copepods are a cornerstone of biological **diversity** in aquatic ecosystems. as such, it is imperative that we begin to understand the physiological responses of these organisms so that we

may better understand the impact of climate change on marine populations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Theory-Grounded Guidelines for Solver-Aware System Architecting (SASA)

Awardee: George Washington University

Amount: \$263,492.00

Abstract: the objective of this project is to advance the scientific understanding of a new paradigm of system architecting in engineering, referred to as solver-aware system architecting (sasa). sasa actively considers the capacity of talent and expertise from outside organizational boundaries (e.g., gig workers, crowd) during the formulation phases of the system design process. this research hypothesizes that the joint consideration of system architecture, diverse external solvers, and contract mechanisms, can significantly improve system design outcomes. the research will result in new theory and best practices for when and how to incorporate novel sources of effort into complex systems design, which has positive implications for workforce management. with an explicit focus on translation to practice, the guidance generated by this work has the potential to make a tangible impact on how system architecting is practiced, and the way organizations engage with outside and non-traditional solvers, which promises greater effectiveness and efficiency in technical business operations. the theoretical innovations will be reduced to practice in the form of actionable guidelines relating sasa principles to design outcomes. additional deliverables of this project include a set of educational tools to educate students and industry practitioners on sasa. if successful, the research will result in scientific foundations for the paradigm shift from traditional approaches to system architecting, which assume traditional players bounded by organizational boundaries, to more open innovation approaches for complex systems design. the research will establish a firm

scientific foundation consisting of (i) socio-technical theory for architecting complex systems; (ii) computational models of open innovation processes for systems design and computational methods for designing contractual mechanisms for sasa; and (iii) empirically-validated design guidelines to support practitioners of sasa. the research will extend the frontier of knowledge in systems engineering research and practice by shedding light on the linkages among innovation processes, designer knowledge, systems architecture and contractual structures. the resulting educational tools will have a direct impact on student learning about system architecting. the tools will be tested at the pis? institutions and then made freely available to other members of the engineering design and systems engineering (edse) community. the focus on leveraging non-traditional contributors has implications for broader societal goals around **diversity** and inclusion, broadening participation in stem through new avenues for access, and eliminating barriers to traditional professional practice. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Using Tutorial-Based Active E-Learning to Broaden Participation and Enhance Scientific Computing Skills in a Seismology Context

Awardee: Miami University

Amount: \$262,507.00

Abstract: this project aims to serve the national interest by improving computational thinking and scientific computing skills of advanced undergraduate students. it will do so by developing a large-enrollment, asynchronous, open access, online computational workshop. such training is important to ensure that future scientists develop the knowledge and skills they need to tackle computer- and data-intensive scientific problems of national importance, such as climate change. this project will provide more than 1200 advanced undergraduates with computational training in a seismological context. the training will build on and refine a pilot tutorial-based, active e-learning

experience called the seismology skill building workshop. the project also aims to generate a more successful, inclusive, and satisfying online learning experience that can be exported to other stem disciplines. because the workshop offers advanced coursework online without fees or prerequisites, it is likely to increase the participation of diverse undergraduates and other learners in computing. in fact, based on data from the pilot workshop, this project will reach many students from communities that have been disproportionately impacted by the covid-19 pandemic. through its research efforts, the project intends to increase understanding about how diverse groups of students engage with and benefit from the tutorial-based active e-learning approach. by identifying workshop features that attract diverse audiences and promote retention, learning, and satisfaction, the project can also define a framework that other stem communities can use to develop similar technical training efforts.

a preliminary seismology skill building workshop was offered in 2020 by the incorporated research institutions for seismology, an nsf-funded university consortium that operates the seismology community data and equipment facility. the pilot workshop was launched in response to the covid-19 pandemic and reached more than 700 students, many more than anticipated and with higher **\*\*diversity\*\*** than typical in-person computing courses. through the pilot workshop, the project team identified challenges and gathered data about workshop effectiveness. this project will investigate the resulting research questions, which are important within and beyond seismology: 1) to what extent does this online scientific computing training model enhance participant learning and behavior? 2) what are the key influences on retention and performance for advanced undergraduates in the online scientific computing training model and can new interventions improve efficacy? 3) to what degree do the elements of the tutorial-based active e-learning approach contribute to learning? 4) how can the value of the seismology skill building workshop and its positioning within the seismology learning ecosystem be optimized to ensure sustainability? these questions will be addressed through a multi-year, mixed methods research investigation that includes development of instruments for summative assessment of computational thinking and programming within a disciplinary context, improved characterization of assignment question types

to examine performance trends, and correlation analysis of participant activity and performance data. expert reviews of the curriculum and community focus groups will be conducted to ensure sustainability of the seismology skill building workshop. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. this project is in the engaged student learning track, through which the iuse program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Illuminating the characteristics, causes, and paleoclimatic importance of the Mid-Cenozoic Loess in the Western USA

Awardee: University of Connecticut

Amount: \$260,818.00

Abstract: loess deposits consist of fine-grained, windblown sediments and contain critical information about continental aridification processes that are key to understanding biotic evolution and climate change. this project integrates field data collected from loess deposited ~37-30 million years ago in wyoming, nebraska and montana, laboratory analyses, and paleoclimate simulations to understand the nature, causes, and paleoclimatic importance of these loess deposits. the research will advance stem **\*\*diversity\*\*** by supporting a two-day geocamp for historically underrepresented high-school students from east texas. in addition, this project will promote further development of the high-resolution community earth system model to be used to better understand ancient climate changes. this project will include field sedimentological observation and lab analyses of bulk sediment and quartz grain-size, quartz surface morphology, detrital and high-precision zircon u-pb geochronology to study the ancient loess deposits in wyoming, nebraska and montana, usa. these proxy data will constrain the extent, timing, pattern and characteristics of the loess; and determine



sediment provenance and sediment recycling mechanisms. these proxy data will be integrated with a coupled atmosphere-land model to simulate changes of regional climate and vegetation induced by topography changes, global climate cooling, glaciation and shoreline regression to understand the cause and climate significance of the loess. in addition to gaining fundamental understanding of the loess deposits, the project will shed light on 1) the influence of climate change on biotic evolution at the eocene-oligocene transition (~34 million years ago); 2) the validity of different models of surface uplift in the western usa; and 3) the potential positive climate feedback of enhanced mineral dust emissions on global cooling at the transition. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: P2C2--MADagascar Caves And Paleoclimate II (MADCAP II), Continuing Study of Climate Variability in the Southern Hemisphere of the Western Indian Ocean

Awardee: Massachusetts Institute of Technology

Amount: \$258,922.00

Abstract: the research team aims to build upon previous research using speleothems from caves in northwest and southwest madagascar to reconstruct late pleistocene and holocene climate from a southern hemisphere tropical site and to examine the role of climate in the ongoing alteration of the island's ecosystems. using previously collected samples, the researchers plan to construct high-resolution (decadal) multiproxy climate records from the last glacial maximum (26,000 years ago) to the present from high-resolution (near annual resolution) analyses for periods of particular climatic interest (e.g., the 4.2 ka event, younger dryas). the researchers will extract organic matter from the speleothems across an interval of marked change in speleothem delta carbon-13 and

measure biomarker concentrations and the same to test a newly developed ?subsistence shift hypothesis? for the disappearance of madagascar?s megafauna. speleothem fluid inclusion water isotopes, combined with carbonate oxygen isotopes, will be examined as a tool to estimate paleotemperatures over the past 117,000 years for southwest madagascar and the past 26,000 years for northwest madagascar. the goal of the project is to produce long, high resolution records of climate from the southern hemisphere tropics. these data will aid in understanding the influences of inter tropical convergence zone (itcz) migration, western indian ocean sea-surface temperature (sst), and regional precipitation. in particular the project will investigate whether the indian ocean monsoon in the northern versus southern hemispheres vary in or out of phase at various timescales and test current hypotheses on tropical rainfall variation. the potential broader impacts include the integration of science across the fields of paleoclimatology, anthropology, and biology to provide background climate data needed for interpreting the impact of climate on a variety of fossil communities of the past. the research team will produce educational materials and exhibits prepared for a general audience to heighten public awareness of tsimanampesotse national park?s natural history, bio\*\*diversity\*\*, and extinction events. the project will help develop a better understanding of the causes of decadal-scale climate variability which can aid in forecasting possible changes in rainfall in a country that experiences severe drought and flooding on inter-annual time scales and relies on subsistence farming for survival. this project includes supporting an early career female post-doctoral scholar in the united states and collaboration with malagasy scientists and students as well. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MRI: Acquisition of Electroencephalography Equipment for the Study of the Neuroplasticity of Language and Cognitive Processes in Bilingualism and Multilingualism

Awardee: California State University, East Bay Foundation, Inc.

Amount: \$258,811.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). the major research instrumentation grant supports the acquisition of a state-of-the-art electroencephalography (eeg) system (actichamp plus 64-channel active electrode system, brainvision llc) that will be used to non-invasively measure electrical activity generated by populations of neurons with very precise timing accuracy. the acquisition of this eeg equipment will permit cross-disciplinary collaborations among faculty at several institutions throughout california to study the neural processes that support language and cognitive processes in bi-/multilingual adults, and how these processes change across the lifespan in response to new experiences or injury (i.e., neuroplasticity). interdisciplinary approaches are critical to the advancement of our understanding of the complex mechanisms in the mind and brain because the complexity of these processes requires perspectives from developmental science, cognitive science, language science, cognitive aging, and neurolinguistics, among others. the new equipment will be used to train a diverse student population in cognitive neuroscience research methods and the study of the neuroplasticity of communication, thereby promoting access to careers in basic science, clinical research, and applied settings. california state university east bay is a hispanic-serving and asian american & pacific islander-serving institution, drawing first-generation and minority students from the diverse bay area community who are historically underrepresented in these fields. despite recent advances in the basic neural changes associated with experience-dependent brain plasticity, our understanding of the structural and functional neural plasticity associated with language and cognitive functioning across the lifespan, and in response to injury, is still limited. the study of bilingualism and multilingualism provides a unique window into these processes; managing two language systems and flexibly switching between them engages the linguistic and cognitive control systems in unique ways, shaping the neural structures that underlie language and cognition. research activities enabled by the eeg equipment include investigating neural activity associated with a) second

language learning in adulthood and the regulation of the native language, b) formal instruction in a heritage language, c) language mixing practices in dense bilingual communities, d) the involvement of the left and right cerebral hemispheres in bilinguals? judgments of learning, e) the preservation of cognitive abilities in aging bilinguals, and f) the connectivity of various brain regions associated with language and cognitive processing in bilinguals with aphasia, a language disorder resulting from neurological damage. moreover, by investigating individual differences among bilinguals in factors such as age of second-language acquisition, language proficiency, and language use patterns, the researchers can explore how the brain responds to diverse language experiences in childhood and adulthood. these projects investigate the neural underpinnings of language and cognition across a broad spectrum of adults across the lifespan, both neurologically healthy and those with neurological damage. eeg allows us to study the online neural processes that lead to the language and cognitive behaviors characteristic of different language users, whose **\*\*diversity\*\*** is critical for developing generalizable theories of language and cognition. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: Theory-Grounded Guidelines for Solver-Aware System Architecting (SASA)

Awardee: Purdue University

Amount: \$258,678.00

Abstract: the objective of this project is to advance the scientific understanding of a new paradigm of system architecting in engineering, referred to as solver-aware system architecting (sasa). sasa actively considers the capacity of talent and expertise from outside organizational boundaries (e.g., gig workers, crowd) during the formulation phases of the system design process. this research hypothesizes that the joint consideration of system architecture, diverse external solvers, and contract mechanisms, can significantly improve system design outcomes. the research will result in new theory and best practices for when and how to incorporate novel sources of effort into complex systems design, which has positive implications for workforce management. with an explicit focus on translation to practice, the guidance generated by this work has the potential to make a tangible impact on how system architecting is practiced, and the way organizations engage with outside and non-traditional solvers, which promises greater effectiveness and efficiency in technical business operations. the theoretical innovations will be reduced to practice in the form of actionable

guidelines relating sasa principles to design outcomes. additional deliverables of this project include a set of educational tools to educate students and industry practitioners on sasa. if successful, the research will result in scientific foundations for the paradigm shift from traditional approaches to system architecting, which assume traditional players bounded by organizational boundaries, to more open innovation approaches for complex systems design. the research will establish a firm scientific foundation consisting of (i) socio-technical theory for architecting complex systems; (ii) computational models of open innovation processes for systems design and computational methods for designing contractual mechanisms for sasa; and (iii) empirically-validated design guidelines to support practitioners of sasa. the research will extend the frontier of knowledge in systems engineering research and practice by shedding light on the linkages among innovation processes, designer knowledge, systems architecture and contractual structures. the resulting educational tools will have a direct impact on student learning about system architecting. the tools will be tested at the pis? institutions and then made freely available to other members of the engineering design and systems engineering (edse) community. the focus on leveraging non-traditional contributors has implications for broader societal goals around **\*\*diversity\*\*** and inclusion, broadening participation in stem through new avenues for access, and eliminating barriers to traditional professional practice. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SBIR Phase I: Developing Technology for Stimulating the Herd Instinct of Livestock to Improve Environmental Impact

Awardee: RANCHCHECK INC.

Amount: \$256,000.00

Abstract: the broader impact of this small business innovation research (sbir) phase i project is to help restore grassland ecosystems and reduce net greenhouse gas emissions from livestock by



developing technology to stimulate the herd instinct of livestock. grassland ecosystems have been shown to benefit from large herds of animals that promote water absorption and replenish important nutrients. however, most livestock in the western united states are currently scattered in large pastures and allowed to roam individually. this project aims to develop and test low-cost ear tags which use audio and electrical stimulation to reinforce the natural herd instinct of individual animals when they stray from the group. high stock density/low duration grazing has demonstrated the potential of reducing livestock greenhouse emissions and turning rangelands into a net carbon sink. higher vegetation **\*\*diversity\*\***, more water absorption, reduced erosion, and more wildlife habitat are just some of the expected ecological benefits of this technology. this technology could also facilitate more efficient and cost-effective ranch management. the risk of livestock theft will be reduced, and the need for fences would decrease since the migratory instincts of livestock work best on larger land areas. this sbir phase i project will develop and test a novel approach of stimulating the herd instinct of livestock rather than geographically confining them. key to the implementation of this approach is the additional innovation of a unique and low-cost strategy to use ear tags with low-power radiofrequency (rf) transceivers to calculate herd proximity from an accumulation of individual distance estimates. this technology will use a highly integrated system using an ear tag attached to each animal in the herd. each tag will use a low power rf transceiver to periodically send brief signals to the other tags in the herd. the tags will use signal strength measurements to calculate their own approximate distance to every other tag. each tag will then use an algorithm to determine whether it is within an appropriate proximity to the rest of the herd. if an animal begins to stray from the herd, the tag will give an audio alert potentially followed by electrical stimulation to encourage the animal to rejoin its peers. the capability of holding a herd at a density from 10,000 to 1,000,000 pounds per acre will be a key metric of success. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SBIR Phase I: Field Demonstration of Ship Hull Inspection with a Fleet of Unmanned Underwater Vehicles

Awardee: BERKELEY MARINE ROBOTICS INC.

Amount: \$256,000.00

Abstract: the broader impact of this small business innovation research (sbir) phase i project is to protect marine ecosystems against invasive species and to help the shipping industry reduce its greenhouse gas (ghg) emissions. marine invasive species are considered to be one of the greatest threats to marine and coastal bio\*\*diversity\*\* worldwide, second only to habitat loss. keeping the oceans healthy is essential to preserve the employment, development and growth of the ocean economy. this is particularly relevant in the united states, where the marine economy contributes nearly \$400 billion to the nation's gross domestic product with 40 percent of the population living in coastal counties. one of the main vectors for the transfer of marine invasive species is the biofouling on ship hulls, described as the undesirable accumulation of microorganisms, plants, algae and animals on the submerged hull. a second impact of biofouling is to increase the drag forces on the hull, resulting in an increase of the ship's fuel consumption and ghg emissions in the atmosphere. this project advances a system for in-water inspection of ship hulls with a fleet of unmanned underwater vehicles (uuv's). the automated underwater inspection system will provide maritime stakeholders with biofouling data to optimize hull cleaning schedules, validate compliance with regulations, thereby improving ship performance and ecosystem health. this project develops a system leveraging a uuv fleet that forms an arch operated from a vessel (e.g. power boat, crew vessel) located at one of the arch's extremities. it can inspect hulls as ships enter or leave ports without having to be immobilized. the uuv's exchange data wirelessly between each other and with the surface, enabling autonomous coordinate inspections without tethers but under human supervision. an advanced positioning system and control scheme will be implemented to enable accurate localization without gps and precise operation in the vicinity of the hull. this project will

conduct in-water experiments to validate the performance of the positioning system and control scheme. the outcome of the project will be a proof-of-concept where a fleet of two uuv's inspect the hull of a vessel, demonstrating that the inspection system is fast, practical and repeatable. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SBIR Phase I: Microbe-based scaffold for the generation of structured cell-based meat

Awardee: NOVEL FARMS, INC.

Amount: \$256,000.00

Abstract: the broader impact of this small business innovation research (sbir) phase i project is to address challenges of animal farming through cell-based meat production. approximately 30% of the earth's surface, 70% of all arable land, and 29% of the global freshwater supply is dedicated to animal farming. livestock is responsible for 18% of global greenhouse gas emissions and is a major threat to bio\*\*diversity\*\*. 70% of all antibiotics used in the united states are used on farm animals and contributes to the emergence of antibiotic-resistant bacteria. cell-based meat development is estimated to generate significant reductions in greenhouse gases and use of land, water, and energy, as well as antibiotics in meat production. the proposed project aims to develop novel technologies that will accelerate cell-based meat development. the proposed project develops a novel scaffolding material for the generation of animal tissue, specifically skeletal muscle. the proposed project will ultimately advance current scientific knowledge on the mechanisms underlying tissue generation and elucidate the molecular principles governing cell adhesion, differentiation, and growth of animal cells during tissue development. key technical objectives include demonstrating that the proposed scaffold can be successfully customized to harbor any cell adhesion molecule of interest, and proving that a novel biomaterial can be adapted as a tissue-culture-grade reagent. fluorescence microscopy will be used to ascertain the extent of animal cell adhesion and growth on

the proposed scaffold. these studies will advance understanding of animal cell interactions with their extracellular milieu, and how environmental molecular properties and cues are tuned to influence de novo tissue development in vitro. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SBIR Phase I: Climate analysis at scale through mapping biomass, water restoration, and soil carbon sequestration

Awardee: EARTHSHOT Labs PBC

Amount: \$256,000.00

Abstract: the broader impact/commercial potential of this small business innovation research (sbir) phase i project is to scale nature-based climate mitigation. the phase 1 project will create and manage comprehensive data sets and models representing the current and proposed future state of ecosystem health as measured by aboveground biomass growth in forests, the health and carbon sequestration in soils, and the restoration of groundwater in arid or otherwise degraded environments through the restoration of hydrological function. through its open source and community-oriented approach, the project intends to be a valuable resource for organizations mitigating loss of bio\*\*diversity\*\*, soil health, forest cover, and groundwater due to extractive land use practices. the information provided by this technology will be useful for landowners, governmental authorities, researchers, and financial institutions. the project will utilize recent advances in remote sensing, cloud compute infrastructure, and machine learning to predict the highest leverage land-based interventions for managing and enhancing the hydrological cycle, protecting forests and increasing reforestation efforts, and building soil health and resiliency through soil organic carbon sequestration. the highest impact water interventions will be determined using random forest algorithms improved through the use of soil models that include porosity, rates of

runoff, and texture. the forest-based interventions for conserving and increasing above-ground biomass will be based on historic land use change and disturbance regimes as monitored through satellite imagery and coupled with potential sequestration rates achieved through restoration and improved forest management. soil health and carbon sequestration modeling will be accomplished using historic soil sample data over an 80 year period and the associated environmental covariates in addition to research into rates of soil sequestration by land management type. this will enable the training of a random forest-based model to predict the highest impact land use interventions to enhance or restore soil organic carbon. these models will be combined to create an interactive land viewer. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: BENEATH THE FOUNTAINS: Shallow conduit processes and diversity in basaltic fissure eruptions.

Awardee: University of Hawaii

Amount: \$255,794.00

Abstract: mildly explosive eruptions?the most frequent manifestations of subaerial explosive volcanism on earth?broadly group into two styles: strombolian and hawaiian. the former is characterized by sequences of intermittent discrete explosions and the latter by sustained pyroclastic fountaining. explosive activity during the 2018 fissure eruption of k?lauea volcano (hawai?i) provided an exceptional opportunity to record a wide range of strombolian and hawaiian behavior (figure 1), thanks to the accessibility of the volcano and the wealth of data types collected throughout the event. this study address which processes in the plumbing system beneath the volcano ?drove? the great **\*\*diversity\*\*** in style and intensity of the 2018 explosive activity compared to previous, more consistent, fissure eruptions at k?lauea and elsewhere? k?lauea is an exceptionally active volcano and its eruptions pose constant challenges for management agencies

because the eruption sites are highly accessible and there is a need to balance the strong popular interest in viewing the eruptive activity against public safety (as seen in 2018). this balance requires critically on sophisticated knowledge of the volcano's current and immediately future behavior. there is both a public desire for better knowledge of the volcano's behavior and a need for improved forecasting of the likely course and footprint of all future eruptions. the observatory partner, usgs, has a federally mandated role to advise response agencies in hawaii and will transfer knowledge from the nsf-funded study to the bodies charged with risk management. this work involves exchange of material and ideas between institutions in the usa, and the united kingdom to the benefit of young researchers and students. the results will be widely disseminated via meetings and workshops, courses offered by the fema-funded national disaster preparedness training center, the internet and scientific publications and a planned virtual field trip to kilauea. the goal of this study is to link existing high-resolution observations of explosive basaltic fissure eruptions to the processes in the very shallow conduit that cause and shape them, focusing on the 2018 kilauea eruption as a case study. it will combine existing data derived from high temporal and spatial resolution videos with: (1) field measurements of five representative pyroclastic footprints, and laboratory characterization of the ejecta, (2) high-precision measurements of two-phase magma rheology, and (3) models tied to newly completed laboratory analog experiments to simulate outgassing patterns. this approach is expected to help identify patterns and precursors that accompany transitions in eruptive style, supporting risk management for communities on the flank of this very active volcano. this study will fundamentally improve our understanding of the dynamics of hawaiian and strombolian eruptions. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Digitization TCN: Extending Anthophila research through image and trait digitization (Big-Bee)

Awardee: California Academy of Sciences

Amount: \$255,400.00

Abstract: declining populations of bees impact plant-pollinator interactions in both natural and agricultural systems. while bees and other insects pollinate most wild plants, and are critical to sustain a large proportion of global food production, they are decreasing in both numbers and **\*\*diversity\*\***. our understanding of the factors driving these declines is limited because we lack sufficient data on the distribution of bee species, and on the behavioral and anatomical traits that may make them either vulnerable or resilient to human-induced environmental changes, such as habitat loss and climate change. fortunately, wild bees have been collected by researchers and deposited in natural history collections for over 100 years, retaining a wealth of associated attributes that can be extracted from specimen images. this project will digitally capture data and images from these historic specimens, develop tools to measure bee traits from these images, and generate a comprehensive bee trait and image dataset to measure changes through time. this will increase our understanding of specific traits that put bee species at risk of decline - a critical need for both sustaining our agricultural economy and the conservation of our natural resources. in addition, the large image datasets created by this project can be used for new artificial intelligence identification tools that will help improve our future pollinator observation and monitoring efforts. the big-bee thematic collection network (big-bee tcn) will create over one million high-resolution 2d and 3d images of bee specimens, representing over 5,000 worldwide bee species, including all of the major pollinating species of the united states. the big-bee network includes 13 institutions and partnerships with us government agencies. novel mechanisms for sharing image datasets will be developed and datasets of bee traits will be available through an open data portal, the bee library, for research and education. the big-bee project will engage the general public in research through community science via crowdsourcing trait measurements and data transcription from images. in addition, training and professional development for natural history collection staff, researchers, and university students in data science will be provided through the creation and implementation of workshops focusing on

bee traits and species identification. all data resulting from this award will be shared with and publicly available through the national digitized biocollections resource, idigbio.org. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Family Bereavement: Societal Prevalence, Patterning, and Consequences

Awardee: University of Southern California

Amount: \$254,788.00

Abstract: this project investigates family bereavement?the phenomenon of experiencing the death of a family member. extensive research has identified how economic and social hardship can contribute to an individual?s risk of death; yet we know less about whether the death of a family member can induce hardships for those bereaved. scientific efforts to understand family bereavement are highly relevant given the covid-19 pandemic?a global mortality event of historic proportions that has left millions of individuals grieving the abrupt death of relatives. this study offers a life course overview of family bereavement and its socioeconomic and health consequences. whereas past studies have focused on singular types of family loss, like parental death, this study considers multiple relatives. this allows clarification of the societal burden of different types of bereavement and their unique consequences for individuals. findings can inform programmatic efforts to address the effects of bereavement on population health, prosperity, and welfare. in addition to generating findings of high relevance to public health, this research supports **\*\*diversity\*\*** in science through the mentoring and training of students from historically under-represented groups. the first goal of the project is to identify the consequences of family bereavement by analyzing rich survey data on a cohort of 1,500 young adults. the data feature detailed family history information, including whether relatives are still alive and if not, how long ago they died, how old they were at the time of death, and whether they suffered from prolonged illness. these data are



used to analyze whether experiences of family bereavement influence young adults' wellbeing, including their mental and physical health and educational success. the second goal of the study is to use cross-national survey data on more than 3.7 million youth and 1.8 million adults to offer a comprehensive overview of the societal and life course patterns of family bereavement in more than 50 locations. by identifying the societal burden of family bereavement at the community, regional, and higher levels, and elucidating between-family and cohort differences in life course patterns of bereavement for multiple birth cohorts, the study offers foundational knowledge on family bereavement. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: GP-UP: Developing STEM Identity by Engaging URM Undergraduate Students in Research on Air Pollution in Chicago Communities

Awardee: Loyola University of Chicago

Amount: \$253,571.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). the geoscience learning community will help students from historically excluded communities build their stem identity through authentic research experience, mentoring, and introduction to geosciences careers. students will learn about air pollution, gain experience with instrumentation, practice computer programming and data analysis, and communicate scientific results by participating in real research with prosocial impact. this project addresses three geopath program goals: (1) increase the number and **\*\*diversity\*\*** of students in geosciences; 2) prepare students for geoscience careers; and 3) contribute to the evidence base for effective student engagement, learning, and retention in stem. the data collected through this project will be of sufficient quality to contribute to community discussions about how best to reduce air pollution and better protect public health, particularly within vulnerable communities. this project seeks to

employ several established evidence-based strategies for the success of students from historically excluded communities. a focus on student success in stem will include authentic collaborative undergraduate research experiences, sustained mentorship, and engagement in research with a direct link to community benefit. by combining authentic prosocial research and mentoring, the pis aim to build a sense of belonging, self-efficacy, and stem identity in two cohorts of students and help with their successful transitions to stem programs related to the earth sciences. this project specifically proposes to create geoscience learning community that engages undergraduate students from historically excluded communities in research to measure and attribute air pollution in two chicago neighborhoods that differ in socioeconomic status, demographics, and proximity to industrial facilities. the pis will recruit a cohort of undergraduate participants at loyola to join a research-intensive learning community each of year 1 and year 2 of the project. student participants will work closely with scientists and the community-based organizations to design and carry out research that addresses community concerns about air pollution. the project's aims are to 1) provide an applied, socially relevant research experience for student participants; 2) understand how particulate pollution in chicago varies over space and time; and 3) provide air quality data for community use. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Research Initiation: Understanding Impacts of Soft Robotics Curricula on Female Students Engineering Identity

Awardee: University of Illinois at Urbana-Champaign

Amount: \$253,122.00

Abstract: participation in k12 educational robotics is a common precursor to enrollment in engineering majors, however the gender gap in traditional pre-college robotics prevents equal

access to these disciplines. we believe soft robotics may create a new pathway for students from underrepresented groups to enter engineering majors. soft robots are those devices made from soft materials and flexible electronics enabling robots to more safely interface with humans and other living organisms. soft robotics presents an opportunity to introduce traditional engineering principles through a human-centered perspective with the potential to diversify engineering. this project will address two aims. first, this project aims to understand changes in the engineering identity of middle and high school-aged female students after having engaged in soft robotics projects in their science classes. second, this project aims to introduce the principal investigator to engineering education research, catalyzing a new research enterprise focused on access to engineering and educational robotics. the research team will utilize existing relationships with local schools to deliver a previously piloted soft robotics curriculum and study student experiences. implementation will include a one-week, hands-on robotics short course for about 200 middle and high school students local to the university of illinois urbana-champaign. to date, the lack of representation of women in mechanical and electrical engineering is well-documented. however, successful pathways for women to these majors are understudied. agency beliefs have been a useful lens for understanding how women do enter some engineering majors, such as bioengineering. the mentor-mentee research team will leverage a mixed methods approach to explore soft robotics as a new pathway to engineering critical engineering agency will be a framework through which to understand the student experience. the research team will use surveys and interview instruments to help answer the overall research question: how can a soft robotics implementation impact high school students? attitudes and self-beliefs, and therefore serve as a strategy to recruit female students to traditionally male-dominated engineering majors? prior to the activity, students will be surveyed using engineering identity and agency belief measures. after implementation, students will complete a post-survey and the research team will interview select students to understand how the activities impacted their engineering identity. the result of this collaborative research project will be an analysis of the elements of pre-college soft robotics curriculum that may lead to diverse recruitment

in engineering. education of local stakeholders in standards-based soft robotics curriculum opens the door for further engagement in our local community. dissemination of research results will enable broad adoption. findings from this study will pave the way for increased representation of women and underrepresented minorities in engineering at the college level and in the engineering workforce, contributing to a **diversity** of solutions to society's critical challenges. soft robotics curricula have the potential to prepare a diverse generation of engineers and reduce the barrier to entry not only for girls, but other students from underrepresented groups. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: REU Site: Multidisciplinary Underground Science at the Sanford Underground Research Facility

Awardee: Black Hills State University

Amount: \$251,244.00

Abstract: this award is funded in whole (or in part) under the american rescue plan act of 2021 (public law 117-2). black hills state university (bhsu) will host a 10-week research experience for undergraduates (reu) program centered on underground science at the sanford underground research facility (surf). this program will recruit six undergraduate students each year to participate in exciting underground research projects as well as professional development, social and outreach activities. underground science offers possibilities for interdisciplinary research across a variety of disciplines including physics, chemistry and biology. recruitment efforts of the bhsu reu site will be especially focused on american indian, female and community college students. surf hosts and performs some of the most important physics experiments of our time, searching for evidence of dark matter and investigating the physics of neutrinos. students the students will particularly be offered the opportunity to engage in research related to these experiments by assaying materials for

radiopurity measurements, helping to characterize the Iz detector and testing the chemical purity of noble gases. additionally, research at surf is being carried out in the study of life deep underground, with applications to medicine and astrobiology, in particular in the **\*\*diversity\*\*** of microbial environments and in the isolation of novel microbes. complementary chemistry research will also be performed to determine the local environment in which these microbes live. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MCA: Advances in Understanding the Biogeochemical Evolution of Serpentinites (AUBES)

Awardee: University of Rhode Island

Amount: \$250,644.00

Abstract: this project is jointly funded by the division of earth sciences' mid-career advancement (mca) program and the established program to stimulate competitive research (epscor). microbial life has refined the fine-scale chemistry of minerals for billions of years of earth history, leaving complex, durable records of metabolic activity behind. fracture networks in rocks preserve a durable mineral record of these ancient processes, often touching questions related to the origin and early adaptive strategies of rock-hosted, microbial life on earth. in this project, iron-rich rocks (also high in chromium, nickel, and other metals) from earth's mantle, collected through scientific drilling in northern california's coast range ophiolite, are targeted for geochemical study. fracture zones in these ~150-million-year-old rocks were hotspots of microbial activity under ancient conditions in the subsurface. this work uses an array of geochemical tools to map the chemistry of materials formed in fractures and applies a high energy x-ray-based technique (fe k edge xanes) to define how oxidized or reduced bound iron in fracture fill minerals may be, as evidence for biogeochemical cycling of iron (for energy) in the past. research involves collaboration with professional beamline scientists at brookhaven national lab and with topic expert dr. d. dyar of mount holyoke college.

increased understanding of the mineral reactions in this rock type (an enormous, continuous layer beneath the global seafloor and also present in extensive blocks at earth's surface) brings multiple societal benefits: the incompletely understood emissions of naturally forming methane (a greenhouse gas) and hydrogen (a flammable but quickly lost gaseous product) from these rocks may be better constrained using geochemical models; the release of iron and associated metals (e.g., health-damaging  $\text{Cr}^{6+}$ ) into percolating water passing through these rocks may be charted and flagged for public health attention; and the case for engineered reaction of these kinds of rocks with carbon dioxide to generate sequestered carbon in solids may be evaluated. completion of this research will also ensure that multiple new generation geoscientists will be trained in cutting edge analytical tools, through **diversity**- and equity-minded graduate and undergraduate education. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: SaTC: CORE: Small: Flanker: Automatically Detecting Lateral Movement in Organizations Using Heterogeneous Data and Graph Representation Learning

Awardee: Trustees of Boston University

Amount: \$250,000.00

Abstract: in modern cyberattacks, adversaries do not target single computer systems. instead, they first set an initial foothold into a company's network and later amplify their breach by compromising additional assets, until they reach their final target inside an organization. this process of advancing computer breaches is known as lateral movement. detecting lateral movement is challenging, because attackers can use multiple vectors for infection (e.g., phishing emails) and computer systems in a network present a large degree of **diversity** (e.g., workstations, network equipment). for this reason, no comprehensive system to effectively detect lateral movement is currently available. yet, detecting and stopping computer breaches as soon as possible is critical to ensure

the safety and the prosperity of u.s. corporations and citizens. the aim of this project is to fill this gap by developing flanker, a system able to automatically detect lateral movement in the network of an organization. unlike existing approaches, the goal of flanker is to operate on a variety of data sources (e.g., data coming from network and applications) to be able to detect cyberattacks as they span different online services and computers across the organization. this project consists of four phases. in the first phase the investigators collect heterogeneous datasets from a variety of sources and develop techniques to clean them from noise and anonymize them to protect the identity of users. in the second phase this data is used to build a graph that represents network activity, and graph representation learning approaches are used to build a model for this network activity. in the third phase this model is used to automatically detect lateral movement attacks, by either applying anomaly detection or supervised learning techniques. finally, the investigators develop visualization techniques to enable a security analyst to properly understand the detection results and adopt appropriate countermeasures against the attack. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: SaTC: CORE: Small: Flanker: Automatically Detecting Lateral Movement in Organizations Using Heterogeneous Data and Graph Representation Learning

Awardee: Northeastern University

Amount: \$249,863.00

Abstract: in modern cyberattacks, adversaries do not target single computer systems. instead, they first set an initial foothold into a company's network and later amplify their breach by compromising additional assets, until they reach their final target inside an organization. this process of advancing computer breaches is known as lateral movement. detecting lateral movement is challenging, because attackers can use multiple vectors for infection (e.g., phishing emails) and computer

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Matched Words: diversity

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Title: Collaborative Research: SaTC: CORE: Small: Flanker: Automatically Detecting Lateral Movement in Organizations Using Heterogeneous Data and Graph Representation Learning

Awardee: Northeastern University

Amount: \$249,863.00

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additional assets, until they reach their final target inside an organization. this process of advancing computer breaches is known as lateral movement. detecting lateral movement is challenging, because attackers can use multiple vectors for infection (e.g., phishing emails) and computer systems in a network present a large degree of **\*\*diversity\*\*** (e.g., workstations, network equipment). for this reason, no comprehensive system to effectively detect lateral movement is currently available. yet, detecting and stopping computer breaches as soon as possible is critical to ensure the safety and the prosperity of u.s. corporations and citizens. the aim of this project is to fill this gap by developing flanker, a system able to automatically detect lateral movement in the network of an organization. unlike existing approaches, the goal of flanker is to operate on a variety of data sources (e.g., data coming from network and applications) to be able to detect cyberattacks as they span different online services and computers across the organization. this project consists of four phases. in the first phase the investigators collect heterogeneous datasets from a variety of sources and develop techniques to clean them from noise and anonymize them to protect the identity of users. in the second phase this data is used to build a graph that represents network activity, and graph representation learning approaches are used to build a model for this network activity. in the third phase this model is used to automatically detect lateral movement attacks, by either applying anomaly detection or supervised learning techniques. finally, the investigators develop visualization techniques to enable a security analyst to properly understand the detection results and adopt appropriate countermeasures against the attack. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: STEPP-NET: Steppe Parasite Networks

Awardee: New Mexico Museum of Natural History Foundation

Amount: \$248,127.00

Abstract: this project focuses on collecting and describing mammals and their tapeworm and flea parasites from the grasslands of central asia. these parasites are highly diverse and ecologically important groups, and many are sensitive indicators of ecosystem quality; further, the parasitic infections they cause can have major negative impacts on wildlife. they also can play an important role in transmitting diseases from wild to domesticated species, and also to humans. however, knowledge of the **\*\*diversity\*\*** of parasite species, their geographic distributions, and the precise hosts they occur on and in remains highly fragmentary for much of the world. central asian mammals and their associated parasites are particularly highly imperiled but also little studied. this project will collect new material and study how tapeworm and flea parasites from the region evolve in conjunction with their mammalian hosts; it will also consider how the hosts and parasites have responded to various ecological changes across the region. this work is extremely time-sensitive, with many central asian ecosystems on the cusp of major land use change as economies shift and major construction occurs in the region. numerous specimens will be collected, and these will serve as a repository of parasite **\*\*diversity\*\*** useful for assessing how future global change influences the distribution of parasites and their hosts. this may ultimately improve public health outcomes. the work will also involve training the next generation of early-career stem researchers for careers in bio**\*\*diversity\*\*** science. the stepp-net project will rapidly advance discovery and description of species **\*\*diversity\*\***, host associations, and community assembly, in two mammal-associated macroparasite clades - fleas and cestodes - across the vast grasslands of central asia. this region is a prototype for exploring host-parasite dynamics and spillover in response to human activity; historically, as a conduit for ancient silk road trade routes, and, currently, from intensifying land use changes and construction. stepp-net leverages existing museum specimens, new expeditionary collections in mongolia and kazakhstan, and genomic analyses of hosts and parasites to advance knowledge of species boundaries, environmental and host niche breadth, and the exploration of novel host interfaces by focal parasite clades in response to global change pressures. a key outcome of stepp-net will be an extended specimen network for central asia, in which mammal and

parasite specimens are durably linked to derived data and immediately useful in global bio\*\*diversity\*\* studies and public health initiatives. the project also creates opportunities for stem graduate and undergraduate students to participate across the spectrum of modern bio\*\*diversity\*\* science, from international fieldwork to specimen curation and digitization, genomics, and integrative taxonomy. it will build out this community of early-career stem researchers even further by developing undergraduate and graduate educational modules that are implemented across our institutions and hosted online for broader bio\*\*diversity\*\* literacy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Effects of Mentoring Relationship Heterogeneity on Student Outcomes among NSF Research Experiences for Undergraduates (REU) Program Participants

Awardee: University of Texas at El Paso

Amount: \$247,938.00

Abstract: understanding mentoring relationships is critical to increasing \*\*diversity\*\* in stem fields. researchers at the university of texas at el paso and the university of utah propose to study the effects of mentor relationship mismatch on student outcomes during nsf research experiences for undergraduates (reu) programs. this project aims to employ a novel approach to studying mentoring by examining multilevel mentoring and demographics of students and the mentor team. the project aims to collect data from participating students and mentors from across the country at the end of the summer research program and during the next year to gauge outcomes related to stem interest and persistence and intent to follow a stem career pathway. this project aligns with the ehr core research program's goal of addressing challenges in stem interest, learning, and participation. the project aims to address three interrelated research questions, including how mentoring relationship heterogeneity impacts short-term and mid-term student outcomes, if these effects can

be moderated by interactional dynamics between mentors and mentees, and how mentoring relationship heterogeneity impacts educational, research, and career goals immediately after the reu experience and after one year. mentoring relationship heterogeneity in context provides a conceptual framework focusing on how student mentees match with multiple mentors, including graduate students and post-doctoral researchers. the concept of programmatic heterogeneity will be used to measure the dissimilarity between students' demographic background and the demographic composition of their reu program. post-reu surveys collected from the center for the improvement of mentored experiences in research (cimer) data will be used along with a matrix analysis of semi-structure individual interview responses. short-and mid-term student outcomes consist of immediate gains in working like a scientist, comfort with science skills, science identity, sense of clarity about career path, research productivity, persistence in stem major, and intent to pursue graduate school. the project seeks to advance knowledge about mentoring relationships and aims to produce mentor and mentee workshops to positively impact undergraduate research students from underrepresented groups. the project is funded by the ehr core research program that supports fundamental research focused on stem learning and learning environments, broadening participation in stem, and stem professional workforce development. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: phyloregion, computational infrastructure for biogeographic regionalization and macroecology in the R computing environment

Awardee: Southeastern Louisiana University

Amount: \$246,317.00

Abstract: establishing geographical comparisons based on shared biota is crucial to the study of biogeography and for managing biological **\*\*diversity\*\*** in the face of rapid warming of the earth's

climate. however, the computational tools to analyze and manipulate the massive-scale species biogeography data has not been fully developed. historically, classifications of biogeographic regions were based on descriptions of the ecology, taxonomic composition or vegetation features of regions. recent approaches provided more quantitative, and objective classifications, but broadly recapitulated earlier efforts and overlooked the evolutionary implications captured by the shared phylogenetic relationships of species. because the field of biogeography has traditionally developed as an observational science rather than an experimental one, developing replicable analytical tools for biogeography into reproducible workflows is critical. the r software package `phyloregion` ? designed for biogeographic regionalization and macroecology ? can overcome these computational challenges. it contains tools for biogeographical regionalization, macroecology, conservation, and visualization, and has potential application in various disciplines including evolution, microbial **diversity**, systematics, ecology, phylogenetics, and many others. in this project, the research team plans to substantially increase computational efficiency of functions in `phyloregion`, to add new functionality, and create a model for user-guided software development in biogeography. the project will develop and implement new tools in `phyloregion` for biome evolution and biogeographical investigations. novel grade of membership model that represents sampling units as partial memberships in multiple groups will be established to analyze large biogeographic datasets. it will extend `phyloregion` with new tools to visualize patterns of biogeography, macroecology and evolution. `phyloregion` will be enhanced to pass objects between r and `revbayes` (a c++ tool for bayesian phylogeography) for phylogeographic visualization through r. finally, it will introduce new tools for conservation that reflect the key dimensions of phylogenetic **diversity** including richness, divergence and regularity. `phyloregion` is already widely used and represents one of only a few biogeographical resources in r tailored for megaphylogenies and macroecological datasets. this research will create new, open-source, and freely distributed software tools with potential for transformative impact in biogeography and beyond. workshops and conferences will be used for dissemination, and to provide introduction to intermediate r coding and implementation of

biogeographical tools. workshops will target a mix of faculty, postdocs, and especially graduate and undergraduate students, who will be trained on the use and application of phyloregion in their research, and to help develop their own novel biogeographic functions to assemble into an r package. the research team will work with existing **\*\*diversity\*\*** programs at texas a&m university-corpus christi and southeastern to recruit diverse undergraduate participants, and provide resources for them to learn about graduate school. all products from this project will be disseminated free and open-sourced through computer codes, publications, conferences, workshops and vignettes. phyloregion vignettes will be used to create an upper-division course for undergraduate and early graduate students. the grant will support the mentoring of one postdoctoral researcher and a graduate student and many undergraduates. women and traditionally underrepresented groups will be specifically encouraged to apply for the postdoctoral research position, as well as for the workshops. the phyloregion project can be accessed at <https://cran.r-project.org/package=phyloregion> this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Testing an Integrative Model of the Social-Psychological Drivers of Participation in Relational Organizing

Awardee: Colorado State University

Amount: \$245,057.00

Abstract: relational organizing is a promising approach for achieving rapid, widespread community action for environmental conservation and other pro-social outcomes. relational organizing involves enlisting motivated volunteers to share information about and encourage others they know to engage in a desired behavior. it is effective because it harnesses the power of people's social connections, which people are generally motivated to maintain, to help spread new information and

create new social norms. although a growing number of studies have documented the effectiveness of relational organizing, a key challenge to implementing this approach is scaling it up, or encouraging a larger number of individuals to reach out to others they know. studies find that most people who are committed to participating in a conservation behavior in their personal lives are reluctant to reach out to others about this behavior. preliminary research suggests this may be a result of specific social-psychological barriers that prevent people from reaching out to others, such as their fear of being judged negatively. this project examines these barriers through public surveys, and develops and experimentally tests messaging approaches for reducing these barriers to encourage greater participation in relational organizing. to do so, the researchers partner with an international ngo, local government, and private industry to focus on a context with immense environmental, health, and animal welfare impacts: relational organizing to reduce meat consumption. the team develops practical handbooks and webinars summarizing the findings to inform the efforts of numerous organizations seeking to harness the power of relational organizing for pro-social behavior.

scaling up the relational organizing approach requires understanding, synthesizing, and developing interventions to address the most salient factors driving people's willingness to reach out to others. the researchers advance a theoretical model of the social-psychological drivers of participation in relational organizing. the model proposes that participation in relational organizing is influenced by: 1) personal norms about reaching out to others; 2) activist social identity; 3) attitudes towards and past engagement in the target behavior; 4) perceptions of others' beliefs about the issue and about reaching out to others about the issue; and 5) beliefs about the efficacy of relational organizing. to test this model, the team first conducts surveys to examine the explanatory power of the model and identify the social-psychological variables that are most associated with participation in relational organizing for reducing meat consumption. the results of the surveys inform the development of messaging interventions to address the most important social-psychological factors. the team tests the effectiveness of the messaging interventions at enhancing relational organizing for reducing meat consumption first

through online experiments and then through field experiments in collaboration with an international ngo, local government, and private sector partners. in the field experiments, they track vouchers for meatless meals that respondents can give to others as indicators of effective relational organizing.

the research addresses three gaps in the literature on pro-environmental and pro-social behavior. first, most studies have focused on motivating personal-sphere behaviors, rather than more collective behaviors that involve engaging with others. the team addresses this gap through the focus on motivating individuals to reach out to others to facilitate relational organizing. second, there is a lack of understanding of the **\*\*diversity\*\*** and relative importance of social-psychological factors influencing whether people reach out to others in their social network. this gap is addressed through the development and testing of the theoretical model. finally, few studies have tested the impacts of theory-based interventions on real-world indicators of conservation behavior, particularly on collective behaviors related to bio**\*\*diversity\*\*** conservation and food choices. this project addresses this gap through a field experiment that implements a real-world relational organizing campaign. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Trace Elements in Pyrite?Validation and Calibration of a Novel Paleoenvironmental Proxy

Awardee: Central Michigan University

Amount: \$244,516.00

Abstract: life in the oceans is often limited by the availability of nutrients, such as nitrogen and phosphorus. other elements occurring in far lower abundances are also bioessential and potentially limiting?particularly trace metals such as iron and molybdenum. these metals are co-factors in many biological processes, and their distributions through time and space are strongly coupled to oxygen levels in the oceans; weathering of the continents; evolving atmospheric composition; and biological



evolution. all of these factors tie intimately to climate change as a critical driver and consequence of metal cycling on land and in the oceans. yet, despite extensive study of metals in modern and ancient oceans, basic gaps remain in our knowledge because of inadequate testing of certain chemical methods, particularly in the modern oceans. these methods, once refined, would allow for more confident exploration of a vast array of past conditions at earth's surface far beyond those seen today. from that reinforced vantage, researchers can begin to imagine more rigorously and comprehensively what may lie in our future. one of the most promising methods for "time travel" through earth's evolving oceans is elemental analysis of pyrite, an iron sulfide mineral common today and in the past that may provide easily accessible and highly preservable historical archives. surprisingly, despite the advantages that may lie with this approach and hints of success already, no previous effort has attempted to validate and calibrate the pyrite tracer in modern oceans where present environmental conditions, local and global, can be tied directly to the composition of the mineral. this study is the first comprehensive investigation of these relationships in modern systems, strengthened by targeted experiments and novel analytical techniques. the principal expected outcome is an improved understanding of the controls and consequences of change at earth's surface as expressed in evolving ocean chemistry past, present, and future and the cause-and-effect relationships with co-evolving life. many studies are now using a technique called laser ablation-inductively coupled plasma-mass spectrometry (la-icp-ms) to measure trace metal contents of pyrite as a tracer for past marine conditions, and the initial results are encouraging. that said, there is still little mechanistic understanding of how and when trace elements are incorporated into pyrite and how these patterns and controls vary across environmental gradients. these uncertainties weaken their utility. the relationships among local controls and the capture of potentially global signals remain largely unknown. thus motivated, this study is designed around a two-pronged approach: (1) sampling in five classic, well-studied modern marine environments with a well characterized **"diversity"** of primary environmental conditions and (2) complementary, carefully conceived laboratory simulations designed to provide unprecedented insight into the mechanisms of

trace metal uptake by iron sulfide minerals and their sensitivity to environmental backdrops. the ultimate goal is to expose the strengths and weaknesses of the proxy and best practices while revealing new opportunities, such as the possibility of tracking the availability of bioessential trace metals in the ancient deep biosphere. plans include analyzing pore waters and sediments from diverse settings in modern oceans and interpreting those data within the framework of experimental results to reveal how trace metal content scales with conditions in the surrounding environment. the utility of the approach will be explored further using novel, highly sophisticated analytical methods applied at high resolution to characterize experimental and natural samples. this will be the first systematic study that correlates pyrite metal contents with metal availability in surrounding fluids and relates such data more generally to the wide range of environmental parameters and proxies often included in studies of earth's ancient biosphere. the impacts of this study will extend broadly through outreach opportunities targeting middle and high school students and ucr undergraduates placed in the lyons lab, while championing **\*\*diversity\*\*** and inclusion at all levels. that community footprint will be expanded through a recurring public lecture series and an on-campus science festival presented entirely in spanish, among other already tested community-directed efforts. at cmu, plans include a geochemical study at two middle schools in flint (mi) emphasizing water quality and use of those data to construct a new, much-needed community-driven water quality database for flint. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: SHF: Small: Feedback-Driven Mutation Testing for Any Language

Awardee: Northern Arizona University

Amount: \$244,487.00

Abstract: testing, validation, and verification are all central activities in programming and software engineering. unfortunately, existing techniques for testing remain inadequate for finding and

eliminating key vulnerabilities before software deployment -- even the most critical modern software is rife with security vulnerabilities and defects that ultimately cost the economy billions of dollars annually in lost productivity and compromised data. a technique known as "mutation testing" has been researched since the 1970s; it aims to help software engineers improve their tests and their software at the same time, by automatically adding bugs to a program and checking whether the test suite can detect them. although in theory this technique is extremely effective for improving software quality, there are several fundamental factors that prevent it from being widely used in practice: it is difficult and time-consuming to use, and the tools that exist for it cannot all handle the **\*\*diversity\*\*** of program languages that are deployed in modern software systems. this project will tackle these challenges and allow this important technique to be used to improve quality of real-world software by developing efficient tools that can apply mutation testing to programs written in any language; prioritize the output of the tools to reduce the amount of time and effort needed to make maximal use of them; and incorporate user feedback into the technique to maximize testing efficiency. the project will be evaluated on real-world open source software like the linux kernel, and build on the researchers' previous collaborations to substantially improve program and test effort quality on critical real-world software. the core problem this project aims to address is making program mutants practical in nonresearch settings, in a way that meets the needs of developers and test engineers, by making it possible for someone creating or enhancing a test suite, or developing code and test suite in tandem, to (1) use "just enough" mutation testing for their needs, maximizing benefit gained in exchange for work performed, and (2) to work in any programming language without worrying about the quality of tool support provided for mutation testing, and without sacrificing the ease of understanding of source-based mutants, while easily adding custom mutation operators that target their specific software development task. this project aims to adapt the furthest-point-first metric previously used in fuzzer bug triaging to the problem of maximizing the novelty of mutants examined by a user, in order to make it possible to quickly discover unkilld mutants that expose serious defects in a testing or verification effort. however, novelty alone is not

sufficient: feedback-driven mutation testing must also help users avoid inconsequential, equivalent mutants, kill mutants high in the dominance hierarchy, and (most importantly) incorporate user feedback. if a user marks a mutant as inconsequential, or equivalent, or (especially) high impact, then that information must be used to inform the ranking of future mutants as well. in order to make such an approach maximally valuable, this project also proposes to improve the state-of-the-art in source-level multilingual mutant generation, allowing users to easily generate mutants for new programming languages, or even for custom dsls that are part of a specific project. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: SHF: Small: Feedback-Driven Mutation Testing for Any Language

Awardee: Northern Arizona University

Amount: \$244,487.00

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real-world software by developing efficient tools that can apply mutation testing to programs written in any language; prioritize the output of the tools to reduce the amount of time and effort needed to make maximal use of them; and incorporate user feedback into the technique to maximize testing efficiency. the project will be evaluated on real-world open source software like the linux kernel, and build on the researchers' previous collaborations to substantially improve program and test effort quality on critical real-world software. the core problem this project aims to address is making program mutants practical in nonresearch settings, in a way that meets the needs of developers and test engineers, by making it possible for someone creating or enhancing a test suite, or developing code and test suite in tandem, to (1) use "just enough" mutation testing for their needs, maximizing benefit gained in exchange for work performed, and (2) to work in any programming language without worrying about the quality of tool support provided for mutation testing, and without sacrificing the ease of understanding of source-based mutants, while easily adding custom mutation operators that target their specific software development task. this project aims to adapt the furthest-point-first metric previously used in fuzzer bug triaging to the problem of maximizing the novelty of mutants examined by a user, in order to make it possible to quickly discover unkillable mutants that expose serious defects in a testing or verification effort. however, novelty alone is not sufficient: feedback-driven mutation testing must also help users avoid inconsequential, equivalent mutants, kill mutants high in the dominance hierarchy, and (most importantly) incorporate user feedback. if a user marks a mutant as inconsequential, or equivalent, or (especially) high impact, then that information must be used to inform the ranking of future mutants as well. in order to make such an approach maximally valuable, this project also proposes to improve the state-of-the-art in source-level multilingual mutant generation, allowing users to easily generate mutants for new programming languages, or even for custom dsls that are part of a specific project. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: SUNY at Albany

Amount: \$243,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity  
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Title: SBIR Phase I: Ultra Wide Band (UWB) Ka-Band Flat Panel Antenna

Awardee: ALLBEAMS, INC.

Amount: \$242,000.00

Abstract: the broader impact/commercial potential of this small business innovation research (sbir) phase i project seeks to advance the development of ultra-wide band (uwb) flat panel antenna (fpa) which is a catalyst for ubiquitous, satellite-based communication. this project focuses on the international telecommunication union (itu) ka-band frequencies (tx 27.5-31ghz, rx 17.7-21.2ghz) with fpa capable of connecting to all three constellations: low earth orbit (leo), medium earth orbit (meo), and geostationary orbit (geo) simultaneously. the development of these fpa will enable a new era of satellite communication, making the internet network a global network regardless of the

user's location on earth, with speeds comparable to, and in some cases higher than, land-based networks. fpa technology may spur further research into higher millimeter-wave (mmwave) frequencies and the bandwidth benefits they offer. fpa technology may also be an enabler of the future hybrid wireless network used in connected cars and machines with direct line of sight (los) to a satellite. this small business innovation research (sbir) phase i project aims to develop a novel method of radiating aperture design for high bandwidth, high efficiency, low-cost, and lightweight next-generation satellite terminal flat panel antenna (fpa). recent activities in the satellite industry such as the new leo constellations and high-throughput satellite (hts) networks in geo orbit have prompted the development of the fpa to be used in the user's terminal. to support such a multi-orbit constellation, certain performance criteria such as bandwidth, polarization **\*\*diversity\*\***, cross-polarization rejection, and antenna gain need to be met with sufficient margin to guarantee reliable communication links. the existing flat panel antenna technologies are either narrowband or bulky, which makes them not suitable for emerging satellite technology or multi-orbit communication. as a result, there is a need for a new flat panel antenna that can cover the entire ka-band frequencies (both tx and rx) to unlock the full potential of satellite communication in the ka-band. the core of this project is developing the novel technology with all the attributes needed for multi-orbit communication. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: SBIR Phase I: A robotic system for removal of invasive plant species

Awardee: BIRDHABITATBOT LLC

Amount: \$240,060.00

Abstract: the broader impact of this sbir phase i project is to improve habitat for native plants and wildlife by removing invasive plants with a mobile robot. worldwide invasion by non-native plant species is a primary concern in forest ecosystem health and bio\*\*diversity\*\*. within the highly fragmented landscape of the connecticut forest, two invasive plants significantly contribute to the degradation of habitat: japanese barberry and multiflora rose. current methods to eradicate them are time-consuming, expensive, and ultimately ineffective. this project presents a novel method of detecting and removing japanese barberry and multiflora rose. deep learning technology enables additional use with other invasive species, increasing the system's value throughout natural resource management. additionally, once programmed, the robots will be easily operated, making them usable for a variety of personnel. this sbir phase i project will advance current robot prototypes being tested for weed detection and removal. there is currently no mobile robot designed and programmed to remove understory invasive shrub species in a deciduous forest ecosystem. the technical challenges that will be addressed in building a feasible robot prototype include navigating over the unstructured terrain of the forest floor, developing a cutting attachment for the robotic arm, and creating a hybrid soft-rigid platform to withstand forest floor hazards while averting tree seedling damage. the proposed system will operate as follows: (1) an unpiloted aerial system (uas, i.e., drone) flies over the canopy to capture images of the forest understory; (2) images are then labeled and converted to species location maps; and (3) utilizing these maps, a semi-autonomous mobile robot navigates to the invasive species locations for removal. the robots will be programmed for semi-automated missions monitored by an operator nearby at a safe distance to ensure worker safety. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: HSI ATE Hub 2: Professional Development for Culturally Responsive Technician Education

Awardee: Westchester Community College

Amount: \$238,123.00

Abstract: this project aims to better serve and support a diverse population of students who are pursuing credentials in skilled technical fields. to do so, the project will guide faculty to adapt and implement culturally responsive instruction in technician education courses. the project is designed to increase the retention of hispanic students in stem career pathways, particularly in advanced-technology fields. the project builds on the hispanic serving community college kickstarter project, the hispanic serving institutions hsi/ate hub project, and the westchester community college photonics and laser project. the project team will develop, pilot test, and disseminate a faculty professional development model that can help to shift faculty understanding, practice, and mindset from emphasis on perceived student deficits to asset-based thinking and mutual respect. the professional development will be organized into three tiers. tier 1 is designed to establish awareness and support first steps. tier 2 will focus on the development, implementation, and testing of culturally responsive instruction practices in technician education. tier 3 will focus on creating a community of instructors and emerging leaders that engages in practice, theory building, and applied research into effective educational practices. the overall project goal is to develop faculty knowledge, skills, values, attitudes, and mindset so that more hispanic students will complete advanced technology programs. in doing so, the project can increase the **\*\*diversity\*\*** of the technician workforce and help to mitigate disproportionate impacts of covid-19 on hispanic communities. this collaboration includes faculty and administrators in technician education programs, higher education researchers, experts in culturally responsive instruction, and industry partners to further conceptualize, operationalize, and test the validity of culturally responsive instruction in the skilled technical fields of applied engineering and applied computing and

cyber-security. additionally, the project will test the hypothesis that micro-credentials are valuable for incentivizing faculty participation in project activities and that micro-credentials will be recognized by educational and industry stakeholders as valuable evidence of expertise and experience. the mixed method evaluation is process -oriented to facilitate development of a model and outcomes-oriented to assess faculty and student outcomes that includes assessment of changes in knowledge/awareness, skills/behavior, and attitudes/mindset. this project is funded by the advanced technological education program that focuses on the education of technicians for the advanced-technology fields that drive the nation's economy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: How are Flood Basalts Fed? A Textural Investigation of the Chief Joseph Dike Swarm

Awardee: University of West Georgia

Amount: \$238,043.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). flood basalts are the earth's most extensive expressions of volcanism. the eruption and emplacement of these voluminous magmas have been linked to global climate shifts and many extinction events. the columbia river flood basalts in oregon, washington, idaho, and nevada are the most recent and best-preserved example of this voluminous volcanic activity. it is believed that degassing during their eruption 17-14 million years ago influenced global temperatures. a key aspect to understanding magmatic systems is deciphering how the magma is transported from depth to surface. at the chief joseph dike swarm in oregon, a portion of the magmatic plumbing system of the columbia river flood basalts is preserved and exposed. while the transport mechanism for these magmas is well understood (i.e., sheet magmatism), the style and timing of magmatism is poorly constrained. namely, were the chief joseph dikes produced through single-pulse events or grown through time as a series of magmatic pulses where each of them contributed with tectonic deformation and degassing? detailing the mechanism of transport and emplacement could constrain the rates of surface deformation and volatile release during magmatism. this study will utilize relatively fast, simple, and resource-light methodologies that will inform us of the dike emplacement and growth mechanisms by studying in great detail the crystal textures recorded in the dikes themselves. this team's research project was designed from the ground up as an unparalleled research experience for underrepresented minority (urm) undergraduate students who will be recruited to participate in the research and dissemination process. this research is built intentionally to contribute to making the geosciences a diverse, equitable, and inclusive discipline by promoting the development of future leaders and mentors for subsequent students in stem research and education. the program will benefit the urm student cohorts with the knowledge, motivation, and inspiration to pursue focused science careers to solve us-national and global challenges. this project will investigate the tectonomagmatic evolution of the columbia river flood basalts (crfb), as recorded within the chief joseph dike swarm (cjds). the team will develop and disseminate a

technique that uses electron backscatter diffraction (ebbsd) to identify dike emplacement style using textural analyses. analyses of dike centers will be performed on a statistically significant number of dikes to meaningfully constrain the actual proportion of single-event and pulsed emplacement styles. dike-center textural analyses will be calibrated using field observations and a subset of detailed textural profiles collected across dikes to identify the overall cooling history. the information generated by the proposed work will address long-standing questions surrounding the generation of space to accommodate hundreds to thousands of dikes with considerable average thicknesses. this will impact future research by generating a detailed database of dike textures and morphologies that will allow future comparisons with other crfb dike swarm systems and cross-comparison with other dike swarms worldwide. results will provide insights into magma transport efficiency through the crust and the relationship between tectonics and magmatism. characterizing the textures of pulsed assembly of dikes or dikes that experienced sustained high reynolds number flow will add to our overall understanding of magmatic plumbing systems and their connection to mineralization zones and hydrothermal fields. furthermore, the project will create linkages with education organizations in the state of georgia. researchers will train and professionally develop six underrepresented minority (urm) student research scientists over three years. the project will broaden the participation of urms in geosciences as we will fully leverage the existing student populations from historically black colleges and universities and minority-serving institutions in georgia. the program will benefit the urm student cohorts with the knowledge, motivation, and inspiration to pursue focused science careers to solve us-national and global challenges. more importantly, this research is built intentionally to make geosciences a diverse, equitable, and inclusive discipline. their mentoring experience is built around creating a welcoming environment with comprehensive guidance by relatable mentors and academic socialization, which have proven to be integrative tools for urms. they want to foment the extraordinary untapped talent that urm students bring to geosciences. to do this, researchers need to work towards transformative change in the way they plan their research. this team believes that their program design strives to bring justice, **\*\*diversity\*\***, and inclusion to the

field of geoscience. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Digitization TCN: Extending Anthophila research through image and trait digitization (Big-Bee)

Awardee: University of California-Berkeley

Amount: \$235,963.00

Abstract: declining populations of bees impact plant-pollinator interactions in both natural and agricultural systems. while bees and other insects pollinate most wild plants, and are critical to sustain a large proportion of global food production, they are decreasing in both numbers and **\*\*diversity\*\***. our understanding of the factors driving these declines is limited because we lack sufficient data on the distribution of bee species, and on the behavioral and anatomical traits that may make them either vulnerable or resilient to human-induced environmental changes, such as habitat loss and climate change. fortunately, wild bees have been collected by researchers and deposited in natural history collections for over 100 years, retaining a wealth of associated attributes that can be extracted from specimen images. this project will digitally capture data and images from these historic specimens, develop tools to measure bee traits from these images, and generate a comprehensive bee trait and image dataset to measure changes through time. this will increase our understanding of specific traits that put bee species at risk of decline - a critical need for both sustaining our agricultural economy and the conservation of our natural resources. in addition, the large image datasets created by this project can be used for new artificial intelligence identification tools that will help improve our future pollinator observation and monitoring efforts. the big-bee thematic collection network (big-bee tcn) will create over one million high-resolution 2d and 3d images of bee specimens, representing over 5,000 worldwide bee species, including all of the major

pollinating species of the united states. the big-bee network includes 13 institutions and partnerships with us government agencies. novel mechanisms for sharing image datasets will be developed and datasets of bee traits will be available through an open data portal, the bee library, for research and education. the big-bee project will engage the general public in research through community science via crowdsourcing trait measurements and data transcription from images. in addition, training and professional development for natural history collection staff, researchers, and university students in data science will be provided through the creation and implementation of workshops focusing on bee traits and species identification. all data resulting from this award will be shared with and publicly available through the national digitized biocollections resource, [idigbio.org](http://idigbio.org). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Research Synthesis of Effective Inclusion Practices for Neurodiverse K-12 Learners in Informal STEM Learning Contexts

Awardee: Northern Arizona University

Amount: \$234,796.00

Abstract: informal stem learning environments, programs, and policies can be designed to support and promote neuro\*\*diversity\*\* through inclusive practices. this project will explore the benefits of informal stem learning for k-12 neurodiverse learners through a systematic review and meta-analysis of extant literature and research grounded in the theory of social model of ability. this framework is an asset-based approach and aims to promote social, cognitive, and physical inclusion, leading to positive outcomes. using various quantitative and qualitative methodologies, this project endeavors to collect and synthesize the evidence for supporting and enhancing accessibility and inclusiveness in informal stem learning for k-12 neurodiverse learners. it will explore key features of informal stem learning and effective, evidence-based strategies to effectively



engage children and youth with neurological conditions such as autism spectrum disorder, attention deficit hyperactivity disorder (adhd), dyslexia, and dyspraxia, in informal stem learning environments. the findings of this complex synthesis will provide a timely contribution to deeper understanding of supports for neuro\*\*diversity\*\* while also highlighting areas that inform further research, shifts in practice, and policy. the systematic review will occur over a two-year period. it will focus on identifying program elements that promote inclusion of children and youth with neurodevelopmental disabilities in informal stem learning contexts. specifically, the review will explore two overarching research questions and several sub-research questions: rq1. what program elements (teaching and learning variables) in informal stem learning settings facilitate inclusion of k-12 neurodiverse stem learners? sub-rq1a: what are the overlapping and discrete characteristics of the program elements that facilitate social, cognitive, and physical inclusion? sub-rq1b: in what ways do the program elements that facilitate inclusion vary by informal stem learning setting? rq2: what program elements (teaching and learning variables) in informal stem learning settings are correlated with benefits for k-12 neurodiverse stem learners? sub-rq2a: what are the overlapping and discrete characteristics of the program elements that correlate with increased stem identity, self- efficacy, interest in stem, or stem learning? sub-rq2b: in what ways do the program elements that correlate with positive results for students vary by informal stem learning setting? the research synthesis will consider several different types of studies, including research and evaluation; experimental and quasi-experimental designs; quantitative, qualitative, and mixed methods; and implementation studies. the research team will (a) review all analyses and organize findings to illustrate patterns, factors, and relationships, (b) identify key distinctions and nuances derived from the contexts represented in the literature, and (c) revisit and confirm the strength of evidence for making overall assertions of what works, why, and with whom. the findings will be disseminated in practice briefs, journal articles, the aisl resource center, as well as presentations and materials for researchers, practitioners, and informal stem leaders. ultimately, this work will result in a comprehensive synthesis of effective informal stem learning practices for neurodiverse k-12 learners and identify

opportunities for further research and development. this literature review and meta-analysis project is funded by the advancing informal stem learning (aisl) program, which seeks to advance new approaches to, and evidence-based understanding of, the design and development of stem learning in informal environments. this includes providing multiple pathways for broadening access to and engagement in stem learning experiences, advancing innovative research on and assessment of stem learning in informal environments, and developing understandings of deeper learning by participants. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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understanding of supports for neuro\*\*diversity\*\* while also highlighting areas that inform further research, shifts in practice, and policy. the systematic review will occur over a two-year period. it will focus on identifying program elements that promote inclusion of children and youth with neurodevelopmental disabilities in informal stem learning contexts. specifically, the review will explore two overarching research questions and several sub-research questions: rq1. what program elements (teaching and learning variables) in informal stem learning settings facilitate inclusion of k-12 neurodiverse stem learners? sub-rq1a: what are the overlapping and discrete characteristics of the program elements that facilitate social, cognitive, and physical inclusion? sub-rq1b: in what ways do the program elements that facilitate inclusion vary by informal stem learning setting? rq2: what program elements (teaching and learning variables) in informal stem learning settings are correlated with benefits for k-12 neurodiverse stem learners? sub-rq2a: what are the overlapping and discrete characteristics of the program elements that correlate with increased stem identity, self- efficacy, interest in stem, or stem learning? sub-rq2b: in what ways do the program elements that correlate with positive results for students vary by informal stem learning setting? the research synthesis will consider several different types of studies, including research and evaluation; experimental and quasi-experimental designs; quantitative, qualitative, and mixed methods; and implementation studies. the research team will (a) review all analyses and organize findings to illustrate patterns, factors, and relationships, (b) identify key distinctions and nuances derived from the contexts represented in the literature, and (c) revisit and confirm the strength of evidence for making overall assertions of what works, why, and with whom. the findings will be disseminated in practice briefs, journal articles, the aisl resource center, as well as presentations and materials for researchers, practitioners, and informal stem leaders. ultimately, this work will result in a comprehensive synthesis of effective informal stem learning practices for neurodiverse k-12 learners and identify opportunities for further research and development. this literature review and meta-analysis project is funded by the advancing informal stem learning (aisl) program, which seeks to advance new approaches to, and evidence-based understanding of, the design and development of stem learning

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Matched Words: diversity

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Title: Eigenvalue Comparison and Integral Curvature

Awardee: University of California-Santa Barbara

Amount: \$234,436.00

Abstract: various problems of mathematical physics can be modeled by the laplacian or more generally schrodinger equations. the difference between the first two eigenvalues of the laplacian is referred to as the fundamental gap, which represents the energy needed to excite a particle from ground level to the next level in quantum mechanics. in the first project, the principal investigator will estimate the fundamental gap for various spaces. the second project relates to volume entropy which is a fundamental geometric invariant for compact smooth manifolds. this concept is closely related to other notions of entropy found in dynamical systems and plays an essential role in differential geometry and geometric group theory among others. the work on entropy rigidity is related to optimal transport, information geometry and discrete geometry. the project will also support educational activities and **\*\*diversity\*\*** through mentoring graduate students and postdocs; recruiting women and other underrepresented groups; organizing seminars, workshops and research programs promoting young scholars. the material discussed in the proposal will be the subject of an advanced graduate course at ucsb in fall 2021. the project has three parts. the first is about eigenvalue and fundamental gap estimates of the laplacian with dirichlet boundary conditions on a convex domain in locally symmetric spaces by comparing with some suitable 1-dim model. the second concerns volume entropy comparison and rigidity for metric measure spaces with

curvature lower bounds. the last is to study integral curvature pinching for the critical power using ricci flow. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: 3 Myr of Laurentide Ice Sheet History Inferred from Cosmogenic Nuclides in Ice-Rafted Debris

Awardee: Boston College

Amount: \$232,428.00

Abstract: the laurentide ice sheet over north america caused large changes in climate and sea level as it grew and shrank over ice age cycles during the past three million years, but little is known about the ice sheet's detailed history throughout this interval. this project will determine how big the ice sheet was through time using chemical markers in layers of sand on the seafloor that melted out of icebergs drifting from north america. this method provides a new way to learn about past changes in the laurentide ice sheet and test ideas for how climate change and ice sheets affect each other. the results should help with predictions of sea-level rise far into the future due to global warming and melting polar ice sheets. this project will also educate and involve a wide range of people in climate science in several ways. videos about the research will be sent to boston public schools through the bostem organization to help students in the area learn about careers in science. the researchers will participate in activities through the mcauliffe center for integrated science learning at framingham state university to teach middle and high school students and teachers about climate change. college students will help with the research during summers through the integrated science for society nsf research experience for undergraduates at boston college, which tries to find students from underrepresented minority groups or who are the first in their family to go to college and that do not have research possibilities at their school. lastly, the project will support a female ph.d. student already at boston college and an m.s. student at the university of vermont. the laurentide ice

sheet over north america was one of the largest drivers of climate and sea level over the ice age cycles of the past three million years, but its history over this interval is shrouded in uncertainty largely due to limitations of conventional geologic records. this project will take a new approach, measuring the concentrations of rare chemicals in quartz sand layers from ocean sediment cores that melted out of drifting north american icebergs. the chemistry of the sand reflects the history of north american ice sheet cover because the chemicals accumulate in land surfaces exposed to the atmosphere but radioactively decay away when the surfaces are buried by ice. four sediment cores will be analyzed to reconstruct long-term laurentide ice sheet evolution, and analyses of sand samples collected across eastern canada will show how their chemistry records ice sheet variations over the most recent ice age cycle. together with similar reconstructions produced over the past five years from greenland and antarctica, these records will provide a comprehensive picture of how these three ice sheets varied in the past and contributed to global sea level. the results will offer much-needed constraints to test theories and models of paleo-ice sheet change, useful for improving long-term future projections of ice sheets on earth today. this project will increase literacy and **diversity** in climate science in multiple ways. ?science bites? videos about the research will be distributed to boston public schools through bostem to demystify careers in science. participation in ongoing efforts through the mcauliffe center for integrated science learning at framingham state university will help educate middle and high school teachers and students on climate change. this project will support an existing female ph.d. student at boston college and an m.s. student at the university of vermont. summer undergraduate research assistants will be recruited through the integrated science for society nsf reu at boston college, which seeks to attract underrepresented minority and first-generation college students from schools with limited research opportunities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: 3 Myr of Laurentide Ice Sheet History Inferred from Cosmogenic Nuclides in Ice-Rafted Debris

Awardee: Boston College

Amount: \$232,428.00

Abstract: the laurentide ice sheet over north america caused large changes in climate and sea level as it grew and shrank over ice age cycles during the past three million years, but little is known about the ice sheet's detailed history throughout this interval. this project will determine how big the ice sheet was through time using chemical markers in layers of sand on the seafloor that melted out of icebergs drifting from north america. this method provides a new way to learn about past changes in the laurentide ice sheet and test ideas for how climate change and ice sheets affect each other. the results should help with predictions of sea-level rise far into the future due to global warming and melting polar ice sheets. this project will also educate and involve a wide range of people in climate science in several ways. videos about the research will be sent to boston public schools through the bostem organization to help students in the area learn about careers in science. the researchers will participate in activities through the mcauliffe center for integrated science learning at framingham state university to teach middle and high school students and teachers about climate change. college students will help with the research during summers through the integrated science for society nsf research experience for undergraduates at boston college, which tries to find students from underrepresented minority groups or who are the first in their family to go to college and that do not have research possibilities at their school. lastly, the project will support a female ph.d. student already at boston college and an m.s. student at the university of vermont. the laurentide ice sheet over north america was one of the largest drivers of climate and sea level over the ice age cycles of the past three million years, but its history over this interval is shrouded in uncertainty largely due to limitations of conventional geologic records. this project will take a new approach, measuring the concentrations of rare chemicals in quartz sand layers from ocean sediment cores that melted out of drifting north american icebergs. the chemistry of the sand reflects the history of

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Matched Words: diversity

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Title: Statistical Learning and Inference for Single-Cell RNA Sequencing

Awardee: University of Chicago

Amount: \$230,000.00

Abstract: single-cell genomics is an emerging technique that has become an indispensable tool for understanding cellular **\*\*diversity\*\*** and cell activities. among the various single-cell sequencing



technologies, single-cell rna sequencing (scrna-seq), simultaneously measuring tens of thousands of rnas inside each individual cell, is the most mature and widely used technology. this project aims to develop new analytical tools for scrna-seq with explicit and coherent statistical frameworks to provide reliable uncertainty quantification and inference. at the same time, the new tool will retain the scalability and user-friendly features in existing algorithmic-based methods. the pi will focus on building probabilistic models for machine learning frameworks such as deep learning and address new challenges to account for biological randomness and technical noise in scrna-seq. the pi will develop open-source software for analyzing scrna-seq data to help scientists understand cell development, the mechanism of gene regulation, and cell-type-specific features of common diseases. because of the interdisciplinary feature of this project, it will also train both graduate and undergraduate students within and outside statistics to become future scientists in the fast-evolving area of applied statistics and computational biology. the pi plans to focus on three research problems that are unique to the analysis of single-cell data: trajectory inference, cell type deconvolution, and gene-gene co-expression / co-bursting. for trajectory inference, the pi will incorporate a hierarchical mixture model into a deep neural network to infer trajectories shared by cells from multiple sources. in the cell type deconvolution problem where scrna-seq data are used as references to estimate cell type proportions in bulk samples, the pi will derive asymptotically valid confidence intervals of the estimated cell type proportions without parametric assumptions and account for three major uncertainty-inflation factors: the technical noise, biological heterogeneity across individuals, and dependence across genes. finally, in the gene-gene co-expression / co-bursting analysis, the pi will estimate the true gene-gene correlation and co-bursting pattern from noisy observed data and design a scalable multiple testing framework that can efficiently find gene pairs that are co-expressed or co-bursting. the pi also aims to link the co-expression and co-bursting signals with the enhancer-promoter contacts in the three-dimensional genome structure to understand causal mechanisms of transcriptional regulation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's

intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: CPS: Medium: RUI: Cooperative AI Inference in Vehicular Edge Networks for Advanced Driver-Assistance Systems

Awardee: Kettering University

Amount: \$229,720.00

Abstract: artificial intelligence (ai) has shown superior performance in enhancing driving safety in advanced driver-assistance systems (adas). state-of-the-art deep neural networks (dnns) achieve high accuracy at the expense of increased model complexity, which raises the computation burden of onboard processing units of vehicles for adas inference tasks. the primary goal of this project is to develop innovative collaborative ai inference strategies with the emerging edge computing paradigm. the strategies can adaptively adjust cooperative inference techniques for best utilizing available computation and communication resources and ultimately enable high-accuracy and real-time inference. the project will inspire greater collaborations between experts in wireless communication, edge computing, computer vision, autonomous driving testbed development, and automotive manufacturing, and facilitate ai applications in a variety of iot systems. the educational testbed developed from this project can be integrated into courses to provide hands-on experiences. this project will benefit undergraduate, master, and ph.d. programs and increase under-represented groups' engagement by leveraging the existing \*\*diversity\*\*-related outreach efforts. a multi-disciplinary team with complementary expertise from rowan university, temple university, stony brook university, and kettering university is assembled to pursue a coordinated study of collaborative ai inference. the project explores integrative research to enable deep learning technologies in resource-constrained adas for high-accuracy and real-time inference. theory-wise, the project plans to take advantage of the observation that dnns can be decomposed into a set of fine-grained components to allow distributed ai inference on both the vehicle and edge server sides for inference

acceleration. application-wise, the pi3 plan to design novel dnn models which are optimized for the cooperative ai inference paradigm. testbed-wise, a vehicle edge computing platform with v2x communication and edge computing capability will be developed at kettering university gm mobility research center. the cooperative ai inference system will be implemented, and the research findings will be validated on realistic vehicular edge computing environments thoroughly. the data, software, and educational testbeds developed from this project will be widely disseminated. domain experts in autonomous driving testbed development, intelligent transportation systems, and automotive manufacturing will be engaged in project-related issues to ensure relevant challenges in this project are impactful for real-world applications. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Testing the reduction of aerobic habitat as a common kill mechanism for major mass extinction events

Awardee: Princeton University

Amount: \$228,080.00

Abstract: the project will study the response of marine animal ecosystems to environmental change using three mass extinction events from the geological record as study systems. specifically, the project will test the hypothesis that a large proportion of extinction during these events can be explained by the stresses that elevated temperatures and reduced oxygen availability place on animal respiration. geochemical data will be used to constrain computer simulations of changing ocean conditions during these mass extinction events. results from laboratory studies on animal respiration will then be paired with fossil data to assess whether differences in extinction intensity in space and across taxonomic groups can be explained by spatial variation in environmental change or differences among taxonomic groups in their ability to withstand environmental change. the

project will provide interdisciplinary training to a group of graduate students and post-docs. it will further impact stem education through the creation of a website that will allow access to model results so that students can visualize and explore model output to understand cause-effect relationships between continental configuration, ocean conditions, and biological **\*\*diversity\*\***. the investigators will also offer short-courses on earth system modeling and data interpretation at major conferences that will be recorded for asynchronous use. the project will also involve the development of a podcast series addressing how we reconstruct the ancient earth system and use these reconstructions to better understand the present and predict the future. in this project, the hypothesis will be tested that the loss of habitat through constraints on aerobic respiration under climate change and ocean deoxygenation can explain the magnitude, taxonomic selectivity, and latitude variation in intensity for the late devonian (frasnian-fammenian), end-permian, and end-triassic mass extinction events. paleoredox and paleoclimate proxy data and geochemical indicators of diagenetic alteration will be used for both global average and local conditions before and after each major event combined with predictions from earth system models and occurrence data from the fossil record of marine animals to separate aspects of extinction than can be explained by physiological stress from those that require other explanations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: MCA: Partnering Land and communities for equitable and inclusive STEM learning

Awardee: Regents of the University of Idaho

Amount: \$227,519.00

Abstract: the goal of the project is to explore land education pedagogy and its curriculum and pedagogical innovations in the preparation of native and non-native educators to engage native and non-native students in environmental stem education on indigenous lands. the investigator will implement a professional development plan focused on pedagogical innovations within various teacher education and environmental stem learning programs to (a) understand the tools and technologies that can support these innovations and (b) develop new research methods for understanding the impact of these innovations on individuals, communities, and socio-ecological systems. the research builds on the investigator's prior inquiries on culturally connected identity and how technology can be used to deepen observation skills and communicate to broader audiences while not distracting from students' engagement. the project will advance this knowledge and build new collaboration through network engagement. the research project uses the actor network theory and critical indigenous research methodologies to frame the research design and approach. there are four driving questions: (1) what affordances does land education pedagogy offer in creating inclusive and epistemologically diverse stem learning environments, building more equitable relationships to particular places and to socio-ecological systems, and impacting the **\*\*diversity\*\*** of the stem workforce? (2) what tools and technologies can assist in sustaining long-term, mutually beneficial relationships to support the preparation of native and non-native educators who will engage in educational strategies that lead to diverse stem workforce on indigenous lands? (3) what are the impacts of a land education pedagogy on individual students' sense of belonging and stem identity, communities of educators' approaches to stem engagement, and the health of broader socio-ecological systems? data will be collected from k-12 and graduate students using autoethnographies, photovoice and symbol-based reflections, observations, and

network mapping. evidence will be analyzed using content and discourse analysis. the research findings will inform programs that employ land education pedagogy to shape more equitable and inclusive environmental stem education for students and teachers and to increase stem persistence among underrepresented populations. the project is funded by the mid-career advancement program that enables scientists and engineers to substantively advance their research program and career trajectory. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Land, Forest and Water Management in a Tropical Environment

Awardee: University of Cincinnati Main Campus

Amount: \$226,489.00

Abstract: this project will investigate the land and water management strategies that supported the development of complex society in a tropical environment. a primary theoretical question to be addressed in this study focuses on how the ancient inhabitants in the environmentally problematic region were able to sustain an urban population. a corollary to this question asks how agricultural intensification was achieved and how other essential resources, such as water and forest products, were managed. the research plan includes ecological assessments such as biomass and species **\*\*diversity\*\***, as well as examination of the sustainability of various land use practices all of which will be useful for the management of the region which currently co-exists in an uneasy tension in competition for land and water. the project is tri-national, involving researchers and students from multiple countries and provides training for graduate students from each country. the archaeological site provides an ideal test case for examining the changing trajectories of human-environment interactions because it grew into one of the paramount cities and political-economic powers during the new world classic period. the research will examine the hydraulic, agricultural,

and forest management strategies that allowed the persistent occupation and growth in the face of changing environmental and political economic conditions. it will provide insights into the variability of adaptive strategies and the rise of social complexity. these issues will be addressed by an interdisciplinary research team that includes professionals and students with training in botany, paleoecology, geoarchaeology, remote sensing, gis, and anthropological archaeology and will employ a unique combination of paleoenvironmental and archaeological methods. the acquisition of lidar imagery of the area will allow the team to select a variety of topographic settings, probable ancient agricultural fields, reservoirs, and residential areas for excavation and coring, thus providing data on resource management across the spectrum of environmental contexts and social strata. these analyses will include edna which offers novel insights into ancient land use and subsistence. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RUI-CHE: Development of Organometallic Complexes for the Next-Generation of Non-Aqueous Redox Flow Batteries

Awardee: Occidental College

Amount: \$225,002.00

Abstract: with the support of the chemical synthesis program in the division of chemistry, emmanuelle despagnet-ayoub of occidental college is studying new redox active materials for energy storage. renewable power sources derived from solar energy are promising and environmentally friendly solutions for generating electric power. however, their intermittent behavior does not align with the typical energy demand. consequently, more efficient energy storage devices need to be developed. redox flow batteries are a promising energy storage technology. however, prior redox-flow technologies have considerable challenges meeting the performance requirements for grid storage applications due to their low energy density. this project, carried out primarily by



talented undergraduates, aims to find solutions to overcome these limitations. the research will be carried out synergistically with other projects promoting **\*\*diversity\*\*** in stem fields at occidental college, such as the cosmos (creating opportunities in science and mathematics for occidental students, s-stem grant) and the reap (research early access program, sherman fairchild grant) programs. emmanuelle despagnet-ayoub of occidental college is developing new redox active materials for high energy density redox flow batteries. indeed, the practical energy density of current redox flow batteries is typically low (10s of wh/l) due to the use of aqueous solutions with narrow potential windows and redox couples with limited solubility. development of organometallic complexes with a high solubility in organic solvents and tunable formal potentials will help advance the field. the pi has recently reported a strategy to anodically shift the formal potential of metal redox couples by outer-sphere coordination of lewis acids. this concept will be further probed with a variety of complex frameworks and lewis acids, in order to develop a relationship map between ligand framework-lewis acid and their electrochemical properties. the project will ultimately lead to more exciting systems involving multiple electron processes at the molecular and macromolecular levels, and the development of symmetric flow batteries with non-innocent ligands and semi-solid flow batteries with immobilized redox active species. this research project will provide research and training opportunities to undergraduates in the fields of organometallic synthesis and electrochemistry within the larger context of flow batteries and energy storage. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Collaborative Research: Development of an Energy-Harvesting Real-time Under-ice Monitoring System in the Arctic Ocean

Awardee: Virginia Polytechnic Institute and State University

Amount: \$225,000.00

Abstract: the arctic is home to some four million people comprising a diverse range of cultures and an economy worth about \$230 billion annually. with global concerns spanning climate change, energy resources, freshwater supplies, and sustainable economic growth, the arctic has sparked intense research and public interest. international efforts to establish sustained arctic observing systems, especially for long-term arctic ocean monitoring with near-real-time data transfer, are urgently needed. the harsh and remote conditions constraining year-round observation sites present significant logistical challenges and energy needs for sustained arctic observations. in addition, monitoring of the arctic ocean using bottom-anchored stationary platforms is limited by a lack of real-time communication between the sensors deployed and arctic operators. the ultimate goal of this project is to develop new energy harvesting and communication solutions so that it is feasible to have a real-time under-ice monitoring system in the arctic ocean. this eager project tests the capacity to address three key challenges, including sustainable power supply through energy harvesting, near-real-time data communication under the sea ice, and survivability under harsh environmental conditions. specifically, the project aims to develop novel techniques to harvest ultra-low-speed oceanic current energy using a two-level diffuser augmented turbine and a novel transverse flux generator. the harvested energy will be used to support sensors and power a novel real-time communication system through the sea ice. the proposed communication system adopts a novel antenna design that overcomes seawater attenuation effects on radio waves and creatively leverages satellite protocols to ensure the under-ice communication unit can transmit observational data to satellites. the project also explores techniques to enhance the survivability of the under-ice monitoring system, such as robust material choice and ice ridge/keel detection and avoidance systems and extends science and engineering education among k-12 and phd-level students in arctic research with an emphasis on **\*\*diversity\*\*** including female and underrepresented students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: A Data-Driven Employer-Academia Partnership for Continual Computing Curricular Change

Awardee: Tuskegee University

Amount: \$225,000.00

Abstract: this project aims to serve the national interest by improving the supply of well-prepared computer science professionals capable of addressing the needs of american employers in the public and private sectors. this project intends to build a national partnership between employers and academia to help identify and mitigate gaps between the competencies of computing graduates and the expectations of potential employers. the project will survey computer science educators and practitioners to develop a model that defines the competencies expected by potential employers. the project team then plans to test the model at three institutions of higher education in alabama ? the university of alabama, tuscaloosa, tuskegee university, and shelton state community college. finally, the project team intends to develop tools and methods for institutions to identify and implement competency-based educational approaches for computer science across the nation. the project plans to use three interconnected strands of evidence-based activities to institute transformational change in the involved communities. first, a national strand will engage u.s. faculty in developing competency-based curricula informed by industry practitioner feedback. second, a local pilot strand intends to create transformative curricular change based on student competencies using an evidence-based change model in the three alabama institutions. sociologists and computing faculty on the team will help to understand, predict, and reduce barriers to competency-based employment of computing graduates from marginalized communities in the heart of the impoverished alabama black belt. the unique perspective relative to **\*\*diversity\*\***, equity, and inclusion needs should serve as a model for other computing departments. the third strand will develop competency-based surveys for practitioners and academics to identify and refine specific competencies that are hoped to drive continual curricular change. outcomes, including the change

process, national workshops, and experiences from the local process will help with transferability in the computing education community. in addition to informing curricula, the project will provide valuable data for educational researchers to help close the gap between employers and higher education. finally, as the competency approach to curricular design is relatively new in computing and engineering disciplines, lessons from this project will have the potential to transform curricular review and design in other stem disciplines. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the institutional and community transformation track, the program supports efforts to transform and improve stem education across institutions of higher education and disciplinary communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Finding an informed approach to oligonucleotide ligand screening to enable antiviral materials

Awardee: Georgia Tech Research Corporation

Amount: \$224,994.00

Abstract: part 1: nontechnical abstract: as bio-inspired ligands for various biological targets, aptamers present key promising advantages over antibodies including their low immunogenicity, animal-free generation, reversible denaturation, and longer shelf-life. moreover, while research and financial investments in therapeutic antibody development and manufacturing have clearly overshadowed that of aptamers, oligonucleotide ligands still hold promising potential as advantageous targeting and even inhibition agents for challenging viral targets whose rapid spread and mutation capabilities can unfortunately outpace traditional therapeutic developments. in the absence of a priori rules to identify potential binding motifs within a self-hybridized oligonucleotide for a non-nucleotide target, finding the right aptamer (or set of aptamers) for a particular target is a daunting search problem, much like finding the right move in a game of chess or go, largely because

the candidate sequence space is staggeringly large. thus, in the absence of any chemical guidelines, researchers traditionally choose instead to simply maximize the sequence **\*\*diversity\*\*** among candidate aptamers by employing screening libraries consisting of large heterogeneous populations (~10<sup>9</sup> or more) of random dna or rna sequence members in a resource-intensive screening process called selex (systematic evolution of ligands by exponential enrichment). here, the goal of the proposed work is to develop a pipeline of candidate dna aptamers for spike protein. to undertake this ambitious goal for this pilot project we will pioneer an integrated experimental and informatics approach to rapidly and reliably identify dna oligonucleotide ligands from informed, designer libraries for a viral protein target called the spike protein.      part 2: technical abstract:

research and financial investments in therapeutic antibody development and manufacturing have clearly overshadowed that of lesser known, oligonucleotide-based ligands called aptamers. aptamers, on the other hand, hold promising potential as advantageous targeting and even inhibition agents for challenging viral targets whose rapid spread and mutation capabilities can unfortunately outpace traditional therapeutic developments. in the absence of design rules, finding the right aptamer (or set of aptamers) for a particular target is a daunting search problem, much like finding the right move in a game of chess or go, largely because the candidate sequence space is staggeringly large. thus, in the absence of any chemical guidelines, researchers traditionally choose instead to simply maximize the size (~10<sup>9</sup> or more different sequences) of screening libraries in a resource-intensive, evolutionary screening process called selex (systematic evolution of ligands by exponential enrichment). to overcome these challenging technical and scientific bottlenecks inherent to this popular aptamer screening platform, we propose to pioneer an integrated experimental and informatics approach to rapidly and reliably identify dna oligonucleotide ligands from designer libraries for a viral protein target called the spike protein. the proposed integrated experimental/computational aptamer discovery approach is intentionally adaptable using a ?lessons-learned? approach to pave the aptamer discovery pathway for viral targets, particularly as viral strains readily mutate. this work will offer unique, multidisciplinary student training opportunities

in the experimental and computational aspects of the work. if successful the pis believe this pilot project will lay the fundamental groundwork for future accelerated bio-inspired ligand discovery to enable desirable bioactivity of materials systems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: How are Flood Basalts Fed? A Textural Investigation of the Chief Joseph Dike Swarm

Awardee: Georgia State University Research Foundation, Inc.

Amount: \$218,153.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). flood basalts are the earth's most extensive expressions of volcanism. the eruption and emplacement of these voluminous magmas have been linked to global climate shifts and many extinction events. the columbia river flood basalts in oregon, washington, idaho, and nevada are the most recent and best-preserved example of this voluminous volcanic activity. it is believed that degassing during their eruption 17-14 million years ago influenced global temperatures. a key aspect to understanding magmatic systems is deciphering how the magma is transported from depth to surface. at the chief joseph dike swarm in oregon, a portion of the magmatic plumbing system of the columbia river flood basalts is preserved and exposed. while the transport mechanism for these magmas is well understood (i.e., sheet magmatism), the style and timing of magmatism is poorly constrained. namely, were the chief joseph dikes produced through single-pulse events or grown through time as a series of magmatic pulses where each of them contributed with tectonic deformation and degassing? detailing the mechanism of transport and emplacement could constrain the rates of surface deformation and volatile release during magmatism. this study will utilize relatively fast, simple, and resource-light methodologies that will inform us of the dike emplacement

and growth mechanisms by studying in great detail the crystal textures recorded in the dikes themselves. this team's research project was designed from the ground up as an unparalleled research experience for underrepresented minority (urm) undergraduate students who will be recruited to participate in the research and dissemination process. this research is built intentionally to contribute to making the geosciences a diverse, equitable, and inclusive discipline by promoting the development of future leaders and mentors for subsequent students in stem research and education. the program will benefit the urm student cohorts with the knowledge, motivation, and inspiration to pursue focused science careers to solve us-national and global challenges. this project will investigate the tectonomagmatic evolution of the columbia river flood basalts (crfb), as recorded within the chief joseph dike swarm (cjds). the team will develop and disseminate a technique that uses electron backscatter diffraction (ebbsd) to identify dike emplacement style using textural analyses. analyses of dike centers will be performed on a statistically significant number of dikes to meaningfully constrain the actual proportion of single-event and pulsed emplacement styles. dike-center textural analyses will be calibrated using field observations and a subset of detailed textural profiles collected across dikes to identify the overall cooling history. the information generated by the proposed work will address long-standing questions surrounding the generation of space to accommodate hundreds to thousands of dikes with considerable average thicknesses. this will impact future research by generating a detailed database of dike textures and morphologies that will allow future comparisons with other crfb dike swarm systems and cross-comparison with other dike swarms worldwide. results will provide insights into magma transport efficiency through the crust and the relationship between tectonics and magmatism. characterizing the textures of pulsed assembly of dikes or dikes that experienced sustained high reynolds number flow will add to our overall understanding of magmatic plumbing systems and their connection to mineralization zones and hydrothermal fields. furthermore, the project will create linkages with education organizations in the state of georgia. researchers will train and professionally develop six underrepresented minority (urm) student research scientists over three years. the project will broaden the participation of urms

in geosciences as we will fully leverage the existing student populations from historically black colleges and universities and minority-serving institutions in georgia. the program will benefit the urm student cohorts with the knowledge, motivation, and inspiration to pursue focused science careers to solve us-national and global challenges. more importantly, this research is built intentionally to make geosciences a diverse, equitable, and inclusive discipline. their mentoring experience is built around creating a welcoming environment with comprehensive guidance by relatable mentors and academic socialization, which have proven to be integrative tools for urms. they want to foment the extraordinary untapped talent that urm students bring to geosciences. to do this, researchers need to work towards transformative change in the way they plan their research. this team believes that their program design strives to bring justice, **\*\*diversity\*\***, and inclusion to the field of geoscience. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: How are Flood Basalts Fed? A Textural Investigation of the Chief Joseph Dike Swarm

Awardee: Georgia State University Research Foundation, Inc.

Amount: \$218,153.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). flood basalts are the earth's most extensive expressions of volcanism. the eruption and emplacement of these voluminous magmas have been linked to global climate shifts and many extinction events. the columbia river flood basalts in oregon, washington, idaho, and nevada are the most recent and best-preserved example of this voluminous volcanic activity. it is believed that degassing during their eruption 17-14 million years ago influenced global temperatures. a key aspect to understanding magmatic systems is deciphering how the magma is transported from



depth to surface. at the chief joseph dike swarm in oregon, a portion of the magmatic plumbing system of the columbia river flood basalts is preserved and exposed. while the transport mechanism for these magmas is well understood (i.e., sheet magmatism), the style and timing of magmatism is poorly constrained. namely, were the chief joseph dikes produced through single-pulse events or grown through time as a series of magmatic pulses where each of them contributed with tectonic deformation and degassing? detailing the mechanism of transport and emplacement could constrain the rates of surface deformation and volatile release during magmatism. this study will utilize relatively fast, simple, and resource-light methodologies that will inform us of the dike emplacement and growth mechanisms by studying in great detail the crystal textures recorded in the dikes themselves. this team's research project was designed from the ground up as an unparalleled research experience for underrepresented minority (urm) undergraduate students who will be recruited to participate in the research and dissemination process. this research is built intentionally to contribute to making the geosciences a diverse, equitable, and inclusive discipline by promoting the development of future leaders and mentors for subsequent students in stem research and education. the program will benefit the urm student cohorts with the knowledge, motivation, and inspiration to pursue focused science careers to solve us-national and global challenges. this project will investigate the tectonomagmatic evolution of the columbia river flood basalts (crfb), as recorded within the chief joseph dike swarm (cjds). the team will develop and disseminate a technique that uses electron backscatter diffraction (ebbsd) to identify dike emplacement style using textural analyses. analyses of dike centers will be performed on a statistically significant number of dikes to meaningfully constrain the actual proportion of single-event and pulsed emplacement styles. dike-center textural analyses will be calibrated using field observations and a subset of detailed textural profiles collected across dikes to identify the overall cooling history. the information generated by the proposed work will address long-standing questions surrounding the generation of space to accommodate hundreds to thousands of dikes with considerable average thicknesses. this will impact future research by generating a detailed database of dike textures and morphologies that

will allow future comparisons with other crfb dike swarm systems and cross-comparison with other dike swarms worldwide. results will provide insights into magma transport efficiency through the crust and the relationship between tectonics and magmatism. characterizing the textures of pulsed assembly of dikes or dikes that experienced sustained high reynolds number flow will add to our overall understanding of magmatic plumbing systems and their connection to mineralization zones and hydrothermal fields. furthermore, the project will create linkages with education organizations in the state of georgia. researchers will train and professionally develop six underrepresented minority (urm) student research scientists over three years. the project will broaden the participation of urms in geosciences as we will fully leverage the existing student populations from historically black colleges and universities and minority-serving institutions in georgia. the program will benefit the urm student cohorts with the knowledge, motivation, and inspiration to pursue focused science careers to solve us-national and global challenges. more importantly, this research is built intentionally to make geosciences a diverse, equitable, and inclusive discipline. their mentoring experience is built around creating a welcoming environment with comprehensive guidance by relatable mentors and academic socialization, which have proven to be integrative tools for urms. they want to foment the extraordinary untapped talent that urm students bring to geosciences. to do this, researchers need to work towards transformative change in the way they plan their research. this team believes that their program design strives to bring justice, **\*\*diversity\*\***, and inclusion to the field of geoscience. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Digitization TCN: Extending Anthophila research through image and trait digitization (Big-Bee)

Awardee: University of Colorado at Boulder

Amount: \$217,080.00

Abstract: declining populations of bees impact plant-pollinator interactions in both natural and agricultural systems. while bees and other insects pollinate most wild plants, and are critical to sustain a large proportion of global food production, they are decreasing in both numbers and **\*\*diversity\*\***. our understanding of the factors driving these declines is limited because we lack sufficient data on the distribution of bee species, and on the behavioral and anatomical traits that may make them either vulnerable or resilient to human-induced environmental changes, such as habitat loss and climate change. fortunately, wild bees have been collected by researchers and deposited in natural history collections for over 100 years, retaining a wealth of associated attributes that can be extracted from specimen images. this project will digitally capture data and images from these historic specimens, develop tools to measure bee traits from these images, and generate a comprehensive bee trait and image dataset to measure changes through time. this will increase our understanding of specific traits that put bee species at risk of decline - a critical need for both sustaining our agricultural economy and the conservation of our natural resources. in addition, the large image datasets created by this project can be used for new artificial intelligence identification tools that will help improve our future pollinator observation and monitoring efforts. the big-bee thematic collection network (big-bee tcn) will create over one million high-resolution 2d and 3d images of bee specimens, representing over 5,000 worldwide bee species, including all of the major pollinating species of the united states. the big-bee network includes 13 institutions and partnerships with us government agencies. novel mechanisms for sharing image datasets will be developed and datasets of bee traits will be available through an open data portal, the bee library, for research and education. the big-bee project will engage the general public in research through community science via crowdsourcing trait measurements and data transcription from images. in addition, training and professional development for natural history collection staff, researchers, and university students in data science will be provided through the creation and implementation of workshops focusing on bee traits and species identification. all data resulting from this award will be shared with and

publicly available through the national digitized biocollections resource, [idigbio.org](http://idigbio.org). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Spatially Resolving the Cellular Landscape of Arbuscular Mycorrhizal Symbiosis with *M. truncatula* and *D. epigaea*

Awardee: Tivey                      Trevor              R

Amount: \$216,000.00

Abstract: this action funds an nsf plant genome postdoctoral research fellowship in biology for fy 2021. the fellowship supports a research and training plan in a host laboratory for the fellow who also presents a plan to broaden participation in biology. the title of the research and training plan for this fellowship to trevor tivey is "using spatial rna-seq and endocycle analyses to spatially resolve the cellular landscape of arbuscular mycorrhizal symbiosis with *medicago truncatula* and *diversispora epigaea*". the host institution for the fellowship is the boyce thompson institute and the sponsoring scientist is dr. maria harrison. a broad **\*\*diversity\*\*** of plants and a limited group of soil fungi interact together in a type of association known as arbuscular mycorrhizal symbiosis. this underground relationship between plants and fungi takes place within plant root cells, and helps both plants and fungi acquire critical nutrients. key plant genes governing this symbiosis have been identified, however the timing and regulation of plant and fungal gene expression during colonization is complex and requires further understanding. to characterize this interaction, this project will measure plant and fungal transcripts during symbiosis at a fine spatial resolution and identify gene expression differences between cells along a gradient of fungal colonization. results from this project will help to develop resources for the study of root-microbe interactions and enable the application of these methods to address similar questions in major crops. in the process, this project will promote research participation of undergraduates who are underrepresented in biology and support students

from the local community through outreach and teaching. this project will use spatial mrna-seq to map the plant and fungal transcriptomes and compare gene expression in all plant cell types along a spatiotemporal gradient of colonization, enable the creation of plant-fungal gene co-expression networks, and correlate transcriptomic and microscopical evidence of endoploidy to identify candidate gene pathways. to address the controls on endoploidy, plant mutants, cell cycle markers, and image analysis will be used to disrupt symbiosis signaling and to examine the effects on endoreduplication. an increased understanding of the significance of endoploidy in am symbiosis has the potential to inform mechanisms of symbiotic and parasitic biotroph colonization in plants. spatial transcriptome datasets will be made publicly available in the ncbi gene expression omnibus. m. truncatula cell cycle marker lines and endocycle regulation mutants will be shared for future experimental studies of the plant cell cycle and biotrophic interactions. keywords: host-microbe, mycorrhiza, spatial transcriptomics, endoreduplication, colonization this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Leveraging Frequent Monoicy-dioicy Transitions in Hornworts to Understand the Rules of Sex Determination

Awardee: Schafran, Peter W

Amount: \$216,000.00

Abstract: this action funds an nsf plant genome postdoctoral research fellowship in biology for fy 2021. the fellowship supports a research and training plan in a host laboratory for the fellow who also presents a plan to broaden participation in biology. the title of the research and training plan for this fellowship to peter schafran is "leveraging frequent monoicy-dioicy transitions in hornworts to understand the rules of sex determination" the host institution for the fellowship is the boyce thompson institute and the sponsoring scientist is dr. fay-wei li. in animals sex determination is

fairly consistent across diverse groups, such as the xy chromosomes that originated once in the common ancestor of all placental mammals including dogs, cows, humans, elephants, whales, etc., over 166 million years ago. in contrast, the evolution of separate sexes in plants has occurred many times and over much shorter time periods. one plant group that shows this is hornworts, in which about half of all species have separate sexes that evolved from hermaphroditic ancestors at least 14 separate times. to understand why sexual system evolution is so flexible in plants, this project will examine how genes and chromosome structure change each time a species evolves to have separate male/female individuals. new genomes will be generated from hermaphroditic and male/female hornwort species representing over 300 million years of evolution in order to determine common genes that may be prerequisites for formation of separate sexes. this project will also examine patterns of change in genome architecture over time, as sex-determining genes eventually cause the formation of sex chromosomes, which then may be more likely to degrade. identifying these processes in hornworts will uncover mechanisms that may provide a model for evolution of separate sexes across all plants and a contrast for the starkly different pattern in animals. a better understanding of how chromosomes and genes function will enhance efforts to improve crop plants. this project will provide varied opportunities for training high school and undergraduate students in tissue culture, genome assembly, comparative genomics, and plant transformation. this project will leverage multiple monoicy-dioicy transitions across the hornworts in order to test whether common rules govern the evolution of sex-linked genes and sex chromosomes. evidence will be drawn from a broad range of phylogenetic **\*\*diversity\*\***, evolutionary time, genomic scales, and gene-phenotype associations. three specific objectives are: 1) characterize the structure and composition of hornwort sex chromosomes; 2) identify candidate sex-determining genes by examining genes associated with sex chromosomes and under selection in multiple lineages; 3) functionally characterize candidate sex-determining genes by transgenically over-expressing them in the monoicous model hornwort *anthoceros agrestis*. multiple genome assembly techniques will be used to create 19 new hornwort genomes representing monoicous and dioicous species assembled

to pseudochromosome level. genetic analyses will examine gene orthologs from pairs of monoicous and dioicous species to identify those with evidence of selection across multiple independent transitions between monoicy and dioicy. for genes found to recurrently appear to be selected for on sex chromosomes, their over-expression in *a. agrestis* is expected to affect the successful development gametes/gametangia and their ability to form viable sporophytes. the expected results will contribute functional knowledge about specific genes, and about the associated chromosome structural and compositional variations that lead to formation of sex chromosomes. all data will be publicly available through genbank as well as hornwortbase, a new platform for hornwort genomic analysis ([www.hornwortbase.org](http://www.hornwortbase.org)). results will be communicated through public lectures and open access publications. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Establishing parametric variability as a driver of plasticity across genotypes with diverse life histories ...

Awardee: Dale, Renee

Amount: \$216,000.00

Abstract: this action funds an nsf plant genome postdoctoral research fellowship in biology for fy 2021. the fellowship supports a research and training plan in a host laboratory for the fellow who also presents a plan to broaden participation in biology. the title of the research and training plan for this fellowship to renee dale is "establishing parametric variability as a driver of plasticity across genotypes with diverse life histories through a novel mathematical modeling framework". the host institution for the fellowship is the donald danforth plant science center and the sponsoring scientists are dr. ivan baxter and dr. shankar mukherji. changes in climate increase the frequency and severity of extreme environmental conditions. organisms with the ability to be flexible (?plasticity?)

can rapidly adapt to these changes. plants need to be especially flexible since they cannot move if their environment suddenly changes. identifying the mechanisms that allow flexibility is increasingly important. due to the amount of information needed to understand plasticity throughout the plant life cycle, models and computational approaches are needed. a new method is proposed to identify ways that plants are flexible using hundreds of plants coming from diverse environments. it is hypothesized that plants from extreme environments will be more flexible, with more modes of growth. modeling will be used to identify different modes of growth and understand the underlying mechanisms. the results could be used in plant breeding programs to improve crop resilience and the approach can be used to understand the growth of other species. the proposed research will provide the pi with training and development opportunities in mathematics (biological stochasticity), biology (quantitative genetics, ecology, and plant physiology), and computation (python coding and high-performance computing). the impact of this work will be broadened through the development and dissemination of an educational video game, intended to improve **diversity** and inclusion of under-represented individuals. the video game will introduce these concepts to high school students in a low-stress way, circumventing the negative social perceptions of math. a novel mathematical modeling framework will be developed to identify processes driving plasticity across hundreds of plant genotypes with diverse eco-evolutionary backgrounds. a family of mathematical models of plant physiology and growth processes will be applied. model parameters will be estimated using bayesian parameter estimation, providing parametric distributions within and between genotypes. this will provide a conceptual framework to understand plasticity by integrating mathematical, computational, and biological theory. processes driving plasticity have agricultural significance, as the ability of crops to adapt and respond to increasing environmental stress is paramount. model parameters will be mapped to genomic loci, which could be used in breeding programs to test model predictions that such loci will confer plasticity, and to improve crop plants. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.



Matched Words: diversity

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Title: CPS: Medium: Collaborative Research: Demand Response & Workload Management for Data Centers with Increased Renewable Penetration

Awardee: University of California-Davis

Amount: \$215,805.00

Abstract: the confluence of two powerful global trends, (1) the rapid growth of cloud computing and data centers with skyrocketing energy consumption, and (2) the accelerating penetration of renewable energy sources, is creating both severe challenges and tremendous opportunities. the fast growing renewable generation puts forth great operational challenges since they will cause large, frequent, and random fluctuations in supply. data centers, on the other hand, offer large flexible loads in the grid. leveraging this flexibility, this project will develop fundamental theories and algorithms for sustainable data centers with a dual goal of improving data center energy efficiency and accelerating the integration of renewables in the grid via data center demand response (dr) and workload management. specifically, the research findings will shed light on data center demand response while maintaining their performance, which will help data centers to decide how to participate in power market programs. further, the success of data center demand response will help increase renewable energy integration and reduce the carbon footprint of data centers, contributing to global sustainability. the pis will leverage fruitful collaboration to eventually bring the research to bear on ongoing industry standardization and development efforts. the pis teach courses spanning networks, games, smart grid and optimization, and are strongly committed to promoting **\*\*diversity\*\*** by providing research opportunities to underrepresented students. built on the pis expertise on data centers and the smart grid, this project takes an interdisciplinary approach to develop fundamental theories and algorithms for sustainable data centers. the research tasks are organized under two well-coordinated thrusts, namely agile data center dr and adaptive workload management. the strategies and decisions of data center dr will be made based on the workload

management algorithms that balance quality of service and energy efficiency and determine the supply functions. the workload management algorithms will optimize quality of service under the electric load constraints imposed by dr accordingly. this project will make three unique contributions: (1) new market programs with strategic participation of data centers in dr, instead of passive price takers, (2) fundamental understanding of the impacts of power network constraints on data center dr and new distributed algorithms for solving optimal power flow with stochastic renewable supplies, and (3) high-performance dynamic server provisioning and load balancing algorithms for large scale data centers under time-varying and stochastic electric load constraints and on-site renewable generation.

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Matched Words: diversity

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Title: Quantum Correlations in Information Theory, Their Interplay, and Their Limitations

Awardee: University of Houston

Amount: \$215,000.00

Abstract: this project will advance mathematical knowledge of quantum information theory. this work is in line with quantum leap, one of the nsf's 10 big ideas. one of the goals of the quantum leap big idea is to develop next-generation quantum technologies. but any technological advancement has

usually been long-preceded through theoretical mathematical progress. this project deals with questions in quantum resource theory, in particular a theory of entanglement. quantum devices use quantum systems to encode and process information. these systems make it possible to harness the effects of purely quantum phenomena such as superposition (the ability of being in "two places" at once) and entanglement (strong connections between two parts of the system) to drastically increase the security and the speed of computational devices. because of entanglement two spatially separated particles can affect each other instantaneously, a phenomenon which was initially considered to be paradoxical, even by einstein. one of the best-known protocols - quantum teleportation - relies on entanglement to destroy a quantum state in one place and perfectly recreate it in another distant location. while entanglement became one of the most valuable resources in quantum theory, many attributes of its behavior remain unknown. the broader impact of this award is to promote progress, **diversity**, and access to science on all levels of society and to broaden participation from underrepresented communities in stem. the major broader impact goals are: 1) to enhance training of graduate students in quantum information at the university of houston; 2) to improve educational opportunities in stem for students in local middle-schools in the economically challenged neighborhoods; 3) to increase public education in stem and quantum information science. entanglement is only one quantifier of "quantumness" in a system. other measures include coherence, discord, and mutual information. entanglement theory has gained its strong mathematical footing in the 1990's, but a closely related coherence theory started only recently. this project will establish proper mathematical limits on and relations between these measures, unify them, and classify them. it is well-known that under certain parameters, entanglement and coherence are dual to each other, in a sense that coherence can be converted to entanglement via incoherent operations, and vice versa in the asymptotic limit. this project will investigate this relation for different entanglement and coherence measures. moreover, the principal investigator will develop and investigate properties of newly proposed correlation measures. a closely related question is the distinguishability between two quantum states. how well we can distinguish different

physical states determines how much information we can encode into a certain system and how quickly we can manipulate it. one of the main problems that this project will focus on is the continuity of these quantifiers, which is a natural property of any quantum system. in other words, if the states are close when measured by one of these distances, how close are they when measured by another? or how well can these states be distinguished? or what is the structure of states that are close to each other? this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: PurSUIT: Species diversity and evolution of parasitic microfungi

Awardee: Butler University

Amount: \$211,455.00

Abstract: fungi are essential to ecosystem functioning, occur virtually everywhere, and form complex relationships with diverse organisms including prokaryotes, algae, plants, invertebrates, vertebrates, and other fungi. nonetheless, fungi are the most undersampled and poorly documented major lineage of eukaryotes, even though total species estimates range conservatively from 1.5-6.1 million species. this uncertainty reflects numerous gaps in knowledge about fungal distributions, especially regarding range and extent of unculturable fungi, microscopic fungi (microfungi), parasitic fungi, and tropical fungi. this project will document **diversity** of fungi in two groups that represent major gaps in our knowledge: the first are unculturable microfungi that associate with insects, called labouls, and the other are unculturable microfungi that associate with plants, called rust fungi. members of labouls and rust fungi are expected to have profound effects on ecosystem health and functioning through both beneficial and harmful interactions with their animal and plant hosts. the research team will explore several global habitats in tropical and temperate regions that have not previously been surveyed for these fungi. it is expected that hundreds of new species will be discovered and

described during this project. in addition to enhancing the documented bio\*\*diversity\*\* on the planet, this project will resolve the ?tree of life? for both groups and use this information to resolve long-standing questions regarding the evolution of the fungi. broader impacts include graduate and undergraduate training, international workshops to enhance collaboration between us and local researchers, and outreach to the public through ?bat night? and ?roach hunt? field trips. these fungal lineages are being studied for several reasons: 1) both represent groups poorly documented from tropical world regions; 2) both represent groups that are not detected by commonly applied culture-based and high throughput sequencing efforts; 3) neither group has been resolved, phylogenetically, by application of multi-locus analyses of known species; 4) both represent obligately parasitic lineages that are rarely studied but expected to have profound effects on ecosystems; and 5) both are or are related to heteroecious fungi (requiring two different hosts), a phenomenon that is extremely rare in fungi. a complementary team of us and other global experts on these fungi, ranging from junior to senior scientists, have designed an experimental approach that includes standardized sampling strategies from tropical and extra-tropical regions with multi-locus phylogenetic, phylogenomic, comparative genomic, and statistical analyses to: 1) determine whether accurate estimates from obligate microparasitic fungi, not included in any other estimates, will affect overall fungi species estimates; 2) whether parasitic microfungi follow the reverse latitudinal gradient posited for other fungal groups; and 3) resolve long-standing unresolved phylogenetic nodes by the incorporation of ?missing? lineages. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: PurSUIT: Species diversity and evolution of parasitic microfungi

Awardee: Butler University

Amount: \$211,455.00

Abstract: fungi are essential to ecosystem functioning, occur virtually everywhere, and form complex relationships with diverse organisms including prokaryotes, algae, plants, invertebrates, vertebrates, and other fungi. nonetheless, fungi are the most undersampled and poorly documented major lineage of eukaryotes, even though total species estimates range conservatively from 1.5-6.1 million species. this uncertainty reflects numerous gaps in knowledge about fungal distributions, especially regarding range and extent of unculturable fungi, microscopic fungi (microfungi), parasitic fungi, and tropical fungi. this project will document **diversity** of fungi in two groups that represent major gaps in our knowledge: the first are unculturable microfungi that associate with insects, called labouls, and the other are unculturable microfungi that associate with plants, called rust fungi. members of labouls and rust fungi are expected to have profound effects on ecosystem health and functioning through both beneficial and harmful interactions with their animal and plant hosts. the research team will explore several global habitats in tropical and temperate regions that have not previously been surveyed for these fungi. it is expected that hundreds of new species will be discovered and described during this project. in addition to enhancing the documented bio**diversity** on the planet, this project will resolve the "tree of life" for both groups and use this information to resolve long-standing questions regarding the evolution of the fungi. broader impacts include graduate and undergraduate training, international workshops to enhance collaboration between us and local researchers, and outreach to the public through "bat night" and "roach hunt" field trips. these fungal lineages are being studied for several reasons: 1) both represent groups poorly documented from tropical world regions; 2) both represent groups that are not detected by commonly applied culture-based and high throughput sequencing efforts; 3) neither group has been resolved, phylogenetically, by application of multi-locus analyses of known species; 4) both represent obligately parasitic lineages that are rarely studied but expected to have profound effects on ecosystems; and 5) both are or are related to heteroecious fungi (requiring two different hosts), a phenomenon that is extremely rare in fungi. a complementary team of us and other global experts on these fungi, ranging from junior to senior scientists, have designed an experimental approach

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Matched Words: diversity

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Title: Collaborative Research: PurSUIT: Species diversity and evolution of parasitic microfungi

Awardee: Western Kentucky University

Amount: \$211,362.00

Abstract: fungi are essential to ecosystem functioning, occur virtually everywhere, and form complex relationships with diverse organisms including prokaryotes, algae, plants, invertebrates, vertebrates, and other fungi. nonetheless, fungi are the most undersampled and poorly documented major lineage of eukaryotes, even though total species estimates range conservatively from 1.5-6.1 million species. this uncertainty reflects numerous gaps in knowledge about fungal distributions, especially regarding range and extent of unculturable fungi, microscopic fungi (microfungi), parasitic fungi, and tropical fungi. this project will document **\*\*diversity\*\*** of fungi in two groups that represent major gaps in our knowledge?the first are unculturable microfungi that associate with insects, called labouls, and the other are unculturable microfungi that associate with plants, called rust fungi. members of labouls and rust fungi are expected to have profound effects on ecosystem health and functioning through both beneficial and harmful interactions with their animal and plant hosts. the research team will explore several global habitats in tropical and temperate regions that have not previously been surveyed for these fungi. it is expected that hundreds of new species will be discovered and



described during this project. in addition to enhancing the documented bio\*\*diversity\*\* on the planet, this project will resolve the ?tree of life? for both groups and use this information to resolve long-standing questions regarding the evolution of the fungi. broader impacts include graduate and undergraduate training, international workshops to enhance collaboration between us and local researchers, and outreach to the public through ?bat night? and ?roach hunt? field trips. these fungal lineages are being studied for several reasons: 1) both represent groups poorly documented from tropical world regions; 2) both represent groups that are not detected by commonly applied culture-based and high throughput sequencing efforts; 3) neither group has been resolved, phylogenetically, by application of multi-locus analyses of known species; 4) both represent obligately parasitic lineages that are rarely studied but expected to have profound effects on ecosystems; and 5) both are or are related to heteroecious fungi (requiring two different hosts), a phenomenon that is extremely rare in fungi. a complementary team of us and other global experts on these fungi, ranging from junior to senior scientists, have designed an experimental approach that includes standardized sampling strategies from tropical and extra-tropical regions with multi-locus phylogenetic, phylogenomic, comparative genomic, and statistical analyses to: 1) determine whether accurate estimates from obligate microparasitic fungi, not included in any other estimates, will affect overall fungi species estimates; 2) whether parasitic microfungi follow the reverse latitudinal gradient posited for other fungal groups; and 3) resolve long-standing unresolved phylogenetic nodes by the incorporation of ?missing? lineages. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Frameworks: Collaborative Research: Integrative Cyberinfrastructure for Next-Generation Modeling Science

Awardee: Consortium of Universities for the Advancement of Hydrologic Sci

Amount: \$211,356.00

Abstract: this project is designed to support and advance next generation, interdisciplinary science of the complexly interacting societal and natural processes that are critical to human life and well-being. computational models are powerful scientific tools for understanding these coupled social-natural systems and forecasting their future conditions for evidenced-based planning and policy-making. this project is led by the network for computational modeling in social and ecological sciences (comses.net). comses.net's science gateway promotes knowledge sharing among scientists and with the general public, and enables open, online access to sophisticated computational models of social and ecological systems. comses.net's partners in this project (the community surface dynamics modeling system and consortium of universities for the advancement of hydrologic science) also enable knowledge sharing and provide open, online repositories of models in the earth sciences. this project will enhance these science gateways and create online educational materials to make these critical technologies easier to find, understand, and use for scientists and non-scientists alike. by integrating innovative technology with training and incentives to engage in best practice standards, this project will stimulate innovation and **\*\*diversity\*\*** in modeling science. it will enable researchers to build on each other's work and combine it in new ways to address societal and environmental challenges. the cybertools and educational programs developed in the project will be openly accessible not just to research institutions but also to smaller colleges, state and local governments, and a broader audience beyond the science community. the project will give decision-makers and the data scientists who support them access to a larger and more varied toolkit with which to explore potential solutions to societal and environmental policy issues. a long-term aim of the project is to support an evolving ecosystem of diverse, reusable, and combinable models that are transparently accessible to anyone in the world. sustainable planetary care and management is a challenge that confronts all of humanity, and requires knowledge, histories, methods, perspectives, and engagement of researchers, decision-makers, and private citizens across the country and throughout the world. the project will develop an integrative

cyberinfrastructure framework (icf) to enable innovative next-generation modeling of human and natural systems, and build capacity in modeling science. it will support a set of activities that integrate the human and technological components of cyberinfrastructure. 1) software tools will be developed that augment model codebases with modern software development scaffolding to facilitate reuse, integration, and validation of model code. 2) the project will provide high-throughput computing (htc) resources for simultaneously running numerous iterations of models needed to capture stochastic variability, explore a parameter space, and generate alternative scenarios; 3) online training activities will build expertise and capacity to make effective use of the cybertools and the htc resources; 4) the icf will engage a global modeling science community to provide professional incentives that encourage researchers to adopt best practices and catalyze innovative science. leveraging existing nsf investments, the icf will be developed and deployed by the network for computational modeling in social and ecological sciences (comses.net), in partnership with the community surface dynamics modeling system (csdms), consortium of universities for the advancement of hydrologic science (cuahsi), open science grid, big data hub/spoke network, and science gateways community institute. computational models have emerged as powerful scientific tools for understanding coupled social-biogeophysical systems and generating forecasts about future conditions under a range of climate, biogeophysical, and socioeconomic conditions. comses.net, csdms, and cuasi are scientific networks, with online science gateways and code archives that enable open access to computational models for an international community of social, ecological, environmental, and geophysical scientists. however, the full value of accessible, well-documented models only can be realized if their code is also widely reproducible and reusable, with a potential for integration with other models. in order to confront critical challenges for understanding the coupled human and natural systems of today's world, modeling scientists also need htc environments for upscaling models and exploring high-dimensional parameter spaces inherent in representing these systems. the icf is designed to meet these challenges. by integrating technology with intellectual capacity-building, the icf will stimulate innovation and **\*\*diversity\*\*** in

modeling science by letting creative researchers build on each other's work more readily and combine it in new ways to address societal-environmental challenges we have not yet perceived. the tools and training resources will be openly accessible not just to leading research institutions but also to the many smaller colleges, state and local governments, and a broader audience beyond science. they will provide decision-makers and the data scientists who support them access to a much larger and more varied toolkit with which to explore potential solution spaces to social and environmental policy issues. the proposed icf is also designed to help transform scientific modeling practice, including incentives that can help early career researchers shift from creating models to solve problems specific to a particular project to models that are also useful for others. the project will help support a future evolving ecosystem of diverse, reusable, and integrable models that are transparently accessible to the broader community. this project is funded by the office of advanced cyberinfrastructure in the directorate for computer and information science and engineering, with the division of social and economic sciences in the directorate for social, behavioral & economic sciences also contributing funds. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: SPARC: Facilitating Research, Experimentation, and Education in Spatial Archaeometry

Awardee: University of Arkansas

Amount: \$209,726.00

Abstract: the spatial archaeometry research collaborations (sparc) program promotes the use of spatial analysis, 3d modeling, as well as satellite, aerial, and terrestrial remote sensing in archaeological research projects. the things archaeologists study?from artifacts to sites to landscapes?almost always have a spatial component and spatial analysis is therefore central to

contemporary archaeological investigations. today, the increasing availability and sophistication of geospatial technologies is not merely generating new data but is facilitating entirely novel means of engaging with the archaeological record and exploring the human past. however, the high costs of instrumentation and software, combined with the expertise they require, create hurdles for many archaeologists who aim to deploy geospatial technologies in research projects. sparc 1) facilitates high-impact spatial archaeometric research, 2) advances emerging methodologies towards greater community use, 3) promotes this new knowledge across the discipline, and 4) promotes inclusion of junior and underrepresented scholars and institutions in leadership roles and in its training schema. through its innovative approach to supporting collaborative archaeological research, the sparc program makes costly geospatial technologies and specialized domain expertise available to researchers from a wide range of backgrounds, including early career scholars and those at minority serving institutions, enhancing **\*\*diversity\*\***, equity, and inclusion within archaeological research. the program also provides education and training opportunities for students and professionals seeking to use geospatial techniques in their own research, broadening the impact of the program far beyond individual supported projects. the sparc program supports archaeological researchers seeking to integrate geospatial technologies and methods into their investigations by facilitating collaborations with research faculty and staff and the technological infrastructure from the university of arkansas' center for advanced spatial technologies (cast), dartmouth college's spatial archaeometry lab (sparcl), and the university of arkansas' microct imaging consortium for research and outreach (micro). researchers apply to the program through a competitive, peer-reviewed process, and successful proposals receive support from geospatial technologies experts in both field and lab settings, access to specialized equipment and software, and intensive training opportunities.

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: EAGER: Collaborative Research: Enhancing Asian American and Pacific Islander Participation and Belonging in the Geosciences

Awardee: Brown University

Amount: \$209,243.00

Abstract: asian americans and pacific islanders (aapi) represent one of the fastest growing demographics in the u.s. today and yet lag in participation and representation in geoscience graduate programs compared to other stem fields. thus, new programs are needed that specifically recruit aapi stem undergraduates to geoscience graduate programs and enhance belonging of aapi geoscientists as a whole. the proposed activities will focus on minority serving institutions (msis) that serve aapi. this project will expose as many as 1,000 undergraduates from msis in geoscience-adjacent stem fields to geoscience research and careers, provide a new research internship opportunity and create national cross-career stage connections between aapi geoscientists to produce a cohort of geoscience leaders from a group often left out of \*\*diversity\*\* discussions. aapi scientists desire to relate their work to local populations and problems relevant to their communities; therefore, diversifying geoscience graduate programs with those identifying as aapi will have a direct impact on communities facing important geoscience problems of the 21st century such as climate change, natural hazards, and resource scarcity. this project supports pilot programs to enhance participation and belonging for asian american and pacific islander (aapi)

communities in geosciences. the proposed activities include: 1) establishing a researcher visit program to recruit undergraduate aapi into geosciences via visits to aapi-serving msis from geoscience researchers; 2) a pilot research internship program for undergraduates at these institutions to carry out research with aapi mentors; 3) organizing virtual and in-person events and a career development workshop to enhance belonging, identity, and leadership within the aapi geoscience community across career stages and sectors. the outcomes of this combination of the proposed activities will help to develop geoscience programs, and create a cohort and community of belonging, access, justice, equity, **\*\*diversity\*\***, and inclusion (bajedi) leaders of aapi geoscientists. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: New superdiffusive pastes from self-motile active particles with extreme penetration capabilities enabling breakthrough biomedical technologies

Awardee: North Carolina State University

Amount: \$207,967.00

Abstract: this eager project will seek to prove the feasibility of new high-risk, high-reward, interdisciplinary ideas in the field of self-propelling active particles. these new classes of particles can convert their internal chemical energy, or energy from external fields, into motion. the motile particles have highly unusual properties and can form the basis of new biomedical products with very high efficiency and radically improved performance. however, the present types of active particles are complicated or require a special medium for propulsion. this project will explore new types of active particles, which will propel themselves by simple osmotic effects, while a portion of the particles dissolve in the medium. a new system made of such particles called a "superdiffusive paste" will have extraordinary properties in being able to rapidly permeate any medium with interconnected pores, infusing any crevice, pore, and cavity, as the motile particles move through



the pore network. this system could be used to deliver compounds in challenging situations. for example, a superdiffusive paste loaded with disinfectant will be able to penetrate the complex inner channel network of teeth and kill microbes concealed within this network. this eager project will explore new physical principles for particle self-propulsion without an external source of energy or special media and will apply these principles by constructing a new type of suspension in the form of a superdiffusive paste. the introduction of the superdiffusive paste could spark new areas of fundamental research due to the rich variety of mass-transport effects that will emerge in such novel active particle systems. the most exploratory and interdisciplinary element will be the application of the superdiffusive paste in biomedical systems. specifically, the project will seek to demonstrate that the high permeation capability of the superdiffusive paste can lead to future transformative products for disinfection of open teeth, tissues, and wounds. the development of the novel paste will be done in collaboration with experienced dental investigators. the broader impacts of the project include providing training ground for a new diverse group of engineering students in the emerging areas of active materials. these students will master multidisciplinary topics ranging from chemical engineering, to design of new active materials, to their translation to biomedical use. it will also contribute to the research team's ongoing activity in maximizing undergraduate and graduate researcher **\*\*diversity\*\*** and preparing enticing materials for hands-on outreach demonstrations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Invaders from the sea: unearthing the genomic basis of marine-to-terrestrial life-history transitions

Awardee: Morgan                      Victoria      M

Amount: \$207,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, broadening

participation of groups underrepresented in biology. the fellowship supports a research and training plan for the fellow that will increase the participation of groups underrepresented in biology. since all life on earth began in the oceans, but most large species currently live on land, the fellow plans to study the genetic basis of sea-to-land transitions to better understand how these transitions, which have profoundly shaped modern bio\*\*diversity\*\* patterns on earth, may have happened long ago. using land crabs that spend part of their lives in aquatic habitats and the other part on land, the fellow will explore gene expression patterns between their juvenile aquatic and adult terrestrial life stages to identify which genes may be associated with their terrestrial metamorphosis. by comparing these patterns across multiple species, the fellow hopes to identify larger evolutionary patterns that might shed light on how life may have adapted to land millions of years ago. the fellow will also create a mentorship program that pairs postdoctoral students from diverse groups with faculty from similar backgrounds to provide them with successful role models and guidance during a critical career phase. the program will also provide professional development opportunities that will prepare the mentees for applying to and securing academic or industry jobs, which will help increase the participation of these underrepresented groups in biology.

the fellow will characterize the larval stages of three land crab species with different developmental modes, and then compare intraspecies gene expression between developmental stages, and interspecies gene expression across developmental strategies to determine which genetic shifts may have been important changes that allowed for lineages with more direct developmental modes to adopt highly terrestrially lifestyles. the findings from this project will provide insight into the nature of evolutionary predictability and its genomic underpinnings, as well as the genetic basis of major biological innovations and transitions. it will also generate novel genomic, transcriptomic, and developmental resources, and lay the groundwork for future studies that use transgenic tools and genome editing protocols to further investigate the genomic basis of convergently evolved terrestriality in this system. by undertaking this project, the fellow will develop new skills in embryology and comparative developmental transcriptomics. in addition to designing and

implementing her diverse mentorship program, the fellow will also directly increase **\*\*diversity\*\*** in biology since she is also from an underrepresented group. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Comparative viromics in vertebrates from the Sonoran Desert of the Baja California peninsula, Mexico and Arizona

Awardee: Vargas, Karla Leonor

Amount: \$207,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2020, broadening participation of groups under-represented in biology. the fellowship supports a research and training plan for the fellow that will increase the participation of groups underrepresented in biology. viruses play essential roles supporting life on earth. they are present in all environments and can affect all types of organisms. viruses are genetically and structurally diverse and their evolution is linked to their hosts. the fellow will characterize viral communities in wildlife and investigate host-virus dynamics in the sonoran desert. the natural variation of this region makes it the ideal setting to explore viral **\*\*diversity\*\*** associated with wildlife and the interactions between the host and the virus. this research is relevant to understanding factors that contribute to genetic variation within species, and also to understand how new species of viruses can emerge. furthermore, investigating undiscovered viral communities in wildlife may be instrumental to gain knowledge on emergence of new viruses and prevent potential spread to humans. this fellowship will support the research, training, and career advancement of a fellow from an underrepresented group in stem. the fellow will develop initiatives for underrepresented groups at the postdoctoral level, provide mentorship and develop educational tools. in collaboration with the nsf funded bajageogenomics consortium, the fellow will sample across the baja california peninsula, mexico (bcp), and the sonoran desert,

arizona (sda) and follow a viral metagenomics approach to a) characterize rna and dna viruses associated with host populations of rodents, lizards, and carnivores, b) compare viral \*\*diversity\*\* within bcp and sda host populations and evaluate potential geo-climatic and demographic predictors of viral \*\*diversity\*\*, and c) assess host-virus dynamics across bcp by investigating whether viral genomic differences are consistent with intraspecific genetic divergence between northern and southern populations. the project will integrate genomic and biogeographic data to fill fundamental gaps in viral \*\*diversity\*\* and explore the role of environmental stressors and host demographics in host-virus systems. the fellow will investigate the lineal history of host and viruses in context of the geo-climatic history of the region, predictors of viral richness, and patterns of divergence in viruses and hosts. as part of this appointment, the fellow will work along an international cross-disciplinary team, receive training in viral metagenomics methods, organize an international postdoctoral seminar series, initiate a virtual network for latinx postdocs, contribute to the development of bilingual educational videos, and promote science education and mentorship for k-12 students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Color polymorphism: a model system for predicting phenotypic evolution in nature

Awardee: Brock, Kinsey M

Amount: \$207,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. climate change is expected to generate extreme environmental conditions, and our ability to predict the way organisms will respond to projected

environmental change is critically important for the future. in nature, thousands of species have evolved color polymorphism. that is where multiple distinct color morphs, that also differ genetically and behaviorally, coexist within the same species. color polymorphic species are an ideal system to develop predictive power in biology because often color morphs of the same species are associated with different aspects of the environment. the aim of this project is to identify repeatable associations between lizard color morph traits, genetics, and specific environmental variables that are expected to change with climate change (temperature, air moisture, precipitation, etc.) to develop predictions about how animals will evolve and adapt to changing environments. the fellow will use the aegean wall lizard, which has three color morphs: orange, yellow, and white, that differ by environment to study how color morph genetics and environmental change variables interact to produce different color morphs in different environments. the fellow will engage undergraduates underrepresented in the sciences in research as lab and field assistants. this project will also include an international outreach component that will communicate basic principles of evolution to elementary school children in the san francisco bay area, united states and athens, greece with art-based activities. this research will use genetically determined color morphs of the aegean wall lizard to identify gene-phenotype-environment interactions that have naturally produced repeated evolution of the same morph phenotypes in similar environments. this research will use color polymorphism as a model system to test for: predictable associations between intraspecific morph **\*\*diversity\*\*** and environmental variation, the evolution of repeated morph phenotype-environment associations in isolated populations, and correlated macroevolution of morph phenotypes and environmental variation across many color polymorphic species. the fellow will train in integrative approaches that combines adaptive landscape theory, genomics, computation, fieldwork, and experiments to identify predictable patterns of phenotypic evolution from complex interactions across biological scales. the fellow will engage undergraduates from underrepresented groups in research and science outreach activities with local and international elementary classrooms. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's

intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: GEOPATHS IN: DIG CAMP - Data in Geosciences: Collaboration and Mentoring Program?Teaming Latinx High School and College Students for Data Use in Geosciences

Awardee: University of California-Berkeley

Amount: \$206,815.00

Abstract: this award is funded in whole or in part under the American Rescue Plan Act of 2021 (Public Law 117-2). Atmospheric, climate, ocean, earth and environmental sciences (geosciences) are among the least diverse fields in science, technology, engineering and math (STEM), with Latinx scientists being significantly underrepresented. A lack of **diversity** in STEM fields means decreased ability to identify and solve critical issues facing society such as climate change, which disproportionately affects the populations that are least represented in STEM. Data literacy is gaining increasing relevance and importance to scientists and the general public as we aim to make informed decisions to solve locally and globally relevant problems. DIG CAMP (Data in Geosciences: Collaboration and Mentoring Program?Teaming Latinx High School and College Students for Data Use in Geosciences) offers a camp-based model to support engagement with geosciences, as well as data literacy. During this project and through its sustainability plan, DIG CAMP provides opportunities for Latinx high school students to engage with authentic and locally relevant geosciences research and data; gain geosciences content knowledge; build their data literacy, critical thinking, problem solving, and collaboration skills; strengthen their identities to do science; and increase the likelihood that they will pursue academic or workplace careers in the geosciences. DIG CAMP - Data in Geosciences: Collaboration and Mentoring Program?Teaming Latinx High School and College Students for Data Use in Geosciences will broaden participation in the geosciences among communities of color by developing a research-based model for overcoming long standing barriers and biases within

the field. the goals of this project are to: (1) design and implement a complementary suite of informal learning experiences to actively recruit latinx high school students into the geosciences by increasing their engagement, capacity building, and opportunities for continuity in the discipline; (2) provide latinx undergraduate geosciences majors with meaningful outreach and mentoring opportunities that engage them with communities, and increase their retention in geosciences fields of study and careers; and, (3) support high school students and their undergraduate mentors to build science and data literacy skills and engage with locally relevant geosciences research data to increase their efficacy and success in college and the geosciences workforce. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: From Quantum Droplets & Spinor Solitons to Vortex Knots & Topological States: Beyond the Standard Mean-Field in Atomic BECs

Awardee: San Diego State University Foundation

Amount: \$201,843.00

Abstract: the realm of bose-einstein condensates (becs) was originally proposed as a curious feature of the statistical properties of atomic particles with integer spin by bose and einstein in the 1920's. this consisted of the condensation of the excited states particles into the ground state of the system and the formation of a macroscopic, coherent "super-wave" therein, allowing the study and observation of quantum mechanical properties beyond microscopic scales. however, the temperatures needed for its experimental realization were so low that it took about 70 years for e.a. cornell, w. ketterle, and c.e. wieman to realize becs in the lab. the importance of this feat was recognized only a few years later via the 2001 nobel prize in physics. this has, in turn, enabled a pristine platform where numerous exciting features of nonlinear dynamics of waves and coherent structures can be studied and experimentally observed. importantly, these coherent structures are

also of wide applicability in numerous other areas of physics including, most notably, nonlinear optics, plasma physics, and water waves. within atomic physics, becs have also been fundamental toward the study of remarkable quantum features such as superconductivity and superfluidity and, in that capacity, they have been front and center toward the experimental discoveries connected to the vortices and their lattices cited in the 2003 nobel prize in physics and the topological phases and their transitions associated with the 2016 nobel prize in physics. the aim of this project is to advance the state-of-the-art at this exciting nexus of atomic physics theory, physical bec experiments, applied mathematical analysis, and the forefront of scientific computing, while at the same time training a new generation of scientists and mathematicians at this scientific interface and transcending disciplinary boundaries. in line with the past trajectory of the pis, an emphasis on the **\*\*diversity\*\***, equity and inclusion of under-represented groups will be sought within this research effort. more concretely, the principal thrust of the present project consists of the study of non-trivial extensions of standard bec settings. in particular, the main axes of the proposal consider the following themes. (1) two-component mutually attractive becs that allow, through quantum corrections and the famous lee-huang-yang (lhy) contribution, for the highly timely formation of so-called quantum droplets. the key realization for such droplets is that their emergence stems from the interplay between repulsive mean-field and attractive beyond-mean-field contributions. (2) three ( $f=1$ ) and five ( $f=2$ ) spin component settings supporting symbiotic (dark-antidark and dark-bright) solitary wave structures with unprecedented integrable or weakly non-integrable properties. (3) 3d vortex knot structures in one and multi-component/spinor settings. vortex knots constitute one of the most elusive types of vortical structures for which limited experimental and theoretical analysis exists. the pis will also explore in the spinor settings complex non-trivial topological patterns such as alicia rings and dirac monopoles. (4) topologically nontrivial toroidal trapping settings, where the interplay of the intrinsic metric and curvature of the system with the effective nonlinearity can yield unprecedented coherent structures and dynamics thereof. more broadly within this theme, the pis will study nonlinear waves such as solitons and vortices confined on different types of curved surfaces. this ambitious program



should push the boundaries of the state-of-the-art mean-field-theoretic understanding, offering numerous beyond-mean-field insights and elucidating their range of validity as well as the interplay of nonlinearity with quantum, as well as thermodynamic effects. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: Audio for Inclusion: Uncovering Marginalized Student Narratives to Provide Insight to Faculty on the Known Unknowns of Inclusion

Awardee: Utah State University

Amount: \$200,982.00

Abstract: this project will bring the experiences of diverse engineering students directly to faculty through edited audio interviews. undergraduate engineering education is a critical juncture in the diversification of the engineering workforce. however, engineering educational culture can marginalize many groups. faculty are key change agents in this culture, and their empathy and understanding for diverse students are critical for enabling and promoting inclusive education. however, faculty may not be aware of diverse student perspectives, and even well-intentioned faculty may fall short of creating inclusive classroom environments. more resources are needed to help develop faculty empathy and understanding for a broad range of student populations in engineering education. qualitative research presents a promising tool for centering the voices and experiences of students, but researchers' typical long form journal publications for disseminating qualitative research are not an accessible and compelling medium. to increase collective impact, more accessible, innovative, and timely dissemination strategies are needed. podcasts and youtube clips can be used to disseminate research findings with more immediacy and personalization than written text. in this study, we will feature these audio formats as media to share diverse student experiences with faculty and to facilitate a broader impact on pedagogy and culture. faculty who listen to the audio will have the potential to gain reflective awareness of student experiences that provoke the creation of more inclusive classrooms. this novel dissemination approach will be sustained through the creation of a widely distributed podcast called audio for inclusion, hosted by the pis. this podcast will include the final versions of edited audio files generated in this study and will be located on the asee \*\*diversity\*\* committee's web and youtube pages, and incorporated into

workshops. we will conduct a nationwide recruitment of students with salient minoritized identities via email distributed through relevant organizations, campus support centers, and snowball recruitment. twenty (20) students will be interviewed twice throughout the duration of the study using a semi-structured protocol that focuses on their experiences in engineering education. interviews will be transcribed, de-identified, edited for conciseness, and re-recorded by student actors. recorded interviews will be disseminated using a survey distributed to 100 faculty members who represent a range of familiarity with \*\*diversity\*\* and inclusion topics. this survey will prompt faculty participants to listen to embedded student narratives and provide feedback using likert-type and open-ended response questions. survey results will be used to observe the impact of the audio resources on faculty views of \*\*diversity\*\*, equity, and inclusion in engineering. this project will be informed by existing theoretical frameworks such as intersectionality, figured worlds, narrative, and critical theorizing. findings from this work will contribute to the knowledge base on broadening participation in engineering in three ways: (1) by providing insights into the experiences of students belonging to minoritized identity groups; (2) by developing an accessible resource for improving faculty knowledge of and strategies for promoting the inclusion of students? undisclosed identities and experiences in engineering education; 3) by establishing a novel research approach to broaden participation in engineering; (4) by employing innovative dissemination techniques that expand the impact of student participant voices; and (5) by contributing to evidence-based foundations for the future development of faculty-centered support structures related to expanding concepts of \*\*diversity\*\* and inclusion. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Improving First-to-Second Year Retention and Closing Equity Gaps through a STEM Academy

Awardee: Columbia Basin College

Amount: \$200,000.00

Abstract: this project aims to improve academic outcomes for hispanic students by creating and piloting a new stem academy which will offer a combination of financial, academic, and social supports to an initial cohort of students. such supports are ultimately expected to result in an increase in the number and **\*\*diversity\*\*** of stem graduates. columbia basin college has consistently had high levels of attrition for first year stem majors, particularly for low-income, first generation, and hispanic students, with only a little more than half (54%) of these students persisting into their second year. through the development of the new stem academy, this project will increase first-to-second year retention rates in the school of math, science, and engineering, and seek to close the school's retention equity gaps with respect to hispanic students. the goals of the stem academy project are to: 1) increase participants' first-to-second year retention by at least 12%, and 2) reduce the retention equity gap by at least 50%. towards that end, the project team will develop a new, cohort-based stem academy of 25-35 students for the pilot year. students in the academy will receive supports including direct financial assistance, reserved enrollment in linked courses, and a new dual-language orientation course specifically designed for stem students. stem academy participants will also benefit from intrusive academic advising, partnership with a peer mentor, and direct access to stem professionals via an industry-led stem colloquium. these high-impact practices are specifically geared toward increasing students' sense of belonging and self-efficacy in stem subjects, which will improve student persistence during the critical transition from the first year to the second year of their postsecondary education. this will result in a larger and more diverse body of students who will be academically prepared to meet the growing needs of the stem workforce. the hsi program aims to enhance undergraduate stem education, broaden participation in stem, and build capacity at hsis. achieving these aims, given the diverse nature and context of hsis, requires innovative approaches that incentivize institutional and community transformation and promote fundamental research (i) on engaged student learning, (ii) about what it takes to diversify and increase participation in stem effectively, and (iii) that improves our understanding of how to build

institutional capacity at hsis. projects supported by the hsi program will also draw from these approaches to generate new knowledge on how to achieve these aims. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: HSI Pilot Project: Broadening Research Experiences for HSI STEM Diversity, Equity, and Inclusion (BREDEI)

Awardee: Texas A&M University-San Antonio

Amount: \$199,999.00

Abstract: with support from the improving undergraduate stem education: hispanic--serving institutions (hsi program), this track 1 project aims to improve the quality, availability, and **\*\*diversity\*\*** of the stem educational pipeline. by building a sustainable undergraduate field research program at texas a&m university--san antonio, the project will develop a strong scientific and professional identity critical to the persistence in stem majors and the motivation to pursue a science--related career. we will develop role models, facilitate student participation in federally--supported research projects, and provide field training programs to heighten the scientific literacy and identity among the participating students. as the project team validates the impact of these practices and develops them into a curricular program, the project will have a long--term impact of cultivating reliable domestic talent from underrepresented populations by improving the disproportionately low representation of hispanic students in south texas in the aquatic ecology profession. aquatic sciences are highly interdisciplinary and require a considerable amount of field experience that has not always been accessible to under--represented student groups. we hypothesize that improving the availability of field research opportunities and role models are key to the success of minority stem majors. thus, the specific aims of the project are to (1) improve scientific literacy among minority communities, (2) broaden undergraduate research experiences

focusing on assessing the health of stream ecosystems, (3) improve recruitment, retention, and graduation of minority students by offering field research and mentoring programs, and (4) establish a sustainable model for a field--heavy curriculum via a collaborative model between hsis, schools, public and private sector entities. these objectives will be achieved by implementing field--training activities supported by the national ecological observatory network (neon), the national hispanic environmental council (nhec), and the texas aquatic science project. the outcome of the project will enable the development of a university faculty-reviewed field--study curriculum for a&m--sa that will benefit students from multiple natural resource majors. the hsi program aims to enhance undergraduate stem education, broaden participation in stem, and build capacity at hsis. achieving these aims, given the diverse nature and context of the hsis, requires innovative approaches that incentivize institutional and community transformation and promote fundamental research (i) on engaged student learning, (ii) about what it takes to diversify and increase participation in stem effectively, and (iii) that improves our understanding of how to build institutional capacity at hsis. projects supported by the hsi program will also draw from these approaches to generate new knowledge on how to achieve these aims. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Catalyst Project: STEM-Business Focused Sustainable Financial Technology ? Clean Technology (Sustainable FinTech-CleanTech) at the University of the District of Columbia

Awardee: University of the District of Columbia

Amount: \$199,997.00

Abstract: catalyst projects provide support for historically black colleges and universities to work towards establishing the research capacity of faculty to strengthen science, technology, engineering and mathematics undergraduate education and research. it is expected that the award will further the faculty member's research capability, improve research and teaching at the institution, and involve undergraduate students in research experiences. this project at the university of the district of columbia (udc) includes support for the development of a financial technology-clean technology certificate. the proposed work has the potential to establish partnerships with other higher education institutions and the local k12 system. it is expected that participating students will contribute to increasing **\*\*diversity\*\*** in the fintech-cleantech workforce. the overarching goal of the stem-business focused sustainable financial technology ? clean technology (sustainable fintech-cleantech) project at the udc is to introduce and provide business and engineering undergraduate students at udc with an innovative and interdisciplinary ?sustainable fintech-cleantech? certificate program available to both business as well as science, technology, engineering and mathematics (stem) majors. specific objectives of the project are: (1) to develop an innovative and interdisciplinary sustainable fintech-cleantech certificate program open to business and stem undergraduates; (2) to enrich and enhance undergraduate student and faculty research

capacity in fintech-cleantech curriculum; and (3) to engage udc students in sustainable fintech-cleantech certificate program through outreach to local high schools and community colleges. the project will utilize a mixed-method approach that emphasizes student surveys, observations, focus groups, and interview protocols for assessing the desired project outcomes. the potential contribution and impact of the project include the development of a cutting-edge fintech-cleantech certificate program for engineering and business undergraduates at udc, an hbcu, leading to the participation of underrepresented groups in this discipline; enhancement of education and research in diverse focus areas by developing instructional materials for enterprise applications (e.g., enterprise resource planning software by sap through sap university alliances program) that can be modeled at other institutions; research collaborations among students and faculty from underrepresented groups; leveraging and building udc's partnerships with academia, industry, and government; and dissemination of project results to the broader community by presenting and publishing project outcomes in peer-reviewed conferences and scholarly journals. the institution-wide fintech-cleantech certificate program has the potential of benefitting engineering and business students and providing a validated replicable model for other similar institutions in the nation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: HSI Pilot Project: The MAESTRO Program - Minority Advancement in Engineering, Science, and Technology by Refactoring the Online Program

Awardee: CSUB Auxiliary for Sponsored Programs Administration

Amount: \$199,993.00

Abstract: with support from the improving undergraduate stem education: hispanic-serving institutions (hsi program), this track 1: ppp aims to address the lack of means and support for hispanic/latinx, low-income, first generation students to effectively participate in postsecondary education. modern students work while going to school. for hispanic/latinx students who work twenty to forty hours a week, this workload may affect attendance and gpa, ultimately resulting in poor workforce placement. addressing the issue that work comes first for many low-income underrepresented students, two approaches will be utilized: 1) supplant non-career-relevant work experience with industry internships, and 2) develop new formats for online learning. the overarching theme is to help students maintain both their income and academics. busy students often turn to online programs that can be as effective as face-to-face instruction when combined with online videos and peer instruction. however, this model dichotomizes at-risk students due to poor regulation and social interaction. preliminary results show that this classroom model does not improve outcomes or attitudes of california state university- bakersfield (csub) students. a system that scaffolds and regulates the class with small groups convened at times around student work will be pioneered. significant, meaningful experiences will be offered for students in data science and wireless communication. participants of this program will have career-relevant internship/work

experience, better retention rates, shorter timelines to graduation, reduced stress, and better motivation. it will contribute to the size and **\*\*diversity\*\*** of the u.s. science and technology workforce. this project will utilize real-time teaching where students proceed at their own pace. the instructor monitors, scaffolds, and self-regulates the class by convening small groups at times convenient to the students for semi-synchronous learning. this approach will be paired with industry internships relevant to careers in computer engineering (ce), computer science (cs), and electrical engineering (ee). the impact of these strategies and how they improve the retention and success of the hispanic/latinx, low-income, and/or non-traditional students in ce, cs, and ee will be assessed. findings will be disseminated broadly through various presentations at conferences, publications, workshops and a project website. the hsi program aims to enhance undergraduate stem education, broaden participation in stem, and build capacity at hsis. achieving these aims, given the diverse nature and context of the hsis, requires innovative approaches that incentivize institutional and community transformation and promote fundamental research (i) on engaged student learning, (ii) about what it takes to diversify and increase participation in stem effectively, and (iii) that improves our understanding of how to build institutional capacity at hsis. projects supported by the hsi program will also draw from these approaches to generate new knowledge on how to achieve these aims. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Discovering the hidden functional trait diversity of Bees (Apoidea) and predicting functional diversity impacts on rendered ecosystem services

Awardee: LAWRENCE UNIVERSITY OF WISCONSIN

Amount: \$199,957.00

Abstract: we often associate pollination with a few external characteristics in bees (e.g., hairiness & tongue length) but bees are complex organisms with a plethora of unstudied morphological and

physiological traits (e.g., gut structure, muscular form, and thermal tolerance) that can strongly influence their effectiveness as pollinators. this project will link unstudied, internal morphological traits with bee physiological responses. at its core this work links structure and function with the functional role of bees as pollinators. microct technology will be used to render high-resolution quantitative imagery of internal morphological traits. honeybees will be used as a model system and the work will be expanded to obtain imaging and an analytical framework of 50 species of wild bees across multiple groups. by linking morphology and physiology with functional **\*\*diversity\*\***, this work has the potential to shape how we think about and manage pollinator bio**\*\*diversity\*\***. this work will provide research and training opportunities to six undergraduate students that will work on microct imaging techniques, biological data science and experimental biology on the physiology of bees. this project will explore the associations between functional **\*\*diversity\*\*** and morphological and physiological traits that directly influence the ecosystem service of pollination provided by bees. the project uses microct technology to image both honeybees and native wild bees over the course of two years. specific emphasis is placed on internal morphological traits in relation to bee's physiological responses (e.g., respiration and thermal tolerance) to environmental stress and thus ultimately impact a bee's efficacy as a pollinator. the pi and undergraduate research assistants will conduct thermal tolerance and respiration assays on bees to determine potential links of functional trait morphology with important physiological responses. this work will provide workforce development opportunities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Catalyst Award: Targeted Infusion Project: Advancing STEM Education Through Transportation Studies (TIP-ASETTS)

Awardee: North Carolina Agricultural & Technical State University

Amount: \$199,938.00

Abstract: catalyst projects provide support for historically black colleges and universities to work towards establishing the research capacity of faculty to strengthen science, technology, engineering, and mathematics undergraduate education and research. it is expected that the award will further the faculty member's research capability, improve research and teaching at the institution, and involve undergraduate students in research experiences. this project at north carolina agricultural and technical state university (nca&t) intends to create a digital badging program for students interested in the transportation industry. the proposed work has the potential to increase student skillsets to increase competitiveness for technical opportunities in the transportation industry and increase **\*\*diversity\*\*** in the transportation field. it is the intent to position the proposed work in the p21 framework which focuses on equipping students with the skills they need to succeed in school and their careers in the 21st century. the goal of the advancing stem education through transportation studies (asetts) digital badge program is to advance knowledge and understanding within stem education through activities designed to increase the number of highly skilled nca&t undergraduate students entering the transportation workforce. this goal will be achieved by using the following approach: (a) creating a stackable-units digital badge program that encourages undergraduate students to increase their skillsets along various dimensions such as life/career, innovation, technology, and core subject matter skills; (b) increasing the number of undergraduate students participating in transportation research experiences and other engaging activities that will expose students to career opportunities in transportation; (c) establishing a professional-to-student and student-to-student mentorship program, and (d) updating current courses by including activities designed to develop specific competencies needed in the transportation workforce. a successfully implemented program has the potential to serve as a case study through which the ability of a stackable-units digital badge program to increase students' engagement in educational activities will be evaluated. by focusing on students across different stem majors, the proposed program will be unique and novel in that it will develop students' competitive skillsets such as initiative and

self-direction as well as introduce them to transportation innovations and technologies. the research projects intend to cover diverse topic areas within the transportation domain including transportation demand management, optimization, emerging technologies, and human factors. finally, through the integration of the p21 and experiential learning components in transportation courses along with the mentorship activities, the asetts program aims to innovate existing curricula and provide a much-needed support network to facilitate the success of students underrepresented in stem disciplines who desire a career in the transportation industry. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Research Initiation: Understanding Teamwork Experience and its Linkage to Engineering Identity of Diverse Students

Awardee: San Francisco State University

Amount: \$199,919.00

Abstract: this project focuses on engineering identity (ei), which measures how strongly a person identifies with being an engineer and serves as an indicator of persistence and retention in engineering. the project is aligned with the goals of the research initiation in engineering formation program by investigating how teamwork explains or is explained by ei among undergraduate engineering students and to support a community of new researchers conducting engineering education research. repeated calls from engineering employers and educational accreditation bodies have stressed teamwork training in undergraduate education. this emphasis has led to a proliferation of studies on how teamwork promotes metacognitive ability, communication, and related skills. however, less is known about how teamwork informs or is informed by the ei of students from diverse backgrounds. the connection between team-based experiences and engineering identity is instrumental to inclusive teaching and learning because ei may be



disproportionately lower for some students. in addition, teamwork designed without considering ei may further exacerbate that gap. although more students from diverse backgrounds are entering engineering programs, the challenges they face in performance expectations, resource access, and peer interactions still hamper their retention and advancement. in a university context, these challenges are most clearly manifested in student teams. this grant will: (1) analyze teamwork experience through the behaviors of and disagreement patterns between team members in a student population with high social and economic **\*\*diversity\*\***; and (2) evaluate how teamwork informs ei. disagreement patterns will be depicted by the variation in team members' views on basic team constructs (task, process, satisfaction, cohesion, and relationship). grounded in dispersion theory, this project will employ a mixed-methods approach to understand the prevalence and disagreement patterns, illuminating how ei, gender, and other student-specific variables (demographics, transfer student, etc.) explain the likelihood of a student to disagree on tasks, process, and other teamwork constructs. the results have the potential to reveal gaps or equity issues. moreover, by leveraging survey instruments that have been tested by prior nsf-funded work, this project will explore how teamwork experience, via a lens of behaviors and disagreement pattern, relate to ei. thus, providing evidence on which behaviors are linked to stronger ei and which types of team dynamics (disagreement patterns) promote ei development when a disagreement occurs in teamwork. the project will develop a more robust model to effectively handle likert-style variables on ei. it addresses new questions that are expected to shape future work on inclusive teamwork design and interventions, while illuminating the gains in estimation accuracy as a result of the use of the new model with codes written in an open-source program to facilitate dissemination. this project will acquaint three early- and mid-career faculty members with new methods in engineering education research. by leveraging teamwork experiences to strengthen the ei of diverse students, they will be able extend this research to many inclusive learning or teaching endeavors. this work will take place at a hispanic-serving institution, where improvements in the curriculum and student experience in team-based coursework will lead to improved learning experiences for a diverse student body. this

award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Chronological context of species loss in a Caribbean vertebrate community

Awardee: Rutgers University Newark

Amount: \$199,839.00

Abstract: today's bio\*\*diversity\*\* crisis is underscored by species loss at a rate many times higher than expected based on the fossil record. it is estimated that since 1500 ce about 61% of species extinctions and 37% of all critically endangered species have been confined to islands. factors such as environmental variability and direct human impacts, such as habitat destruction and overhunting, are among the top threats to insular species. species losses caused by these increased pressures may disrupt biotic communities and affect their function in the long term. understanding how these factors affect bio\*\*diversity\*\* and why some species survive while others become extinct is important to devise strong policies for bio\*\*diversity\*\* conservation in the face of environmental change. the aim of this research is to examine past and present changes in the island vertebrate communities of hispaniola and puerto rico to investigate how species responded to different factors before and after the arrival of humans. by combining data from well-preserved fossils and modern communities, this study will target the following questions: what is the timeline of change in each island community? does species loss vary with the characteristics of each island? what members of each island community persist or were lost over time? what factors contributed to species loss? the answers to these questions will provide an opportunity to contextualize losses and community change across time and learn from these processes to help mitigate bio\*\*diversity\*\* loss today. this research will train undergraduate students, many of whom are from underrepresented groups in science; promote local scientific literacy via outreach; and benefit society by providing information about bio\*\*diversity\*\* change. through a detailed chronological study of the changes in vertebrate

communities, this project will provide a basis for predicting species responses to factors related to past environmental variability, human colonization history, and island and species characteristics. the primary focus will be on a comparative analysis of bat communities between islands, however fossilized remains of other vertebrates will also be quantified, in light of theoretical expectations of island biogeography. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RAPID: The Impact of Bans on Peremptory Challenges On Voir Dire, Jury Composition, and Case Outcomes

Awardee: Arizona State University

Amount: \$199,750.00

Abstract: despite decades of effort aimed at reducing disparities in the american legal system, they persist. certain demographic groups are overrepresented in prisons and among those falsely convicted, due, in part, to their continually being underrepresented on juries. increased **\*\*diversity\*\*** on juries improves the quality of deliberation and reduces bias in jury decisions?but prosecutors? use of peremptory challenges is a primary mechanism for creating disparities on juries. prosecutors strike jurors from some groups at higher rates and successfully provide neutral reasons when challenged. arizona is about to take a truly transformative step by banning peremptory challenges, a ground-breaking reform taking effect on january 1st, 2022. the stated goal of the ban is to combat bias in jury selection; the assumption being that this will increase jury **\*\*diversity\*\*** and reduce bias in verdicts. this project advances basic science on **\*\*diversity\*\***, group decision-making, and combating bias in a real-world setting. it tests whether a structural change to the jury selection process alters how jury selection decisions are made and the downstream consequences for **\*\*diversity\*\*** and bias on juries. it tests whether racial discrimination in jury selection persists because attorneys shift their

tendency to offer compelling neutral justifications for excluding jurors of some groups from peremptory challenges to challenges for cause. this project furthers nsf values of combating bias and promoting equity, **diversity**, and inclusion by testing the impact of a large-scale ground-breaking intervention designed to do just that in the legal system. this project also creates important databases for future research and involve many members of underrepresented groups as research assistants in every stage of the research. this rule change presents an important and ephemeral opportunity to collect data on voir dire practices, composition of juries, and case outcomes before and after this change. this transdisciplinary, multi-method project is designed to achieve the following research aims: (1) test whether superior court juries are significantly more diverse and representative after the peremptory challenge ban, (2) test whether conviction or liability rates in cases with defendants of some groups will significantly decrease after the peremptory challenge ban, (3) test whether the percentage of persons of some groups excused for hardship/cause will significantly increase after the peremptory challenge ban is enacted, thereby mitigating the overall impact of the ban, (4) test whether the way challenges for cause are argued and decided in court changes after the peremptory challenge ban is enacted in ways that mitigate the overall impact of the ban, and (5) conduct interviews with judges and attorneys regarding how they might alter their jury selection strategies in ways that limit the impact of the ban on overall jury composition. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: MRI: Acquisition of a Micro-Transfer Printer for Heterogeneous Integration of Electronic/Photonic Microsystems

Awardee: Rochester Institute of Tech

Amount: \$199,500.00

Abstract: micro-transfer printing ( $\mu$ tp) is a recently developed technique that enables the integration of various micro-device technologies that cannot be easily manufactured on a common substrate. for example, laser light sources could be integrated onto a silicon photonics chip rather than fiber coupled. this proposal requests funds for the acquisition of an x-celeprint (xdc)  $\mu$ tp system well suited for research and development, and prototype fabrication, with the capability of seamless technology transfer to pilot-line or high-volume production using larger xdc automated systems. the proposed instrument will support next-generation research activities in technology areas such as display devices, computing, energy conversion, quantum photonics, 2d materials, and biosensors. results from the supported research will provide significant contributions to the literature in relevant and emerging scientific fields. participants will include graduate and undergraduate student researchers in several disciplines of engineering and science, with a particular emphasis on **\*\*diversity\*\*** and inclusion. the proposed investigations will advance scientific knowledge and support activities that contribute to the betterment of society. these include preparing a diverse workforce for next-generation engineers and scientists, outreach activities with k-12 programs in the rochester, ny region to promote stem, and professional development opportunities for high school

teachers and industry partners. heterogeneous integration involves the combination of separately fabricated micro-devices (e.g., transistors, leds, sensors) or device components (e.g., interface layer, porous membrane) at the pre-package stage. the  $\mu$ tp system uses an elastomer stamp typically made of polydimethylsiloxane (pdms), which is deformable and surface-compliant, transparent, and adhesive; all characteristics needed to transfer devices with precise alignment. the devices must be singulated and released using an undercut etch of sacrificial material, yet still anchored to the source substrate with one or more tethers at the perimeter. sacrificial release layers are engineered such that tethers will be overcome by the pickup force, which allows device coupons to be removed from their native substrate. the stamp adhesion is pull-rate sensitive, or kinetically modulated, allowing it to remove anchored or tethered devices using a high pull-rate, and release the same device onto a destination substrate using a low pull-rate. the formation of local electrical/optical interconnects between mixed-technology devices in close proximity allows them to interact at an intimate level, realizing microsystems that are otherwise not possible. the investigators propose to utilize the  $\mu$ tp system for the heterogeneous integration of device components in several areas of research. these are listed (with specific applications) as follows: silicon cmos and thin-film electronics (backplane platforms, back-end devices); display devices (iii v and iii n micro-leds); photovoltaics and power conversion (iii v multi junction cells); integrated photonics (lasers, electro-optic materials, modulators); quantum integrated photonics (quantum emitters, single photon detectors, photonic cavities); mixed-dimensional hybrid nanosystems (iii-v devices on 2d monolayers); nanoporous biodevices (electrode transfer, sensor arrays). the  $\mu$ tp system will enable the realization of "monolithic-like" microsystems, with associated advantages in electronic/photonic system performance. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Responsible Engineering across Cultures: Investigating the Effects of Culture and Education on Ethical Reasoning and Dispositions of Engineering Students

Awardee: University of Pittsburgh

Amount: \$198,562.00

Abstract: responsible engineering across cultures: investigating the effects of culture and education on ethical reasoning and dispositions of engineering students      engineering is more cross-cultural and international than ever before, resulting in potential disagreements about (in)appropriate courses of action, which can impede engineering work. despite high rates of international enrollment and an increased focus on global dimensions of engineering in us programs, ethical issues arising from global engineering have been insufficiently addressed. to address these issues, this project will assess the impact of culture and education on ethics among engineering students in north america, europe, and asia. understanding if and how diverse cultural backgrounds and educational experiences affect professional decision-making and collaborations requires empirical investigation, to develop training that addresses the kinds of challenges engineering students, practitioners, programs, and organizations will increasingly encounter in the globalized world. this project will be beneficial for training the next generation of engineers who are competent in working professionally and ethically in the global context and are responsive to the value of **\*\*diversity\*\*** in quality and sustainable engineering work.      the goal of this project is to identify educational interventions with the greatest effects on ethical reasoning and dispositions of engineering students, whether these effects differ among cultural and national groups, and if/how to modify these interventions to respond effectively to cultural and national differences. to do so, researchers from colorado school of mines, university of pittsburgh, delft university of technology, and shanghai jiao tong university will implement mixed-method, quasi-experimental, longitudinal, and cross-sectional research to: (1) determine the effects of culture and foreign language on the ethical perspectives of first-year engineering students; (2) assess the relative effects of culture and education on these perspectives over four years; (3) use engineering ethics assessment tools across cultures and countries to



examine their cross-cultural validity. findings from this project will be essential to develop educational interventions that effectively respond to the globalized environments of contemporary engineering practice. they will also contribute to the development of more inclusive engineering education, by identifying perspectives potentially marginalized in the reigning paradigms. finally, this project has implications for the development of responsible research education at the graduate level: despite the fact graduate student bodies in stem fields have become increasingly international, limited work has focused on developing culturally responsive ethics curricula for graduate students from diverse backgrounds. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Responsible Engineering across Cultures: Investigating the Effects of Culture and Education on Ethical Reasoning and Dispositions of Engineering Students

Awardee: Rowan University

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Title: Collaborative Research: GP-UP: Developing STEM Identity by Engaging URM Undergraduate Students in Research on Air Pollution in Chicago Communities

Awardee: Colorado State University

Amount: \$195,935.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). the geoscience learning community will help students from historically excluded communities build their stem identity through authentic research experience, mentoring, and introduction to geosciences careers. students will learn about air pollution, gain experience with instrumentation, practice computer programing and data analysis, and communicate scientific results by participating in real research with prosocial impact. this project addresses three geopath's program goals: (1) increase the number and **\*\*diversity\*\*** of students in geosciences; 2) prepare students for geoscience careers; and 3) contribute to the evidence base for effective student engagement, learning, and retention in stem. the data collected through this project will be of sufficient quality to contribute to community discussions about how best to reduce air pollution and better protect public health, particularly within vulnerable communities. this project seeks to employ several established evidence-based strategies for the success of students from historically

excluded communities. a focus on student success in stem will include authentic collaborative undergraduate research experiences, sustained mentorship, and engagement in research with a direct link to community benefit. by combining authentic prosocial research and mentoring, the pis aim to build a sense of belonging, self-efficacy, and stem identity in two cohorts of students and help with their successful transitions to stem programs related to the earth sciences. this project specifically proposes to create geoscience learning community that engages undergraduate students from historically excluded communities in research to measure and attribute air pollution in two chicago neighborhoods that differ in socioeconomic status, demographics, and proximity to industrial facilities. the pis will recruit a cohort of undergraduate participants at loyola to join a research-intensive learning community each of year 1 and year 2 of the project. student participants will work closely with scientists and the community-based organizations to design and carry out research that addresses community concerns about air pollution. the project's aims are to 1) provide an applied, socially relevant research experience for student participants; 2) understand how particulate pollution in chicago varies over space and time; and 3) provide air quality data for community use. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Collaborative Research: GEOPATHS IN: DIG CAMP - Data in Geosciences: Collaboration and Mentoring Program?Teaming Latinx High School and College Students for Data Use in Geosciences

Awardee: University of California-Santa Cruz

Amount: \$194,760.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). atmospheric, climate, ocean, earth and environmental sciences (geosciences) are among the least diverse fields in science, technology, engineering and math (stem), with latinx scientists being significantly underrepresented. a lack of **\*\*diversity\*\*** in stem fields means decreased ability to identify and solve critical issues facing society such as climate change, which disproportionately affects the populations that are least represented in stem. data literacy is gaining increasing relevance and importance to scientists and the general public as we aim to make informed decisions to solve locally and globally relevant problems. dig camp (data in geosciences: collaboration and mentoring program?teaming latinx high school and college students for data use in geosciences) offers a camp-based model to support engagement with geosciences, as well as data literacy. during this project and through its sustainability plan, dig camp provides opportunities for latinx high school students to engage with authentic and locally relevant geosciences research and data; gain geosciences content knowledge; build their data literacy, critical thinking, problem solving, and collaboration skills; strengthen their identities to do science; and increase the likelihood that they will pursue academic or workplace careers in the geosciences. dig camp - data in geosciences: collaboration and mentoring program?teaming latinx high school and college students for data use in geosciences will broaden participation in the geosciences among communities of color by developing a research-based model for overcoming long standing barriers and biases within the field. the goals of this project are to: (1) design and implement a complementary suite of informal

learning experiences to actively recruit latinx high school students into the geosciences by increasing their engagement, capacity building, and opportunities for continuity in the discipline; (2) provide latinx undergraduate geosciences majors with meaningful outreach and mentoring opportunities that engage them with communities, and increase their retention in geosciences fields of study and careers; and, (3) support high school students and their undergraduate mentors to build science and data literacy skills and engage with locally relevant geosciences research data to increase their efficacy and success in college and the geosciences workforce. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: LEAPS-MPS: Predator Competition in Systems with Seasonal Birth

Awardee: Texas Tech University

Amount: \$192,908.00

Abstract: in many ecosystems, seasonal processes are experienced as sudden events, disrupting continuous processes. these disparate processes are closely linked, for example when resource consumption (a continuous behavior) determines reproductive capacity (a seasonal event).

describing the links between these processes is fundamental to long-term descriptions of seasonal ecosystems. this project bridges a gap between common mathematical methods which describe these processes separately, combining them into a hybrid framework. the framework permits long-term models of seasonal ecosystems. long-term models are necessary for ecological forecasts and seasonal behavior is especially relevant for incorporating sensitivities to annual climate. hybrid models are therefore broadly applicable to a range of ecological problems. this project focuses on hybrid descriptions of competition between predatory insects which consume pests in agricultural ecosystems, with attention to how changing temperatures affect pest control. the project also assesses hybrid model performance in arbitrary ecosystems, building broader capacity to address conservation and management problems. the project is hosted at a hispanic serving institution and supports undergraduate research in ecological modelling, which is an accessible entry point to mathematical research and fosters computational skills applicable to a multitude of technical careers. participation includes travel to a scientific conference for postgraduate planning and community building among groups underrepresented in mathematics, where the pi will also seek applicants for supported graduate student research. the project improves institutional capacity to support students from groups underrepresented in mathematics through the development of tailored resources for retention and job placement, which also amplifies existing initiatives broadening participation in mathematics.

describing the interface between long-term (discrete) and short-term (continuous) changes to an ecological population requires mathematical models which couple continuous differential equations and discrete difference equations. this coupling results in a hybrid model, which incorporates population processes over disparate timescales and describes seasonal ecosystems? long-term development. however, dynamics of such models are difficult to assess if the continuous equations incorporate complex behaviors, as is necessary for the target model of predator-prey interactions in a community of generalist predators. this project investigates the effects of competition and seasonal birth on long-term prey abundance and predator coexistence in hybrid models in three stages: (1) through the analysis of simple, two-predator models to build

intuition for the interplay between predator competition and seasonal birth; (2) by extending the hybrid model to investigate the effects of predator **diversity** and temperature variability on pest control in a real agricultural ecosystem; and (3) through the numerical simulation of many complex, theoretical ecosystems to compare persistence outcomes between hybrid and continuous models. preliminary theoretical analysis of fixed points and other stable outcomes yields a thorough understanding of how specific behaviors influence population trajectories, facilitating later work. parameterizing the hybrid competition model from prior abundance data and empirical observations provides insight into the effects of similar behaviors in real agricultural ecosystems. simulating hybrid models for a range of parameters and feeding interactions establishes the conditions under which species persistence is affected by seasonal behaviors. together, the three stages establish a foundational understanding of hybrid models in seasonal ecosystems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: ERI: Investigation of the Effect of Venous Valve Morphology on Fluid Flow Conditions and Disease

Awardee: Utah Valley University

Amount: \$192,521.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). this engineering research initiation (eri) award will support fundamental research that will build understanding of the impact of venous valve properties on the development of disease. therefore, this work will promote the progress of science and advance the national health, prosperity and welfare. the body pumps blood using a combination of venous valves and muscle contractions. together, the valves and muscles pump blood against gravity to get from locations such as the legs back to the heart. deep vein thrombosis occurs when blood cells build up in the veins near venous valves to form blood clots known as thrombi. thrombi prevent the valves from functioning properly, and can lead to pulmonary embolism, which is a leading cause of death in the united states and other industrialized countries. it is known that fluid flow conditions in the veins influence when and where a thrombus forms. however, the effect of various properties of venous valves on flow conditions and thrombus formation is mostly unknown. this work will use both computer simulations

and experimental testing to identify the most important venous valve properties. then, this work will determine how these properties affect flow conditions and lead to thrombus formation. this work will reveal how and where venous valves contribute to thrombosis. these results will ultimately improve assessments of thrombosis risk. additionally, this research will advance engineering education and **\*\*diversity\*\***. community outreach activities will include the use of venous valve models in local schools in underserved neighborhoods. this project will also provide opportunity for undergraduate students, including those from underrepresented groups, to learn the research process. fluid dynamic factors such as shear stress, fluid stasis, and fluid residence time are thought to generally be critical to thrombus formation. in this supported work, a combined approach consisting of both fluid-solid interaction modeling and simulation, and experimental model valve flow imaging and characterization will be employed. these two approaches will complement and support each other in elucidating the effect of valve morphology on the aforementioned disease-conducive flow conditions. the work here will not only help give understanding of the effects and behavior of physiological valves, but will also lead to more effective design of prosthetic valves to avoid problems seen in certain physiological morphologies. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Integrating river hydrology across scales: advancing understanding of the global river-atmosphere interface

Awardee: Texas A&M University

Amount: \$191,952.00

Abstract: rivers are natural hotspots for greenhouse gas emissions and are included in global carbon budget evaluations. however, the amount of greenhouse gas emitted by rivers is highly uncertain largely due to a fundamental gap in the current understanding of hydraulic scaling between small

streams and large rivers. this project will develop a predictive understanding of how geomorphic and hydrologic processes combine to drive river-atmosphere interface dynamics across spatial and temporal scales. it will test underlying assumptions involved in estimating the global surface area of earth's rivers and streams and it will be used to more accurately estimate the global rates of greenhouse gas emissions from inland waters. the integrated research and teaching program will promote hydrologic and environmental literacy and awareness through public outreach and education, and it will help recruit and retain underrepresented minority students with the goal of increasing participation and **diversity** in stem. this research will quantify the full size-distribution of river surface area within a continental-scale river basin by combining satellite, airborne, and fieldwork observations. using these observations, this work will assess the interactions between river surfaces and streamflow at different time and spatial scales and develop a novel open-source model for predicting the river-atmosphere interface dynamics based on hydrologic drivers. the knowledge generated from this project will help fill in the conceptual gaps in our understanding of the river-atmosphere interface and develop the next generation of global river surface area products used in carbon budgets. this research will also untangle the hydrologic and geomorphic drivers of changing river morphology, advancing our understanding of how humans are impacting river systems and aquatic ecosystems. this award is co-funded by the hydrologic sciences and geomorphology & land-use dynamics programs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Indiana University

Amount: \$190,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a

highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: ERI: A Novel Solution to Enable High-Voltage DC-Links in Electric Vehicles

Awardee: SUNY College at Oswego

Amount: \$187,599.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). the history of electric vehicles can be traced back to the 19th century. after the initial rise, electric vehicles declined with the mass production of cheaper gasoline cars. until the last century, electric vehicles came back into sight due to fossil fuel shortage and environmental concerns. besides reducing fossil fuel consumption and environmental benefits, electric vehicles offer numerous other benefits such as increasing fuel **\*\*diversity\*\***, providing opportunities to integrate more renewable energy into the grid, and offering individual benefits including better driving experience and less expensive and frequent maintenance, etc. today, the wider adoption of electric vehicles will rely on future technological advances to further reduce the cost and charging time of electric vehicles and increase efficiency, power density, and performance at the same time. one of such technologies is to use high-voltage dc links in electric vehicles. it has been reported that using higher dc voltage in electric vehicles gives higher power density, less weight, smaller components, less loss and heat, and faster charging, etc. thus, using a high dc link voltage has become a new design trend in the electric vehicle industry. the proposed project will focus on the power conversion solutions in electric vehicles to address the challenges encountered in this transition from low-voltage dc links to high-voltage dc links. it will advance the power conversion technology for electric vehicles and other similar power conversion systems, which eventually will improve the united state's competitiveness in the global electric vehicle market, reduce fossil fuel consumption and co2 emissions by promoting the adoption of electric vehicles, and increase energy **\*\*diversity\*\*** and foster national security and energy independence. the education components in the project will enhance engineering education and produce a highly skilled and qualified engineering workforce, attract more students in stem learning as the future workforce in the high-need areas, and help improve the competencies of future stem teachers. the project will also broaden the

participation of underrepresented groups, particularly, first-generation college students and children in poverty. the goal of the project is to develop a cost-effective, highly efficient, and easy-retrofit inverter technique to facilitate the faster development and adoption of high-voltage dc links in electric vehicles. more specifically, the goal will be achieved by 1) developing less costly traction inverter solutions for electric vehicles with a high-voltage dc link by using four-switch three-phase inverter topology, 2) investigating and optimizing the control and efficiency of the inverters using simulations, 3) developing prototypes of the proposed inverters and demonstrating their performance as a comparison to traditional solutions to validate the proposed method, and 4) exploring the applications of silicon carbide devices in the proposed inverters for further efficiency improvement and conducting comparative studies in these methods. the project will advance the knowledge of the proposed inverters and providing mathematical insights on their analysis and control. it will also provide a novel, original, and potentially transformative solution to enable high voltage dc-links in electric vehicles, which can facilitate the faster development of high-voltage dc-link designs. the technology that will be developed in the project can also benefit many other systems such as solar and wind generation, energy storage, utilities, and industrial drive, etc. by providing a low-cost alternative. besides, it provides the possibility to overcome the cost barrier of wide-bandgap devices and promote their applications for better efficiency and more energy savings.

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: ERI: Towards Data-Capable Engineers with a Variability-Capable Mindset

Awardee: Franklin W. Olin College of Engineering

Amount: \$186,861.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2) engineers are responsible for delivering safe, efficient solutions. for instance,

automobile manufacturers need to design cars that are light enough to be gas-efficient, but still sturdy enough to protect the passenger. a complication in this design process is variability: no engineer can predict with 100% confidence what a driver will do with their car or what conditions it will encounter. traditionally, engineers handle variability by "overdesign"---making things heavier than they need to be. however, scientists from other disciplines (such as statisticians) have more efficient ways to handle variability. a better understanding of variability---and how engineers themselves react to it---will lead to safer, more efficient engineering designs. achieving these efficiency gains is critical for american economic competitiveness and for addressing anthropogenic climate change. funded by the nsf's research in the formation of engineers initiative, this project will study how real engineers react to variability and will train them to handle it more efficiently.

variability is a key challenge in data analysis: in order to realize the nsf's big idea of harnessing the data revolution, engineers will need to have a variability-capable mindset. however, present engineering education results in professionals who struggle to recognize and manage variability in engineering applications. this lack of engineering workforce capability leads to inefficient designs, and in some cases, dangerously unreliable systems. the aim of this research is to study and improve the formation of engineers' variability-capability. the challenges of variability are well-documented: people generally have difficulty reasoning about variability in climate science, election forecasting, and matters of human judgment. this lack of variability-capability leads to climate inaction, political disengagement, and an unacceptably capricious application of justice. focused on engineering, the primary investigator's previous work identified decades-standing safety issues in aircraft design, stemming from a misidentification of a source of deviation (design-relevant variability) as noise (induced measurement variability). this project will be a mixed-methods study of practicing engineers: to investigate their ability to identify and treat different sources of variability, to develop a quantitative instrument to characterize present engineering workforce capabilities, and to design and deploy teaching interventions to improve engineers' variability-capability. data collection will be paired with professional development workshops, which will synergistically create broader impacts

via direct training. the project will advance our collective understanding and treatment of statistical variation, grounded in engineering practice. the mixed-methods study will fill gaps in the literature on how practicing engineers reason about variability. working closely with engineers in professional development workshops will surface a library of real-world examples of noise and deviation, strengthening the novel theoretical framework with a **diversity** of practical examples. sampling practitioners from across disciplines will also provide novel understanding of the differences across engineering fields, comparing current statistical practices in engineering and attributing them to differences in training and paradigm. the proposed work will develop and deploy teaching interventions to train data- and variability-capable engineers through professional development workshops. thus broader impact will be realized both directly (through the professional development workshops) and indirectly (through dissemination of the teaching interventions to other institutions).

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Integrative ecological perspectives on extinction processes - a multi-proxy case study of Hispaniolan subfossil and extant rodents

Awardee: University of Cincinnati Main Campus

Amount: \$185,556.00

Abstract: this project brings together researchers and educators specializing in genetics, anatomy, and ecology to explore the factors that led to the recent extinction of endemic rodents on hispaniola. hispaniolan rodents provide an exceptional case study for examining the triggers and timeline of island extinction events. bio**diversity** loss is a global concern, and over 70% of mammalian extinctions in the last 500 years have occurred on islands. the caribbean has suffered the greatest species loss of any region in the world. fossil data generated from this project have the potential to contribute to conservation policy by clarifying which factors most contributed to extinction events,

and will be helpful for understanding the disappearance of species on other islands. this project will contribute to education by providing mentorship to young scientists at multiple levels, including caribbean and caribbean-american undergraduates and by developing teaching modules for k-12 students. finally, a database of extinct hispaniolan mammals will provide better public access to scientific information both in haiti and the usa. this project will use morphometrics, stable isotope ecology, and ancient dna to (1) identify the ecological relationships among hispaniola's extinct endemic rodents, (2) determine the timing of species loss, (3) resolve phylogenetic relationships among extinct taxa, and (4) clarify extinction triggers. the research team will rely on previously collected fossil material from three paleontologically-rich caves on the tiburon peninsula in southwestern haiti. the data generated will allow a more nuanced understanding of the roles that human behavior, climate, and individual species characteristics (e.g., body size, habitat, genetic **diversity**) have played in extinctions on hispaniola. the data generated can be leveraged by conservation biologists to inform conservation policy aimed at preserving the remaining biological **diversity** on hispaniola and in island systems more generally. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SBP: CAREER: Race, Gender, and the Science of Science

Awardee: University of Notre Dame

Amount: \$184,412.00

Abstract: the "science of science" has recently exploded in popularity as researchers turn scientific methods of investigation around to investigate the practice of science itself. while some attention has been paid to issues of marginalization and representation, these concerns have generally not been brought to bear on other questions within the science of science regarding how to enhance scientific progress. the research component of this project fills the resulting gaps in our

understanding. the project demonstrates when attempts to improve science not only further entrench (or even amplify) current injustices, but backfire, ultimately impeding scientific progress. moreover, it examines how ideas spread throughout diverse communities, both providing insight into how current inequities hinder scientific progress and illuminating questions surrounding belief spread and polarization. finally, it uncovers hidden, unsuspected roadblocks for marginalized groups and suggests potential remedies, promoting **\*\*diversity\*\*** in scientific fields. this research component is intertwined with teaching and outreach components, with initiatives including the development of courses discussing diverse methods used to investigate scientific practice (e.g., from philosophy, history, sociology, science of science), a national workshop for members of underrepresented/marginalized groups intending to pursue research in the science of science, and innovative k-12 stem programming which demonstrates the importance of **\*\*diversity\*\*** in action.

this project employs tools from evolutionary game theory and network science to provide a picture of how aspects of social identity, e.g. race and gender, matter both to scientific progress and to how researchers scientifically investigate the institution of science. these tools, which capture the dynamics of scientists' interactions and the structure of scientific communities, enable the project to integrate insights from feminist philosophy of science with insights from science of science, to the benefit of both fields. many theories in the science of science take for granted that there are the same credit incentives, chances of work being published and cited, etc. for all scientists, regardless of social identity. yet, as has long been recognized within feminist philosophy of science, these considerations matter: researchers are excluded or marginalized according to social identity, and scientific progress is hampered by the resulting lack of diverse ideas and perspectives. this project reveals how our understanding of how to achieve well-functioning science can change drastically once social identity is taken into account. meanwhile, the scientific tools used in this project have clear power to illuminate questions of interest to feminist philosophers of science, e.g. how communication networks within scientific communities influence knowledge generation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the

foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: GCR: Collaborative Research: Designing a Sustainable Agricultural Production System through Convergence Research Using a Multi-Scale Ecosystems Approach

Awardee: Indiana University of Pennsylvania Research Institute

Amount: \$181,090.00

Abstract: this project addresses the grand challenge of sustainability of food systems, a complex issue that requires deep integration of scientific and engineering disciplines as well as participation by all stakeholders. this project brings together conservation biologists, ecologists, agronomists, farmers, indigenous peoples, economists, social scientists, land managers, and engineers to co-design and implement a framework for testing approaches to sustainable agricultural production. the research team will use this to study the impact in a model system, coffee production, of integrating technological innovations, such as us-built, industrial renewable-energy dryers and clean wet mills that recycle coffee pulp and reduce water pollution, with environmentally-friendly economic development where farmers are compensated for preserving forest on their lands through carbon offset credits, and community-led training and outreach and microcredit programs intended to increase both the participation of women and production. such a system has the potential to conserve forest critical to reducing carbon emissions, support bio\*\*diversity\*\*, including migratory birds, and enhance the stability of economic and social conditions. the goal of the project is to develop a framework for convergence research targeting the development of sustainable food systems using the tools of socio-ecological systems, extended to a multiscale ecosystem framework. the research team will construct a multi-scale empirical socio-ecological model of the food production system, identifying the structural elements at all relevant scales, the inter- and intra-scale interactions among those elements, and ecosystem and social services at multiple scales. this model will allow quantification of sustainability metrics under different scenarios. it will

be used to identify tradeoffs, synergies and critical points among sustainability indicators and to perform scenario analyses of the impacts of critical exogenous drivers, including market fluctuations and climate change, on the elements of the system. this project is jointly funded by the growing convergence research program and the established program to stimulate competitive research (epscor). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: How many routes to the same phenotype? Genetic changes underlying parallel acquisition of mimetic color patterns across bumble bees

Awardee: University of Alabama Tuscaloosa

Amount: \$179,228.00

Abstract: hundreds of bumble bee species are important pollinators worldwide. they also have interesting behaviors and morphologies that tell us about evolution. color pattern **\*\*diversity\*\*** is the most notable of these traits. these species have hundreds of different patterns of yellow, orange, black, and white hairs across their bodies. this **\*\*diversity\*\*** is related to mimicry, whereby species converge upon the same pattern to avoid predation. however, that dominant color pattern differs by region. this repeated evolution of color patterns can be used to understand how genes are targeted during evolution. in the western united states, several bumble bee species undergo parallel changes across the landscape. this research will examine the genes that drive coloration shifts in each of these western species and provide a better understanding of how repeatable evolution is. broader impacts of the research include training undergraduate students to develop functional genetics tools. the researchers will also share their gained knowledge outside the scientific community through several events for the public and develop color pattern field guides for bumble bees. the study will compare genes across repeated color shifts to tell if the same genes are repeatedly targeted or if



there are many ways to get to the same phenotype. the proposed research uses a combination of genome-wide trait association analysis and cross-developmental transcriptome comparisons to determine gene networks for color variation across five sets of mimetic species in the western united states. this includes identifying genetic targets specific changes in final pigmentation genes. it will tell which regions within genes are most likely to be targeted. it will determine if there are major developmental genes that get used in new functions or if downstream genes are more often targeted. it will also tell us how genetic variants inherited and transferred within and across species influence total **\*\*diversity\*\***. this study will provide genome sequences for several north american bumble bees, clarifying species boundaries hidden by mimicry. it will also improve understanding of the role of developmental and pigmentation genes in animals. genomes will be sequenced for species across a clade of mimics to reveal how color-determining genes evolve. these objectives will provide a case study of how genetic variants and resulting changes in gene expression evolve across species under selection. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: Does responding to stressors prime greater resilience? Testing the

long-term effects of challenges on behavior, physiology, epigenetic state, and fitness.

Awardee: Franklin and Marshall College

Amount: \$178,935.00

Abstract: when faced with a major challenge ? severe weather, the attack of a predator, an injury ? organisms mount a coordinated physiological and behavioral stress response. this response can be vital for surviving and recovering from immediate threats. this project will test whether activating the stress response system has another overlooked benefit that operates over much longer time-scales: priming the system to respond better to future challenges. coordinated experiments will address fundamental questions about when and how environmental challenges prime greater resilience to future challenges, and examine whether those effects persist across generations. this study will also adapt and refine newly developed sensor technology that enables non-invasive monitoring of heart rate in free-living animals ? a tool that could yield considerable advances across fields. a more comprehensive understanding of the lingering impacts of challenges will also be valuable for other fields, including conservation and human health. additionally, the team will lead a career development program that combines a field research internship ? in which students participate in addressing the research objectives outlined in this proposal ? with a laboratory- and classroom-based skills development program for students from underrepresented groups who are interested in careers in stem fields. this opportunity is designed to foster interactions among students from a small liberal arts college and from a large research-intensive university. this project will test the hypothesis that transient challenges experienced in adulthood prime greater resilience or robustness to future challenges, defined as the ability to return to or maintain a stable state. research will use a long-term study population of tree swallows (*tachycineta bicolor*) in which large-scale behavioral and physiological data can be collected from free-living individuals. in the first year of study adult females will be exposed to either an ecologically relevant challenge or a simulated glucocorticoid stress response. in the following year(s) a **\*\*diversity\*\*** of phenotypic traits, and context-dependent performance and fitness, will be measured. this study design will enable

comparison of the direct effects of exposure to a challenge with the effects of exposure to a mediator of the response to that challenge. these experiments will also reveal whether the long-term effects of stressors on behavior, physiology, and fitness are mediated by glucocorticoids and by glucocorticoid-induced changes in dna methylation. this research will also test whether parental exposure history carries over to affect the phenotype and fitness of offspring produced in the year(s) after the challenge. by combining targeted experiments in a free-living population with integrative methods of behavioral, physiological, and epigenetic assessment this project will provide insights important for developing and revising conceptual models of stress and phenotypic plasticity. it will also broaden our understanding of the mechanisms of behavior, how organisms are shaped by their environments, and how sub-organismal responses contribute to organismal resilience and robustness. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Low-cost Manufacturing of Bioinspired Damage-Tolerant Ceramic Composites

Awardee: Arizona State University

Amount: \$177,675.00

Abstract: despite favorable properties of ceramic-metal composites, they have not been applied commercially to date, due in large part to processing cost and challenges. the conventional method for manufacturing lamellar ceramic-metal composites is melt-infiltration of the metal phase into the gaps of the ceramic scaffold. the smaller the gap, the more difficult the infiltration. because of the poor wetting between most metals and ceramics, the process requires high pressure and temperature to squeeze the molten metal into the gaps in the ceramic phase. this project aims at developing manufacturing strategies inspired by nature to enable low-cost fabrication of ceramic-metal composites. natural materials such as bone and the nacreous part of sea-shells have developed structural composites, using a set of rather ordinary constituents, which exhibit

extraordinary mechanical properties. for example, seashells convert a brittle ceramic material to a super-tough material (nacre) by incorporation of around 5% polymer, in a layered "brick-and-mortar" microstructure. the scientific community has been very successful in identifying the design principles of biological structural composites. however, manufacturing knowledge gaps persist. these include the challenge of infiltration of small gaps between ceramic bricks, the challenge of obtaining ductile (while strong) mortars; the challenge in design of proper (metal-ceramic) interfaces; and the high cost. low-cost processes for fabrication of metal&#8722;ceramic composites can substantially increase their applications in various industries including automotive, aerospace, oil and defense, in products such as high performance wear-resistance parts, cutting tools, lightweight structural composites, and aero-engine components. for these reasons, the project directly impacts american economic welfare and national security. the educational objective of the project is focused on increasing the **\*\*diversity\*\*** in nanotechnology-stem through "nanoexplorer" summer program for high school students, with particular emphasis on female students, including latinos. the goal of this research is to investigate the mechanisms underlying processing and manufacturing of ceramic composites for damage-tolerant structural applications. the project is focused on understanding infiltration of nanotwinned metals into nano-gaps (<100 nm) of a 3-dimensional porous ceramic scaffold by pulsed electrodeposition. a conservative estimate shows that the energy consumption in this process is more than 200-fold smaller than the conventional molten metal infiltration process. the liquid electrolyte in electrodeposition has much less viscosity compared to molten metals, and hence can effectively penetrate into the small gaps between the ceramic bricks. a class of metals that defeat the trade-off between strength and toughness are "nanotwinned" metals. nanotwinned metals have high density of coherent twin boundaries, which has been shown to enhance both strength and ductility. pulsed electrodeposition is one of the primary methods of synthesis of nanotwinned metals. to address the metal-ceramic interface challenge, electroless deposition of a thin metal layer on ceramic bricks is planned, which will result in uniform coating, as well as strong adhesion between ceramics and

metals. this research, if successful, will result in new fundamental knowledge in following subjects:

(i) growth mechanism and microstructure of nanotwinned metals directly synthesized by pulsed electrodeposition into a laminated ceramic scaffold; (ii) kinetics of pulsed electrodeposition process in nano-channels (<100 nm); and (iii) infiltration of a nano-porous ceramic scaffold by electrodeposition. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Digitization TCN: Extending Anthophila research through image and trait digitization (Big-Bee)

Awardee: Harvard University

Amount: \$177,103.00

Abstract: declining populations of bees impact plant-pollinator interactions in both natural and agricultural systems. while bees and other insects pollinate most wild plants, and are critical to sustain a large proportion of global food production, they are decreasing in both numbers and **\*\*diversity\*\***. our understanding of the factors driving these declines is limited because we lack sufficient data on the distribution of bee species, and on the behavioral and anatomical traits that may make them either vulnerable or resilient to human-induced environmental changes, such as habitat loss and climate change. fortunately, wild bees have been collected by researchers and deposited in natural history collections for over 100 years, retaining a wealth of associated attributes that can be extracted from specimen images. this project will digitally capture data and images from these historic specimens, develop tools to measure bee traits from these images, and generate a comprehensive bee trait and image dataset to measure changes through time. this will increase our understanding of specific traits that put bee species at risk of decline - a critical need for both sustaining our agricultural economy and the conservation of our natural resources. in addition, the

large image datasets created by this project can be used for new artificial intelligence identification tools that will help improve our future pollinator observation and monitoring efforts. the big-bee thematic collection network (big-bee tcn) will create over one million high-resolution 2d and 3d images of bee specimens, representing over 5,000 worldwide bee species, including all of the major pollinating species of the united states. the big-bee network includes 13 institutions and partnerships with us government agencies. novel mechanisms for sharing image datasets will be developed and datasets of bee traits will be available through an open data portal, the bee library, for research and education. the big-bee project will engage the general public in research through community science via crowdsourcing trait measurements and data transcription from images. in addition, training and professional development for natural history collection staff, researchers, and university students in data science will be provided through the creation and implementation of workshops focusing on bee traits and species identification. all data resulting from this award will be shared with and publicly available through the national digitized biocollections resource, [idigbio.org](http://idigbio.org). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: GRate ? Integrating data and modeling to quantify rates of Greenland Ice Sheet change, Holocene to future

Awardee: Dartmouth College

Amount: \$175,229.00

Abstract: the greenland ice sheet has experienced devastating melt in recent years. recent scientific reports highlight how vulnerable the greenland ice sheet is to arctic climate change and draw a dire picture of the impact of sea-level rise. in order to equip society with the best forecasts of sea level rise for planning, scientists need to improve the ability to simulate ? or model ? the response of ice sheets to climate change. for this project, scientists from different branches of ice-sheet research will

work together to improve ice sheet modelling. the researchers will leverage recent scientific advances to model the entire greenland ice sheet in order to investigate long-term ice-sheet sensitivity to changes taking places in the ocean and atmosphere. the research group is committed to creating an inclusive environment where all team members can learn and excel. the team contains **\*\*diversity\*\*** in ethnicity, gender and rank, and will train six early career scholars, recruiting specifically from groups underrepresented in the geosciences, which is among the least diverse stem fields in the u.s. results will be made publicly available and will facilitate a broad range of future research about the arctic system, including ice sheet modeling, model spin-up, paleoclimate reconstruction/synthesis and glacier history. to elevate the capacity of outreach and education programs developed during their first project, the team will build on their ?scientists are superheroes? outreach program and leverage other, existing outreach frameworks, including making connections with greenlandic communities and with high school student intern programs at their universities linked to the young women?s leadership school (bronx, ny) and the spring valley (ny) branch of the naacp, coordinated by our dedicated project educator and outreach specialist.

reducing uncertainties in ice-sheet model predictions is crucial in society?s handling of the sea level crisis. uncertainties related to ice-sheet instability arise from limited observations, inadequate model representation of ice-sheet processes, and limited understanding of the complex interactions between the atmosphere, ocean, and ice sheets. how atmospheric and oceanic forcing vary through time, and at what timescales each are capable of forcing rapid change, are critical for predicting future ice mass loss, but scientists have been observing ice sheet change for only a short period of time (decades). the pis propose to scrutinize greenland ice sheet change spanning from the beginning of the holocene (12,000 years ago) to 2100 ce, making it possible to evaluate the varying roles of atmospheric and ocean forcing on decadal-to-centennial timescales relevant for the future greenland ice sheet evolution. the pis will utilize their established multi-disciplinary collaboration to combine ice sheet modelling, climate forcing and reconstructions of past ice-sheet change. this will position the team to make predictions of future ice sheet change that are grounded in greenland ice



sheet behavior during past climate swings that occurred prior to our brief window of modern observation. the work will lead to lasting products to serve the community's collective effort to better understand ice sheet change: 1) a state-of-the-art ice-sheet model optimized for simulations over long timescales, 2) a holocene-through-modern set of atmospheric and ocean state estimates optimized for forcing an ice-sheet model, and 3) a database of past-ice sheet configurations and paleoclimate records formatted for model-data comparison. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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research about the arctic system, including ice sheet modeling, model spin-up, paleoclimate reconstruction/synthesis and glacier history. to elevate the capacity of outreach and education programs developed during their first project, the team will build on their "scientists are superheroes" outreach program and leverage other, existing outreach frameworks, including making connections with greenlandic communities and with high school student intern programs at their universities linked to the young women's leadership school (bronx, ny) and the spring valley (ny) branch of the naacp, coordinated by our dedicated project educator and outreach specialist.

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intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Digitization PEN: BatPEN! A Partnership to Facilitate Scientific Inquiry into the Vast Functional Trait Diversity of Phyllostomid Bats

Awardee: Texas Tech University

Amount: \$175,000.00

Abstract: through the process of diversification, more organisms exist today than at any other time during the history of life. however, this bio\*\*diversity\*\* is not evenly distributed through space, time, or across the tree of life. understanding phenotypic trait variability across taxa provides information that is valuable for answering some of the most fundamental questions in biology such as, what determines the relationship between form and function, how do different phenotypes facilitate coexistence across communities, or how has the evolution of phenotypic characteristics influenced the levels of bio\*\*diversity\*\* exhibited today? variation in phenotypic traits forms the bedrock of understanding in much of ecology, evolution, and systematics. in partnership with the overt tcn, the batpen! project will mobilize high-resolution phenotypic functional-trait data from the neotropical bat family phyllostomidae. the aim of batpen! is to increase the abundance of available functional trait data, create scientific infrastructure, and facilitate scientific inquiry into the most diverse family-level clade of mammals. moreover, the project will fuel novel stem training opportunities and enable major research avenues in ecology and evolutionary biology. batpen! will generate about 1000 high-resolution computerized tomography (ct) scans of entire museum specimens to fill in representation of the 214 phyllostomid species with the aim to substantially compliment the one species per genus taxonomic coverage of overt. this will also add additional novel coverage to overt in two ways, first by including deeper intraspecific coverage of 5 taxa that phylogenetically span the higher-level monophyletic subclades of phyllostomidae based on 10 individuals from each of 10 different sites distributed across the neotropics, and second, by scanning ontogenetic series from

three species exhibiting three different degrees of sexual dimorphism. immediate educational and research impacts will occur by adherence to core data management protocols of the overt-tcn, including hosting open phenotypic data on morphosource (morphosource.org) and seamlessly linking these data back to original specimens and other specimen-derived resources via idigbio (idigbio.org). batpen! will facilitate museum-based scientific infrastructure through not just making digitized data streams available but by training the next generation of museum scientists. batpen! will be based at a hispanic serving institution and will ensure direct involvement of under-represented groups in stem. the project will draw undergraduates from texas tech's ethnically diverse population to assist with research related to batpen! through the center for the integration of stem education and research (ciser). in cooperation with the museum science and heritage graduate program at texas tech, museum science students will be trained in curational/collections activities to contribute to the next generation of collection-based researchers and educators. in addition, a formal course will be offered entitled "vertebrate curational techniques," which will provide a hands-on approach to curation and collection activity. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Digitization PEN: Small and Hungry: Enhancing LepNet TCN with microlepidoptera and 50 years of host plant data from the Essig Museum

Awardee: University of California-Berkeley

Amount: \$174,976.00

Abstract: lepidoptera (butterflies and moths) is the most diverse order of insect herbivores. rich in ecological data they are often models for co-evolution, population dynamics, and environmental change. because of their dependence on particular plant species and climate zones, many species are used as environmental indicators of habitat quality and climatic shifts. however, digitization of

insect collections, particularly lepidoptera, lag far behind most other groups due to the large size of collections, the small and delicate nature of specimens, and the tiny, difficult to read specimen labels. the lepidoptera of north america network (lepnet) tcn is addressing this paucity of data by digitizing occurrence records of butterflies and moths from over 28 institutions across the united states, along with high resolution images of over 95,000 species. the essig museum is contributing to this effort by adding over 100 years of specimen records and ecological data from western north america. all data and images are freely and immediately available online through aggregators, including idigbio, gbif, scan, and the essig museum database, to researchers, educators, land managers, conservation planners, and the public. the essig museum is a leading collection of lepidoptera in the western us with extensive taxonomic breadth and occurrence density, particularly for microlepidoptera in northern california and mexico. past and ongoing projects of the essig museum focus on specialized habitats such dunes, coastal scrub, and offshore islands, as well as recovery from wildfires and long-term sampling of regional preserves. moreover, a long tradition of rearing specimens from host plants, including fruit and stem borers, gall-formers, and leaf-miners, has resulted in many decades of detailed records of interaction data including host plants and parasitoids. this project will disseminate georeferenced digital data for 125,000 butterfly and moth specimens, along with high resolution images of 2000 species, including 608 holotypes. these data will fill many gaps for western north america to improve niche modelling efforts and investigate population dynamics for the past 100 years. high resolution images are used to train automated identification services to address bottlenecks in ecological and conservation research and rapid identification of pests. much of the digitization work will be carried out by undergraduate students who will also receive training in bio\*\*diversity\*\* informatics and insect biology. data and analyses derived from this effort will be used in online and public exhibits related to insect evolution, global change biology, and natural history of western north america. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CRII: CNS: Bringing Predictable Real-time Computing to Connected Autonomous Driving Systems

Awardee: Wayne State University

Amount: \$174,944.00

Abstract: connected vehicle technology is a promising solution to provide reliable autonomous driving that will change the traditional transportation system by building stable, interactive wireless communications between vehicles, the smart infrastructures (e.g., the roadside unit), and personal communications devices. however, achieving reliable and safe connected autonomous driving (cad) is still very challenging. on one hand, the safety of the cad system hinges critically on its timing correctness, as crucial driving decisions fully depend on the output of the real-time perception system. on the other hand, requesting information from other devices mayl create additional delays for the on-vehicle real-time perception tasks, and thus the timing correctness of the cad system can be easily violated by unpredictable communications. this project seeks to bring predictable real-time computing to cad systems, and the goal of the proposed research is to enable the connected autonomous vehicle and exterior devices to perform real-time perception tasks as a whole by (i) establishing a practical real-time task model to integrate exterior devices into the on-vehicle perception system, which can be implemented on the gpu-enabled computing platforms; (ii) proposing real-time task scheduling algorithms and associated timing validation analysis to guarantee that all the real-time perception tasks can complete at the right time; (iii) developing a prototype cad system on the autonomous vehicle testbed, hydraone, and the roadside unit, equinox, to evaluate the real-time performance of the proposed solutions. building a cad system will constitute a major technological breakthrough towards realizing fully autonomous vehicles. in particular, this project emphasizes both scheduling algorithm design and system implementation. the establishment of a real-time suspending-gang task model will enable the first-of-its-kind

formalization for depicting the executing flow of real-time workloads executed between the autonomous vehicle and the exterior devices. the real-time task scheduler oversees the entire system and ensures its timing correctness. the creation of new real-time resource allocation methods together with the associated analysis for validating timing constraints will drive the scheduling theory towards real applications in future cyber-physical systems. the proposed research aims to realize the cad system on the physical platforms (hydraone/equinox), with indoor and outdoor studies beyond simulation. especially, hydraone/equinox are ready-to-use platforms that will allow experts/researchers to easily examine their research designs regarding autonomous driving. educational efforts will be devoted to (i) develop the hydraone educational toolkit for undergraduate education and research, (ii) curriculum design for hands-on learning in the bs/ms program, (iii) summer camp development for k-12 students and teachers, (iv) broadening participation in computing and engineering to enhance **\*\*diversity\*\***. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: CRII: CNS: Auction Mechanism Design for Energy-Efficient High Performance Computing

Awardee: University of South Carolina at Columbia

Amount: \$174,770.00

Abstract: high performance computing (hpc) systems (such as supercomputers) are generally large infrastructures containing thousands of server nodes that can perform computations in a fast and efficient manner. hpc systems can consume an enormous amount of power during their operation. for example, current top-ranked supercomputers can consume tens of megawatts of power during peak operation. as a direct consequence of power consumption increase, energy cost has become a major component of the overall cost of the operation of an hpc system. to achieve energy sustainability in hpc, this project plans to develop novel models to reduce energy cost and contribute to the power system stability. there are three primary objectives of this project: (1) develop machine learning models to predict the power and performance of parallel applications; (2) develop an auction mechanism model to reduce hpc system's energy cost via collective energy reduction of hpc users, while incorporating the renewable energy generation into the model; and (3) experiment and validate the proposed auction mechanism model via simulation. overall, the project is expected to reduce the energy cost of large-scale systems, as well as to achieve power grid energy conservation and stability. this project will contribute towards advancement of the state-of-the-art in energy-efficiency of hpc, as well as to balance the energy-performance trade-offs in hpc. in doing so, this project will increase hpc system's participation in sustainable computing. the proposed research will enable hpc systems to closely interact with the power grid system, and enable feedback-based energy reduction based on electricity price variation and renewable energy generation. this project will increase research participation of both graduate and undergraduate

students. additionally, the project will train and educate students in the area of parallel and high performance computing, and energy-efficient computing. furthermore, through various outreach activities and research involvement, the project plans to promote **\*\*diversity\*\*** in computing by involving underrepresented groups. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CRII: CNS: A Hybrid Software Defined Networking-Information Centric Networking Framework for the Reuse of Computation at the Network Edge

Awardee: University of Nebraska at Omaha

Amount: \$174,736.00

Abstract: the adoption of next-generation applications, such as augmented reality and internet-of-things (iot), is expected to grow rapidly in the years to come. the number of iot devices is expected to reach 75 billion by 2025, while the scale of potential use-cases (e.g., smart cities with hundreds of thousands or millions of residents) is also expected to grow. in such use-cases, users may request the processing of data with temporal, spatial, or semantic similarity by servers physically close to them. the repeated processing of considerably similar data may result in the same processing outputs and thus the execution of duplicate (redundant) computation. this project advances our understanding of the notion of ?computation reuse?, where the processing outputs are reused/shared among processing requests for similar data, having the potential to: (i) reduce the time for the processing of similar data and thus the overall latency perceived by next-generation applications; and (ii) eliminate the execution of redundant computation, so that the available computing resources are effectively utilized. our project will result in a novel network framework, so that requests for the processing of similar data are identified and forwarded to the same servers, facilitating the reuse of computation in realistic infrastructure deployments. the research outcomes of

this project will be incorporated into university course curriculum, while this project will also offer opportunities that broaden participation and **\*\*diversity\*\*** in stem. this project aims to advance the state-of-the art in edge computing architectures in order to facilitate the reuse of computation through a novel, hybrid network framework based on information-centric networking (icn)/named-data networking (ndn) and software-defined networking (sdn). the proposed framework capitalizes on the best of both icn/ndn and sdn to realize a service-centric, computation reuse-aware, and "softwarized" architecture through: (i) the semantically meaningful icn/ndn naming and stateful forwarding plane for the seamless and adaptive task forwarding towards edge servers that can reuse similar previously executed tasks; and (ii) the separation of forwarding and control planes and the programmable (logically) centralized sdn intelligence for the orchestration of the computation reuse semantics. this project will tackle fundamental challenges in the design and development of network systems for the realization of computation reuse in realistic edge computing environments, where multiple edge servers may be available for redundancy, fault tolerance, and load balancing purposes, facilitating the pervasive edge computing deployment. this project is jointly funded by networking technology and systems(nets)program and the established program to stimulate competitive research (epscor). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Digitization PEN: Adding a world-class flea collection to the Terrestrial Parasite Tracker network

Awardee: Carnegie Institute

Amount: \$174,570.00

Abstract: parasitic insects have a global impact on human health, livestock production, and wildlife conservation. building robust datasets of parasites? host preferences, seasonal activity, and geographic range can help scientists and public health professionals understand and predict patterns of disease transmission; however, much of the data needed for these assessments is accessible only through museum collections. the primary goal of this project is to extract this data from a world-class collection of fleas and associated parasites at the carnegie museum of natural history (cmnh). as part of the terrestrial parasite tracker thematic collections network (tpt tcn), high-quality specimen images and host/locality data will be captured, digitized, and shared via public data portals. this will allow entomologists, epidemiologists, and other researchers to make essential connections between disease vectors and their host species. in turn, understanding these connections will support future assessments of economic and health risks from insect-vectored disease. the robert traub flea collection at cmnh is one of the largest and most meticulously curated collections of mammal parasites in the world, with 74,897 specimens mounted under glass on 60,596 glass slides with 4,615 associated genitalic dissections. this project will use automated slide scanning technology developed for pathology laboratory use to capture whole-slide and specimen images efficiently. these images will then be linked with digitized host and locality data

from both slide labels and traub's fieldwork logs. this project will more than quintuple the siphonaptera specimen records for the terrestrial parasite tracker tcn and complete its representation of flea families. this will represent a valuable dataset and image resource not just for tpt tcn and epidemiology research, but for systematic research on siphonaptera in general. disseminating this data through the online data portals, including idigbio.org, symbiota collection of arthropods network (scan), and the global bio\*\*diversity\*\* information facility (gbif). broad digital access will enable researchers and diagnosticians worldwide to access an enormous database of host-parasite relationships as well as to compare their specimens to high-quality specimen images with reliable species-level identifications. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: ER-PF: Using Distributed Acoustic Sensing for Tremor Detection and Site Characterization in Cascadia to Evaluate Earthquake Hazard

Awardee: Mendoza, Manuel Matthew

Amount: \$174,000.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). dr. manuel mendoza has been granted an ear postdoctoral fellowship to carry out research and education plans at university of colorado boulder and colorado school of mines. dr. mendoza plans to develop a new technique for earthquake monitoring called distributed acoustic sensing (das). das uses dark (unlit/unused) existing telecommunication fiber optic cables and turns them into an instrument that acts as a network capable of detecting tiny or distant seismic (earthquake) events. in the pacific northwest of the us where two tectonic plates converge, the conditions are right for large earthquakes which could result in other hazards such as tsunamis. therefore, large-scale and continuous seismic monitoring is needed to evaluate the impending risks.

in this project, dr. mendoza will work alongside professors anne sheehan and dr. ge jin to test and demonstrate das performance capabilities by carrying out a das experiment in northwestern washington. specifically, the work will investigate seismic events known as "tremor" and determine how local geologic conditions vary along the fiber cable. dr. mendoza's work will advance understanding of earthquakes, how the ground shakes in response to them, and consequent seismic hazards. the proposed study will provide opportunities for das to be applied at larger scales alongside existing seismic networks to perform multi and interdisciplinary research and monitoring of earth processes. the project will also allow dr. mendoza to teach and mentor students from underrepresented groups, including as a mentor on the \*\*diversity\*\*, inclusion, and access committee at the colorado school of mines and as a summer internship mentor at university of colorado boulder. other activities associated with this project include designing and leading a local das experiment for a geophysics course and supervising the professional and educational development of an undergraduate student who will conduct original research with the das data. at both campuses, the pi will engage in outreach activities aimed at increasing public scientific literacy and broadening participation in the s.t.e.m fields.

distributed acoustic sensing (das) using fiber-optics to measure deformation (strain) caused by seismic perturbations in the earth has, in recent years, proved to be a highly applicable and promising tool in seismology. this is owed to its ability to be configured as a seismic array with an aperture on the order of tens of kilometers, meter-level sensor (i.e. channel) spacing, and performance comparable to that of conventional broadband seismometers. this implies that das arrays can blanket a large area while not suffering from spatial aliasing when sampling the seismic wavefield ? unlike traditional networks ? and provide new information in high fidelity that often goes missed. a single das experiment can therefore be used to simultaneously investigate a variety of earth processes occurring across different spatial and temporal scales. here, the investigators will conduct the first known das experiment in cascadia using fiber from an existing telecommunication cable, to monitor tremor and characterize site conditions for the purpose of evaluating seismic hazard. specifically, the pi will

pursue three primary scientific goals: (1) use das to detect and locate tremor in cascadia; (2) characterize its spatiotemporal behavior and infer its contribution to stressing the up-dip locked portion of the plate interface; and (3) determine meter-level variation in site conditions along the das array. these goals will be addressed by employing seismic array-based techniques such as beamforming and beam back-projection to capture tremor, as well as ambient noise interferometry techniques to estimate shear wave velocities of the top 30 meters (vs30). the results obtained from this study will be compared to other observations performed using different instruments and methods, to demonstrate the efficacy of das in improving earthquake and ground shaking models in cascadia and assess its implications for future experiments in a variety of tectonic settings. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAR-PF: Evolution of landscapes buried by Quaternary sediments

Awardee: Kwang, Jeffrey S

Amount: \$174,000.00

Abstract: dr. jeffrey kwang has been awarded an nsf ear postdoctoral fellowship to carry out research under the mentorship of dr. andrew wickert at the university of minnesota (umn) and dr. isaac larsen at the university of massachusetts-amherst (umass). this project aims to understand how landscapes buried by recent sediments evolve over time. rivers and their networks drive change in landscape evolution; they reorganize in response to changing climate, tectonics, and rock type, drastically restructuring the earth's surface. field observations have shown that a rock's susceptibility to erosion exerts control in determining how rivers erode into landscapes, an assumption based in the idea that landscapes are made of a single material. because natural rivers cut through multiple materials, it is important to study landscapes with contrasting erodibilities. this project focuses on regions that were previously glaciated where ancient river networks are buried



under tens to hundreds of meters of sediments deposited by glaciers. after burial, a new river network is established on the surface that may have a geometry that is quite different from the ancient river network. as rivers erode into the glacial sediments, they re-expose the old landscape, triggering a competition between the ancient and new river networks. using numerical models and field techniques, the pi will (1) determine important metrics that control the outcome of these competing networks and (2) predict timescales required for glacial sediments to be fully removed. because contrasts in erodibility are common in other landforms, this research will provide important insight into how the structure of the rock below our feet determines rivers formation and landscape evolution in a broad spectrum of geologic settings. the pi also aims to promote earth science education and **\*\*diversity\*\*** by designing interactive numerical models/games about river evolution. at umn and umass, dr. kwang will collaborate with local girls inc. organizations to develop summer workshops for eureka!, a program that aims to close the gender-gap in stem. in addition, the pi will co-mentor an undergraduate research student with dr. phillip larson at the minnesota state university.

landscapes dissected by dendritic networks are ubiquitous across the continental surfaces of earth. understanding how these geopatterns emerge and reorganize reveals how geomorphic processes create landforms. drainage networks seldom change in landscapes that are in dynamic equilibrium, but drainage networks are actively forming and reorganizing in landscapes in disequilibrium. regions in the american midwest that were previously glaciated are classic examples of disequilibrium landscapes. before pleistocene glaciation, these regions generally contained sedimentary rock dissected by dendritic river networks. after glaciation, the sedimentary rock was buried by quaternary sediments, i.e. till, and essentially, the landscape was reset. such landscapes are ideal locations to study drainage networks because (1) new drainage networks are actively forming on the till-covered surfaces, and (2) old drainage networks from the buried topography are being exhumed. in this region, the pi will use numerical landscape evolution models to test how drainage network reorganization is affected by (1) rock erodibility contrasts between the glacial till and buried sedimentary rock and (2) the orientation of the surface drainage network with respect to

the buried drainage network. the results will also detail a new mechanism for the formation of barbed tributaries, offering a new geologic interpretation for these river network features. using field work and remote sensing, the pi will also calibrate a numerical model to predict timescales that are required for the full evacuation of glacial till from these landscapes. more broadly, the pi anticipates that this research will benefit our understanding of other geologic settings with contrasts in substrate erodibility. field studies have found that variability in erodibility has a first-order control on landscape evolution and morphology, and moreover, it has been determined that substrates with contrasting erodibilities are the norm in terrestrial landforms, not the exception. therefore, this research can provide a transformative insight into how lithologic variation and stratigraphy affect surface processes, drive drainage reorganization, and create geopatterns. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAR-PF: Investigating the effects of bedrock dip angle on knickpoint morphology and evolution via flume experimentation and numerical modeling

Awardee: Chilton, Kristin

Amount: \$174,000.00

Abstract: dr. kristin chilton has been awarded an nsf ear postdoctoral fellowship to investigate how the orientation of rock fractures (cracks) in river beds influences the ease with which that rock is eroded (worn away) by flowing over waterfalls (also called knickpoints). knickpoints are often zones of concentrated erosion within rivers and this project will involve creatively designed experiments that examine the role of cracks in controlling river erosion into rock. the results of this study will allow scientists to better predict how earth's surface will change over time, interpret climatic and geologic histories from the landscapes we see today, and improve engineering designs for the safety and longevity of important infrastructure. the work will be carried out at virginia tech and west

virginia university in collaboration with mentors, dr. kyle strom and dr. charles shobe, respectively. dr. chilton's project will also provide opportunities for undergraduate involvement in academic research, support **diversity** in stem fields through summer outreach programs, and introduce a broader audience to earth science topics via educational videos and blog posts focused on river erosion processes. the primary goal of this project is to test how the orientation of discontinuities (which can be fractures, joints, or bedding planes) influences hydraulic plucking of bedrock blocks within knickpoints, and therefore knickpoint morphology and evolution. this will be accomplished via a series of flume experiments, which will use stacked porcelain tiles to simulate layered sedimentary bedrock at various dip orientations, coupled with continuous monitoring of knickpoint morphology, retreat rate, and plucking events. the results of the flume experiments will then be integrated into numerical landscape evolution models to expand implications to broader spatial and temporal scales. this investigation will fill a critical gap in our understanding of the fundamental controls on bedrock channel morphology and fluvial incision processes, improve robustness of landscape evolution models by incorporating specific bedrock characteristics, and help ensure appropriate interpretation of knickpoints as indicators of climatic and uplift history by characterizing a potential control on knickpoint form and celerity. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: EAR-PF: Morphological and ecological disparity of Spiriferida (Brachiopoda) at local, regional, and global scales

Awardee: Sclafani, Judith A

Amount: \$174,000.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). dr. judith sclafani has been awarded an nsf ear postdoctoral fellowship to conduct research, professional development, and outreach activities at the university of california davis under the mentorship of dr. sandra carlson. evaluating changing ecosystems during intervals of climate perturbation in earth's history can offer important clues to how ecosystems might respond to anthropogenic climate change. this project will focus on the recovery of shallow marine seafloor communities after the second largest mass extinction (~440 million years ago) and investigate whether the evolution of certain biological traits correlates with increased abundance and survivorship with ecological communities. results of this work will be incorporated into high school earth science lessons developed in partnership with the bilingual teacher education program at uc davis. shallow marine ecosystems are important for maintaining ocean bio\*\*diversity\*\* and supporting the economic and cultural services derived from nearshore environments. this means that it is important to both better understand the complex ecological dynamics at play and disseminate information to increase the \*\*diversity\*\* of scientists addressing these problems. the specific goal of this study is to focus on the order spiriferida, which was dominant in the middle-late paleozoic, to: 1) determine whether morphospace occupation is correlated with environmental affinity from global occurrences, and 2) quantify abundance along an environmental gradient from regional stratigraphy. this study will generate substantial new specimen and field-based data about spiriferida from both continental/global and local/regional scales to examine if data, analyses, and results obtained at smaller scales can be meaningfully extrapolated to trends at larger spatial scales. combining data from multiple spatial and taxonomic scales is necessary to address ecological hierarchical scaling in the fossil record and understand the fidelity between global phanerozoic

trends and local specimen and field-based data. studies of the relationship between local sections and global hypotheses are needed to understand the macroecological and macroevolutionary processes responsible for ocean ecosystem structure, stability, and collapse. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: EAR-PF: Mammals as sentinels of biotic recovery and the topographic diversity gradient in the aftermath of the Cretaceous?Paleogene mass extinction

Awardee: Weaver, Lucas N

Amount: \$174,000.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). dr. lucas n. weaver has been awarded an nsf ear postdoctoral fellowship to investigate the ecological recovery of mammals during the cretaceous?paleogene (k?pg) mass extinction event. insight from other environmental catastrophes in earth?s past can provide information about the current environmental crisis. additionally, impacts of environmental disturbances are not equal across time and space; therefore, it is important to see how resilient or susceptible species are to extinction in different temporal and geographic settings. the k-pg mass extinction event, which occurred 66 million years ago and is famous for leading to the extinction of

the dinosaurs, is similar to the kind of extinction seen today. towards this end, this project aims to study how mammal communities (including the ancient ancestors of the group to which humans belong) recovered from the k?pg mass extinction over the first 1 million years of the ?age of mammals,? in the denver basin of colorado. mammals are often used as ?canaries in the coal mine? for ecological health because environmental variables such as temperature and moisture are related to mammals? ecological health. the work is based on the hypothesis that the rocky mountains acted as a buffer during the k?pg mass extinction and allowed more mammalian species to survive and diversify in a post-dinosaur world. given that the earth is likely in the midst of a sixth mass extinction event in its history, this study provides crucial insight into which ecosystems are at greatest risk, and which ecosystems are better able to ?weather the storm.? broader impacts of this work include working with the denver museum of nature and science to disseminate results to a broad audience through their exhibits; mentoring of undergraduates at university of michigan and city university of new york, and development of curriculum for high school students. this project aims to investigate the spatial and temporal heterogeneity of mammal recovery after the cretaceous?paleogene (k?pg) mass extinction (66 million years ago) in the denver basin of colorado. denver basin fossil localities are highly resolved chronostratigraphically, allowing precise correlation of the pattern and timing of biotic recovery in different paleogeographic regions of the basin during the first ~1 million years of the paleogene. since mountainous regions today are bio\*\*diversity\*\* hotspots, this project is based on the hypothesis that mammal communities close to the emerging rocky mountains (1) were more resistant to the k?pg mass extinction, and (2) recovered more quickly in its aftermath. to explore these hypotheses, the work will quantify and compare the taxonomic (richness, relative abundance), dietary (inferred via tooth shape), and body mass (inferred via tooth size) \*\*diversity\*\* between two stratigraphic sequences of fossil mammal assemblages: (1) close to and (2) far from the rocky mountain front range. this project will involve field and laboratory work and will use new paleoecological methods to infer community-level mammal \*\*diversity\*\* patterns through time. this study will be the first to (1) look at spatial



heterogeneity in post-k?pg mammalian recovery in high resolution and (2) explore whether mountain habitats were a driver of early mammalian **\*\*diversity\*\***. these results will help identify geospatial features that promote biological community resilience/reassembly after environmental disasters, and will shed light on the tempo and mode of the post-k?pg radiation of mammals, which ultimately led to the distribution of terrestrial bio**\*\*diversity\*\*** we see today. this work will also integrate data from the mammal fossil record with the broader vertebrate and plant fossil record, and with paleoclimate proxies. this novel multidisciplinary approach will allow collaboration with other scientists to track whole-ecosystem recovery in the aftermath of the k?pg mass extinction. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAR-PF: Mammals as sentinels of biotic recovery and the topographic diversity gradient in the aftermath of the Cretaceous?Paleogene mass extinction

Awardee: Weaver, Lucas N

Amount: \$174,000.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). dr. lucas n. weaver has been awarded an nsf ear postdoctoral fellowship to investigate the ecological recovery of mammals during the cretaceous?paleogene (k?pg) mass extinction event. insight from other environmental catastrophes in earth?s past can provide information about the current environmental crisis. additionally, impacts of environmental disturbances are not equal across time and space; therefore, it is important to see how resilient or susceptible species are to extinction in different temporal and geographic settings. the k-pg mass extinction event, which occurred 66 million years ago and is famous for leading to the extinction of the dinosaurs, is similar to the kind of extinction seen today. towards this end, this project aims to study how mammal communities (including the ancient ancestors of the group to which humans

belong) recovered from the k?pg mass extinction over the first 1 million years of the ?age of mammals,? in the denver basin of colorado. mammals are often used as ?canaries in the coal mine? for ecological health because environmental variables such as temperature and moisture are related to mammals? ecological health. the work is based on the hypothesis that the rocky mountains acted as a buffer during the k?pg mass extinction and allowed more mammalian species to survive and diversify in a post-dinosaur world. given that the earth is likely in the midst of a sixth mass extinction event in its history, this study provides crucial insight into which ecosystems are at greatest risk, and which ecosystems are better able to ?weather the storm.? broader impacts of this work include working with the denver museum of nature and science to disseminate results to a broad audience through their exhibits; mentoring of undergraduates at university of michigan and city university of new york, and development of curriculum for high school students. this project aims to investigate the spatial and temporal heterogeneity of mammal recovery after the cretaceous?paleogene (k?pg) mass extinction (66 million years ago) in the denver basin of colorado. denver basin fossil localities are highly resolved chronostratigraphically, allowing precise correlation of the pattern and timing of biotic recovery in different paleogeographic regions of the basin during the first ~1 million years of the paleogene. since mountainous regions today are bio\*\*diversity\*\* hotspots, this project is based on the hypothesis that mammal communities close to the emerging rocky mountains (1) were more resistant to the k?pg mass extinction, and (2) recovered more quickly in its aftermath. to explore these hypotheses, the work will quantify and compare the taxonomic (richness, relative abundance), dietary (inferred via tooth shape), and body mass (inferred via tooth size) \*\*diversity\*\* between two stratigraphic sequences of fossil mammal assemblages: (1) close to and (2) far from the rocky mountain front range. this project will involve field and laboratory work and will use new paleoecological methods to infer community-level mammal \*\*diversity\*\* patterns through time. this study will be the first to (1) look at spatial heterogeneity in post-k?pg mammalian recovery in high resolution and (2) explore whether mountain habitats were a driver of early mammalian \*\*diversity\*\*. these results will help identify geospatial

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Matched Words: diversity

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Title: Collaborative Research: MRA: Distributions of Macrofungi: Quantifying Ecosystem and Climate Drivers of Fungal Reproduction

Awardee: Denver Botanic Gardens

Amount: \$173,853.00

Abstract: fungi are essential components of terrestrial ecosystems worldwide. many fungi produce fruiting bodies in the form of mushrooms. these mushroom-forming fungi are key to forest nutrient cycling and, in association with plants, range from beneficial symbionts to pathogens. yet, we know very little about how regional, landscape, and local factors such as fire combine to affect the distributions of mushroom-forming species, nor how such distributions may be changing with a shifting climate. understanding mushroom distributions is particularly challenging because these fungi spend most of their lives as branching filaments of asexual cells (hyphae) below the soil, and their presence only becomes known if and when they produce a mushroom. recent work has shown that some fungi may occur as hyphae inside plants thousands of kilometers outside their known ranges, which are based on their sexual reproduction (i.e., mushrooms). these extended ranges of fungal hyphae suggest that different factors drive the distributions of life stages of these fungi, complicating efforts to forecast how fungi will respond to changing environments. this research will

examine the distributions of mushroom-forming fungi across the united states by combining mushroom collections with sampling of fungal dna in soils, litter, plant tissues, and the air, at study locations in eight different states (ak, az, co, fl, ks, nh, mn, or). information at each site such as climate, plant communities, fire and soils will then be used to determine the conditions under which particular fungi are able to sexually reproduce and where they can only live as hyphae. the project will connect scientists with more than a thousand community members from mushroom clubs, local schools, and museums who will be involved in collecting mushrooms and working with fungal dna for scientific purposes. using the extensive climatic and geographic scope of the study, containing diverse plant communities and fire disturbances, we will test how environmental variables at multiple scales influence distributions of sexual and asexual stages of fungi. we will also determine whether occurrence of a fungus in one stage (e.g., mushrooms) is predictive of its occurrence in other substrates at a site (e.g., soils, air, or plant tissues), allowing improved sampling schemes for fungi. together, this study will build the most complete picture to date of how macrofungal communities and their relationships change across climate gradients, thus building capacity to predict changes in fungal distributions and ecosystem processes under changing climate. further, unprecedented fires in recent years have placed fire ecology in the public eye like never before, such that expanding understanding of fire as a driver of cryptic aspects of bio\*\*diversity\*\* and ecosystem dynamics is timely and of broad interest. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Examining the Vulnerability and Recovery of Small Farms to Natural Hazards and the Impact to Rural Community Resilience

Awardee: University of Nebraska-Lincoln

Amount: \$173,572.00

Abstract: this disaster resilience research grant (drrg) project contributes to the advancement of national health, prosperity and welfare by creating new knowledge on disaster recovery for the agricultural industry. despite the criticality of agriculture to u.s. and global food production, the lack of economic **\*\*diversity\*\*** and prevalence of agriculture in many rural areas, particularly in the central us, is theorized to be a major contributor to low disaster resilience. resilience is a complex function of socio-economic dimensions and the built environment; and the population, economics, and physical infrastructure that comprise agricultural regions are distinct from the urban and suburban areas that are the common focus of most disaster and community resilience studies. this research generates a fundamental understanding of the resilience of farms and agriculture-prevalent rural communities in the face of severe windstorms, which will be of broad benefit to society and to national resilience. the research team will identify, evaluate, and recommend actions to enhance resilience of farms. to maximize the impact of these findings, the team will partner with the extension disaster education network for outreach and technology transfer. implementation of these mitigation measures can transform the disaster resilience of rural and agricultural regions, safeguarding the lives of citizens, regional and national economies, and global food production. the long-term goal of this research is to enhance the resilience of rural communities to natural hazards, which requires state-of-the-art research on the infrastructure that support farm operations, the recovery processes of individual farms, and the interaction of individual farms within the regional agricultural economy. as a first step towards enhancing rural resilience, the interdisciplinary team will conduct a three-year research project carefully tracking resilience from hazards to structures to farms to communities. the project is characterized by two primary goals. the first goal is to generate a fundamental understanding of the vulnerability and recovery of farms following windstorms through longitudinal reconnaissance of impacted agricultural communities, surveys of impacted farmers, correlation of hazard intensity with infrastructure response, and the examination of the linkages between recovery of individual infrastructure with farm-level recovery. the second goal is to develop and validate a risk-informed resilience assessment framework comprised of a farm-level resilience factors and

community-level economic analyses to support decisions on business continuity and infrastructure investment for farms and the broader agriculture-prevalent rural communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: BPC-AE: STARS: Catalyzing Action-Oriented Academic Communities for Broadening Participation in Computing

Awardee: University of North Carolina at Charlotte

Amount: \$173,277.00

Abstract: it is critical to address the longstanding issue of underrepresentation of women, black, and hispanic students in computing degree programs to provide an equitable foundation for all to participate in our society and the global economy as controllers and creators of technology, and to advance the preparation of a diverse, innovative, and competitive tech workforce. building on the prior success of the stars computing corps alliance for broadening participation in computing, the goal of the stars catalyst project is to: 1) increase the number of women, black, and hispanic students that persist in computing degree programs, and 2) advance the careers of students and faculty from groups that have been historically underrepresented in computing. through research and evaluation around stars catalyst activities, this project will advance knowledge about practices designed to increase persistence and support career advancement in computing for college computing students and faculty, particularly for those from underrepresented and intersectional groups in computing. the stars catalyst alliance is a collaborative effort across temple university, north carolina state, kent state, florida state university, morgan state, and university of north carolina charlotte. the stars computing corps alliance for broadening participation in computing (bpc) engages computing faculty and students at colleges, universities, and community colleges in a community of practice with a shared commitment to take action to advance **\*\*diversity\*\***, equity, and

inclusion in computing. stars computing corps conferences, communities, and networks create significant institutional and human resources that can expand bpc research to a larger audience of researchers, educators, administrators, cs departments, and k-20 students, and can dramatically increase the number of people taking action in bpc efforts. prior results show that the stars computing corps alliance increases intentions to persist in computing among stars students and faculty, with enhanced outcomes for black students and faculty. this project will significantly extend the stars alliance to expand upon those impacts, by 1) including new partners that expand the reach of stars and that emphasize participation of black and hispanic students and faculty, particularly from emerging hispanic serving institutions and community colleges, 2) creating new program elements that test new and propagate evidence-based bpc practices within computing departments, and 3) leveraging partnerships to support identity-focused affinity groups, and 4) developing stars alumni groups employed in industry positions to promote transition to and retention within the tech workforce. extensions to the stars leadership corps program, stars launch program, and the stars celebration conference will serve to develop and propagate evidence-based approaches aimed at improving the teaching and learning of computing for black and hispanic students and build evidence of their effectiveness, and the respect research conference will continue to advance peer-reviewed bpc scholarship. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Core Support for Future Earth International Global Change Research

Awardee: George Mason University

Amount: \$172,761.00

Abstract: this project supports the us secretariat of future earth. future earth harnesses the insights and capacity of the global scientific community to address global problems, like a warming and

increasingly unstable climate, and a rapid loss of bio\*\*diversity\*\* and ecosystem services. the future earth effort is based on the recognition that modern global change challenges require coordinated research efforts bringing together the world's best researchers in the natural, social, behavioral, and engineering sciences, and connecting these researchers with the needs and capacities embedded within a wide range of stakeholder institutions and communities. the secretariat leads and co-leads core functions that include research enabling, networks and capacity, information technology, and communications. in addition, the us global hub leads the evolution and growth of future earth's global efforts and directs many of future earth's core global initiatives, including a flagship capacity building program, communications products, and collaborative data-platforms. future earth provides a critical service to the science community by advancing global change science in the us and around the world, and by supporting the full range of research modalities from fundamental disciplinary research to transdisciplinary research. by connecting research across geography and discipline, the project supports the emergence of novel, integrative scientific ideas. by elevating the spread and impact of scientific results and connecting these results with constituencies in business, government, and civil society, future earth's work supports decision making around the world. it also connects us researchers with a vast and rapidly growing network of leading international scholars in global change research and provides direct access to new knowledge and initiatives. this work includes a broad range of communication capacities in the us and around the world, like the establishment of the sustainability research and innovation congress, the first global convening that brings the global change research and innovation communities together, on an annual basis. the future earth us global hub has also established partnerships to build and diversify the next generation of global change researchers through an internship program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Cell biology of cnidarian-dinoflagellate symbiosis: Signaling, regulation and host response pathways

Awardee: University of Florida

Amount: \$172,749.00

Abstract: coral reef ecosystems are bio\*\*diversity\*\* hotbeds that provide valuable environmental and economic services to half a billion people globally, including millions in the us. reefs are faced with almost complete destruction by the end of the century due to global warming unless humanity can cap global temperature rise. coral biologists are working together to develop a broad array of solutions to help with the coral reef crisis. as a part of these efforts, discovery has a critical role to play. corals are an intimate symbiosis between the coral animal and millions of single-celled algae that reside inside of coral cells. the algae provide photosynthetically derived sugars to the host in return for nutrients and a habitat. dysfunction of the symbiosis, caused by global warming and other human-caused impacts, is the driver of coral bleaching and is causing widespread reef degradation globally. this award will examine the cellular and molecular mechanisms governing the coral-algal partnership. the researchers will use state-of-the-art cellular and molecular tools to discover the chemical signals exchanged between the partners. they will describe the role of the algae in early development of the host and explore the mechanisms of inter-partner regulation during healthy symbiosis and bleaching. the award includes extensive education and outreach aims. undergraduate, graduate student and postdoctoral fellow training is central to the work. finally, the researchers will engage directly with the public, both in oregon and florida, through a variety of activities aimed at illustrating the importance of corals to science and society. many cnidarians, including corals and anemones, engage in a symbiosis with photosynthetic dinoflagellates (family symbiodiniaceae) that together form the trophic and structural foundation of the coral reef ecosystem. despite the importance of corals to coral reefs and the threatened state of coral reef health in an era of climate change, we have an incomplete understanding of how the partnerships are established, regulated and maintained. the researchers will examine inter-partner signaling and

regulation during onset, maintenance and breakdown of cnidarian-dinoflagellate symbioses. experiments will be conducted largely in a laboratory-based sea anemone-symbiodiniaceae model system. the team will carry out the following specific aims: aim 1: characterize algal-host signaling dynamics during onset, maintenance and breakdown of symbiosis by molecular glycan profiling of different symbiont species and by using a unbiased dna aptamer technique to identify surface determinants of symbiotic algae. aim 2: describe the spatio-temporal patterning of symbionts in hosts and their impact on host development and growth by examining the role of symbiosis on polyp development and exploring the dynamics of symbiont invasion in developing polyps. aim 3: examine the role of host response pathways in regulation of symbiosis by measuring changes in nadph oxidase activity and sphingosine rheostat signaling in host tissues both during onset of symbiosis and in dysbiosis. the researchers will develop a course-based undergraduate research experience (cure) based on the sea anemone-symbiodiniaceae model system and they will examine the effectiveness of the cure in student learning and in building of science identity. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Digitization TCN: Extending Anthophila research through image and trait digitization (Big-Bee)

Awardee: Arizona State University

Amount: \$171,235.00

Abstract: declining populations of bees impact plant-pollinator interactions in both natural and agricultural systems. while bees and other insects pollinate most wild plants, and are critical to sustain a large proportion of global food production, they are decreasing in both numbers and **\*\*diversity\*\***. our understanding of the factors driving these declines is limited because we lack sufficient data on the distribution of bee species, and on the behavioral and anatomical traits that

may make them either vulnerable or resilient to human-induced environmental changes, such as habitat loss and climate change. fortunately, wild bees have been collected by researchers and deposited in natural history collections for over 100 years, retaining a wealth of associated attributes that can be extracted from specimen images. this project will digitally capture data and images from these historic specimens, develop tools to measure bee traits from these images, and generate a comprehensive bee trait and image dataset to measure changes through time. this will increase our understanding of specific traits that put bee species at risk of decline - a critical need for both sustaining our agricultural economy and the conservation of our natural resources. in addition, the large image datasets created by this project can be used for new artificial intelligence identification tools that will help improve our future pollinator observation and monitoring efforts. the big-bee thematic collection network (big-bee tcn) will create over one million high-resolution 2d and 3d images of bee specimens, representing over 5,000 worldwide bee species, including all of the major pollinating species of the united states. the big-bee network includes 13 institutions and partnerships with us government agencies. novel mechanisms for sharing image datasets will be developed and datasets of bee traits will be available through an open data portal, the bee library, for research and education. the big-bee project will engage the general public in research through community science via crowdsourcing trait measurements and data transcription from images. in addition, training and professional development for natural history collection staff, researchers, and university students in data science will be provided through the creation and implementation of workshops focusing on bee traits and species identification. all data resulting from this award will be shared with and publicly available through the national digitized biocollections resource, [idigbio.org](http://idigbio.org). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: Collaborative Research: BPC-AE: STARS: Catalyzing Action-Oriented Academic Communities for Broadening Participation in Computing

Awardee: Morgan State University

Amount: \$171,094.00

Abstract: it is critical to address the longstanding issue of underrepresentation of women, black, and hispanic students in computing degree programs to provide an equitable foundation for all to participate in our society and the global economy as controllers and creators of technology, and to advance the preparation of a diverse, innovative, and competitive tech workforce. building on the prior success of the stars computing corps alliance for broadening participation in computing, the goal of the stars catalyst project is to: 1) increase the number of women, black, and hispanic students that persist in computing degree programs, and 2) advance the careers of students and faculty from groups that have been historically underrepresented in computing. through research and evaluation around stars catalyst activities, this project will advance knowledge about practices designed to increase persistence and support career advancement in computing for college computing students and faculty, particularly for those from underrepresented and intersectional groups in computing. the stars catalyst alliance is a collaborative effort across temple university, north carolina state, kent state, florida state university, morgan state, and university of north carolina charlotte. the stars computing corps alliance for broadening participation in computing (bpc) engages computing faculty and students at colleges, universities, and community colleges in a

community of practice with a shared commitment to take action to advance **diversity**, equity, and inclusion in computing. stars computing corps conferences, communities, and networks create significant institutional and human resources that can expand bpc research to a larger audience of researchers, educators, administrators, cs departments, and k-20 students, and can dramatically increase the number of people taking action in bpc efforts. prior results show that the stars computing corps alliance increases intentions to persist in computing among stars students and faculty, with enhanced outcomes for black students and faculty. this project will significantly extend the stars alliance to expand upon those impacts, by 1) including new partners that expand the reach of stars and that emphasize participation of black and hispanic students and faculty, particularly from emerging hispanic serving institutions and community colleges, 2) creating new program elements that test new and propagate evidence-based bpc practices within computing departments, and 3) leveraging partnerships to support identity-focused affinity groups, and 4) developing stars alumni groups employed in industry positions to promote transition to and retention within the tech workforce. extensions to the stars leadership corps program, stars launch program, and the stars celebration conference will serve to develop and propagate evidence-based approaches aimed at improving the teaching and learning of computing for black and hispanic students and build evidence of their effectiveness, and the respect research conference will continue to advance peer-reviewed bpc scholarship. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: Collaborative Research: CNS Core: Small: Adaptive Smart Surfaces for Wireless Channel Morphing to Enable Full Multiplexing and Multi-user Gains

Awardee: University of Colorado at Denver-Downtown Campus

Amount: \$170,000.00

Abstract: the connectivity solutions need to scale up massively to support unprecedented exponential growth in data rates and the number of devices. the primary approach to meet the demands has been to upgrade the infrastructure, such as adding base stations with multiple antennas and/or upgrading clients. unfortunately, these approaches have fallen short of their goal as in practice, the channels between users and base stations have limited scattering or richness to enable spatial multiplexing, and users are not sufficiently separated in the spatial domain. this proposal will shape the channel to unlock the full potential of wireless networks without requiring updating the base station or user device at a low cost in terms of power and expense. the proposed research aims to adaptively modify and morph the wireless medium using smart passive reflector surfaces to materialize the spatial multiplexing gains. the underlying idea is to use smart reflectors to create additional channel **\*\*diversity\*\*** to manipulate the received signal before reflecting it to



minimize interference at the receivers. the research brings together pis and techniques from communications theory, networked system design, and antenna design to build scalable and low-cost wireless networks. the project also proposes a synergistic educational and outreach plan that leverages the technical work to build exciting demos for undergraduate and k-12 classrooms. for example, a smart surface-based demo, which increases the data rate and coverage of current wi-fi devices, will introduce students to the wonders of engineering in a pragmatic yet compelling way, with the hope of increasing **\*\*diversity\*\*** in stem-related education environments. the proposal would develop smart surface designs capable of morphing the channel, and develop the hardware prototype and algorithms to provide coverage and multiplexing gains to support massive numbers of users and the exponential increase in data rates. the designed smart surface with fine-grained control would allow us to morph the wireless channel or environment to increase the **\*\*diversity\*\*** and multiplexing gains as deemed necessary during optimization. we further establish smart surface placement theory and algorithms and quantify the performance-size trade-offs. we develop low-overhead channel estimation and low-latency optimization algorithms for the base station to support temporal channel changes and improve the data rate and connectivity. the proposed effort would develop the theory and algorithms for multi-user setups to ensure scalability with smart surfaces. the proposed work would enable the first low-cost, practical smart surface and algorithms supporting high-mobility users with significant data-rate improvements. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Digitization TCN: Extending Anthophila research through image and trait digitization (Big-Bee)

Awardee: San Diego Society of Natural History

Amount: \$167,278.00

Abstract: declining populations of bees impact plant-pollinator interactions in both natural and agricultural systems. while bees and other insects pollinate most wild plants, and are critical to sustain a large proportion of global food production, they are decreasing in both numbers and **\*\*diversity\*\***. our understanding of the factors driving these declines is limited because we lack sufficient data on the distribution of bee species, and on the behavioral and anatomical traits that may make them either vulnerable or resilient to human-induced environmental changes, such as habitat loss and climate change. fortunately, wild bees have been collected by researchers and deposited in natural history collections for over 100 years, retaining a wealth of associated attributes that can be extracted from specimen images. this project will digitally capture data and images from these historic specimens, develop tools to measure bee traits from these images, and generate a comprehensive bee trait and image dataset to measure changes through time. this will increase our understanding of specific traits that put bee species at risk of decline - a critical need for both sustaining our agricultural economy and the conservation of our natural resources. in addition, the large image datasets created by this project can be used for new artificial intelligence identification tools that will help improve our future pollinator observation and monitoring efforts. the big-bee thematic collection network (big-bee tcn) will create over one million high-resolution 2d and 3d images of bee specimens, representing over 5,000 worldwide bee species, including all of the major pollinating species of the united states. the big-bee network includes 13 institutions and partnerships with us government agencies. novel mechanisms for sharing image datasets will be developed and datasets of bee traits will be available through an open data portal, the bee library, for research and education. the big-bee project will engage the general public in research through community science via crowdsourcing trait measurements and data transcription from images. in addition, training and professional development for natural history collection staff, researchers, and university students in data science will be provided through the creation and implementation of workshops focusing on bee traits and species identification. all data resulting from this award will be shared with and publicly available through the national digitized biocollections resource, [idigbio.org](http://idigbio.org). this award

reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Frameworks: Convergence of Bayesian inverse methods and scientific machine learning in Earth system models through universal differentiable programming

Awardee: University of Colorado at Boulder

Amount: \$166,590.00

Abstract: understanding and quantifying parameter sensitivity of simulated systems, such as the numerical models of physical systems and mathematical renderings of neural networks, are essential in simulation-based science (sbs) and scientific machine learning (sciml). they are the key ingredients in bayesian inference and neural network training. seizing on the opportunity of emerging open-source earth system model development in the julia high-level programming language, this project is endowing these open-source models with automatic differentiation (ad) enabled derivative information, making these converging data science and simulation-based science tools available to a much broader research and data science community. enabling a general-purpose ad framework which can handle both large-scale earth system models as well as sciml algorithms, such as physics-informed neural networks or neural differential equations, will enable seamless integration of these approaches for hybrid bayesian inversion and bayesian machine learning. it merges big data science, in which available data enable model discovery with sparse data science, and the model structure is exploited in the selection of surrogate models representing data-informed subspaces and fulfilling conservation laws. the emerging julia language engages a new generation of researchers and software engineers, channeling much needed talent into computational science approaches to climate modeling. through dedicated community outreach programs (e.g., hackathons, minisymposia, tutorials) the project team will be working toward increasing equity, **\*\*diversity\*\***, and inclusion across the participating disciplines. the project is

developing a framework for universal differentiable programming and open-source, general-purpose ad that unifies these algorithmic frameworks within julia programming language. the general-purpose ad framework in julia leverages the composability of julia software packages and the differentiable programming approach that underlies many of the sciml and high-performance scientific computing packages. compared to most current modeling systems targeted for hpc, julia is ideally suited for heterogeneous parallel computing hardware (e.g., cuda, rocm, oneapi, arm, powerpc, x86 64, tpus). the project is bringing together expertise in ad targeted at earth system data assimilation in high performance computing environments with sciml expertise. the project team is working with the julia computing organization and package developers to ensure sustainability of the developed frameworks. the project's earth system flagship applications consist of (i) an open-source, ad-enabled ocean general circulation model that is being developed separately as part of the climate modelling alliance (clima), and (2) an open-source, ad-enabled ice flow model. each of these application frameworks is being made available to the community for science application, in which derivative (gradient or hessian) information represent key algorithmic enabling tools. these include sciml-based training of surrogate models (data-driven and/or model-informed), parameter and state estimation, data assimilation for model initialization, uncertainty quantification (hessian-based and gradient-informed mcmc) and quantitative observing system design. academic and industry partners are involved, who are using the frameworks for developing efficient power grids, personalized precision pharmacometrics, and improved eeg design. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Dimensions US-China: Collaborative Research: Consequences of diversity in Asian and American oak syngameons for functional variation, adaptation and symbiont biodiversity

Awardee: Duke University

Amount: \$164,419.00

Abstract: the world's approximately 425 oak species maintain species identity even while exchanging genes with their close relatives through hybridization. this history of evolution and genetic exchange has shaped the bio\*\*diversity\*\* of northern hemisphere ecosystems. oaks are ecologically diverse, with related species often growing in close proximity but specializing on areas of the forest landscape that differ in soil texture and moisture level or in the frequency of natural fires. gene exchange can move such ecological specializations between oak species, broadening their ranges and ability to respond to climate change. the impacts of these genetic exchanges may extend beyond the oaks themselves. oaks host an estimated 1000 gall wasp species worldwide and highly diverse communities of fungi associated with their roots (as mycorrhizae) and inside their leaves (as endophytes). using paired field surveys and common garden experiments the pis will evaluate the effects of hybridization and introgression on the genetic, phylogenetic, and functional \*\*diversity\*\* of focal oak species and their symbionts in the us and china. this work will also provide inquiry-based k-12, undergraduate, and graduate education; critical natural history training to the public through a community-science initiative in oak phenology; and publications that will bring research to public audiences. two interdisciplinary teams of researchers, one based in the us and one in china, will investigate how genomic, functional, and phylogenetic \*\*diversity\*\* of oak trees shape the mycorrhizal fungi, endophytic fungi, and gall wasp and other insect communities that associate with them. research will focus on two related groups of interbreeding species: bur oak (*quercus macrocarpa*) and relatives in the us and bao li (*quercus serrata*) and relatives in china. the project has three objectives, each conducted in parallel in china and the u.s. in objective 1 the teams will perform range-wide phylogenomic surveys of natural populations to reconstruct genomic mosaics, characterize geographic patterns of leaf functional traits, and characterize functional and phylogenetic \*\*diversity\*\* of associated mycorrhizal fungi, leaf endophytic fungi, and gall wasps. in objective 2 common gardens will be planted across climatic gradients to evaluate the effects of genetic variation and population differentiation on oak functional and spectral traits and relative

fitness in different climates, and how these influence the phylogenetic and functional **diversity** of oak-associated fungal and insect communities. in objective 3 the teams will use a second set of common garden experiments to evaluate how plant community and phylogenetic **diversity** affects focal oak species genetic, phylogenetic, and functional **diversity**. the project will provide an integrative perspective on how oak **diversity** within and among species impacts the broad **diversity** of oak-dominated ecosystems across the northern hemisphere. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Self-incompatibility in elderberry

Awardee: University of Missouri-Columbia

Amount: \$162,000.00

Abstract: roughly half of the approximately 352,000 species of flowering plants on earth possess mechanisms that favor cross-pollination. this reproductive strategy is crucial for generating and sustaining the genetic **diversity** that plants need to survive and adapt. humans rely on plant **diversity** both directly, for crop improvement, and indirectly, for ecosystem support. many plants have evolved ways to recognize and reject self-pollen and pollen from close relatives. these so-called "self-incompatibility systems" are among the most common and effective mechanisms that prevent self-pollination and favor cross-pollination. to date, the genes controlling self-incompatibility, called s-genes, have been identified in only three systems that operate in a handful of plant families. this project will identify s-genes in elderberry, an emerging specialty crop rich in antioxidants that is used in wine, supplements, and other products. candidate genes were identified using a novel approach prioritizing dna sequence differences that could relate to pollen recognition as well as expression data. experiments will evaluate these candidate genes by testing whether the presence or absence of particular s-genes reliably predicts what types of pollen are

accepted or rejected. other experiments will identify additional s-gene variants. the approach used to identify elderberry s-genes may be applied to additional self-incompatibility systems and, thus, further contribute to understanding maintenance of plant **diversity**. self-incompatibility (si) systems are among the most important genetic mechanisms plants use to control mating. typically, the genes controlling si, s-genes, have numerous allelic variants, and, basically, si allows plants to reject pollen from potential mates with similar alleles. si species are obligate outcrossers because self-pollen always has the same s-alleles as the pistil. notwithstanding their outsized importance for plant **diversity**, evolution and adaptability, s-genes have only been identified in a handful of si systems. here, the overall goals are to elucidate a new si system, identify the controlling s-genes, and facilitate their use in the scientific and agriculture communities. we characterized si in elderberry (*sambucus canadensis*) and used rnaseq to identify candidate s-genes. genetic experiments will ascertain whether these candidate s-genes truly control si in elderberry. four populations segregating for distinct s-allele candidates will be genotyped and test pollinated to determine whether they reject pollen from plants bearing the same alleles. elderberry is an emerging specialty crop valued for potential health benefits, and additional s-alleles will be identified in elderberry and related plants to support the elderberry improvement community. specifically, the project will allow breeders and producers to predict the crossing behavior of commercial varieties. project activities related to elderberry production and improvement will be broadly disseminated via presentations, video, and extension publications. the project also will contribute to human resource development by providing undergraduate research training in both laboratory- and field-based plant science. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Revitalizing a field wireless network for research, education and outreach at the Harvard Forest

Awardee: Harvard University

Amount: \$161,588.00

Abstract: research in environmental science is increasingly dependent on sensor arrays, computer networks, and near-real-time data processing and visualization. at the harvard forest, the field wireless network extends the university computer network into the research forest where there is little or no cell phone reception. since 2010 the field wireless has supported a wide range of research projects with investigators from many different institutions, resulting in (as of march 2021) 27 datasets publicly available online and 291 related scientific publications. many of these projects are long-term experiments associated with the lter and ameriflux networks; others are short-term projects by researchers drawn to the forest because of its infrastructure and long-term data. the field wireless enables scientists to monitor and control their equipment and collect data remotely, reducing travel costs and loss of data from problems that would otherwise have gone undetected since the last in-person visit. in recent years, and especially after the onset of the pandemic, the field wireless has supported virtual field trips and remote instruction, broadening the audience and geographic reach of the forest's education and outreach efforts. this project will greatly improve the performance of the field wireless by significantly increasing network bandwidth and the number of sites with wi-fi capability. these improvements will enable exciting new possibilities for research, including data collection from more extensive sensor arrays, video streaming, and near-real-time ecological forecasting. they will also expand the number and **\*\*diversity\*\*** of field sites available for remote instruction, especially benefiting groups that are underrepresented in the sciences and often unable to visit the forest in person due to distance, cost, or physical accessibility. virtual field trips and remote learning via the field wireless will remain a major means for reaching a broader audience long after the pandemic has receded. this project will expand and revitalize the harvard forest field wireless network, which was commissioned in 2010 with support from nsf, doe, and harvard university and is jointly managed by the forest and harvard network operations. the field wireless currently provides internet access to field sites spread across the 375-ha prospect hill tract,



including 10 major sites with a walk-in equipment shed, 24-port network switch, and wireless access point (ap), and 10 minor sites with an instrument enclosure and data logger or phenology camera. sites are connected by carrier-grade unlicensed spread-spectrum radios: 5.8 ghz radios for tower-to-tower communications with unobstructed line of sight and 900 mhz radios for tower-to-ground communications through the forest canopy. network bandwidth is limited by the radios and ranges from 2 to 5 mbps, depending on the site. a dedicated virtual private network (vpn) allows researchers to access their equipment remotely when not at the forest. this project will retain the basic design of the field wireless but greatly improve its performance by (1) replacing the current radios (which are no longer available) with new radios at least an order of magnitude faster, (2) adding two new experimental sites, (3) adding wi-fi capability at nine sites that currently lack it, and (4) augmenting wi-fi at four sites that are regularly used for education and outreach. the resulting increase in network bandwidth and wi-fi availability will significantly improve support for data-intensive research projects, virtual field trips, and remote instruction; by improving communications, it will also enhance safety for students and scientists working in the prospect hill tract of the harvard forest (<https://harvardforest.fas.harvard.edu>). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Digitization TCN: Extending Anthophila research through image and trait digitization (Big-Bee)

Awardee: Regents of the University of Michigan - Ann Arbor

Amount: \$160,392.00

Abstract: declining populations of bees impact plant-pollinator interactions in both natural and agricultural systems. while bees and other insects pollinate most wild plants, and are critical to sustain a large proportion of global food production, they are decreasing in both numbers and

**\*\*diversity\*\***. our understanding of the factors driving these declines is limited because we lack sufficient data on the distribution of bee species, and on the behavioral and anatomical traits that may make them either vulnerable or resilient to human-induced environmental changes, such as habitat loss and climate change. fortunately, wild bees have been collected by researchers and deposited in natural history collections for over 100 years, retaining a wealth of associated attributes that can be extracted from specimen images. this project will digitally capture data and images from these historic specimens, develop tools to measure bee traits from these images, and generate a comprehensive bee trait and image dataset to measure changes through time. this will increase our understanding of specific traits that put bee species at risk of decline - a critical need for both sustaining our agricultural economy and the conservation of our natural resources. in addition, the large image datasets created by this project can be used for new artificial intelligence identification tools that will help improve our future pollinator observation and monitoring efforts. the big-bee thematic collection network (big-bee tcn) will create over one million high-resolution 2d and 3d images of bee specimens, representing over 5,000 worldwide bee species, including all of the major pollinating species of the united states. the big-bee network includes 13 institutions and partnerships with us government agencies. novel mechanisms for sharing image datasets will be developed and datasets of bee traits will be available through an open data portal, the bee library, for research and education. the big-bee project will engage the general public in research through community science via crowdsourcing trait measurements and data transcription from images. in addition, training and professional development for natural history collection staff, researchers, and university students in data science will be provided through the creation and implementation of workshops focusing on bee traits and species identification. all data resulting from this award will be shared with and publicly available through the national digitized biocollections resource, [idigbio.org](http://idigbio.org). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: A Self-Study of Contingent Faculty and their Impact on Undergraduate STEM Education at a Research-Intensive Institution

Awardee: William Marsh Rice University

Amount: \$160,365.00

Abstract: this project aims to serve the national interest by addressing contingent faculty labor equity to improve stem education. contingent faculty comprise 69.5% of higher education instructional faculty nationwide. they include both part-time and full-time faculty who are appointed off the tenure track. contingent faculty play a critical role in undergraduate stem education and hold great potential for advancing student success as well as institutional commitments to **\*\*diversity\*\***, equity, and inclusion. transforming faculty labor conditions to better support contingent faculty, particularly at research-intensive institutions, is critical for educating an increasingly diverse population and providing equitable stem education. this capacity building project will offer a model self-study of the role of contingent faculty within university structures. the study has potential to deepen and transform current understandings of faculty roles at the university. project outcomes include: (i) identifying a replicable set of institutional changes that enhance stem education; (ii) revealing institutional models and best practices for achieving equitable stem educational outcomes with a diverse faculty workforce; and (iii) identifying a theory of change that will be generalizable to similar research-intensive institutions. the goal of this project is to use a grounded theory approach to identify how research-intensive institutions can transform organizational structures, processes, and policies to ensure that contingent faculty enhance stem education, educational equity, and institutional reputation. as the project's scope focuses on systemic, transformational change, the project team will consist of both tenured and contingent stem faculty, upper administration, and staff who support undergraduate teaching and learning. the project will conduct a self-study that employs a mixed method approach, including institutional data analysis and surveys, interviews, and focus groups with faculty and administrators, to understand how the labor conditions of contingent faculty

affect stem education. the project will engage in four key activities: 1) an assessment of the institutional and individual factors at the proposing institution that affect contingent faculty labor conditions and perceptions; 2) an analysis of the impact of contingent faculty labor conditions on stem teaching and learning at the proposing institution; 3) identification of a theory of change that provides a framework for interventions and institutional transformation of the contingent faculty role at research-intensive institutions; and 4) identification of and collaboration with an institutional partner to build upon the foundation laid through the self-study. this project will yield new information on how contingent faculty agency and integration in research-intensive institutions affect stem outcomes and address a gap in understanding of the institutional processes, structures, resources, and policies necessary to ensure that contingent faculty enhance stem education. focus on the research-intensive context will advance understanding of the impact of contingent faculty on student learning to an institutional type that has received less attention in the literature despite a critical role in preparation of the professional stem labor force. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the institutional and community transformation track, the program supports efforts to transform and improve stem education across institutions of higher education and disciplinary communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: The geological and paleoecological contexts of early Miocene hominoid evolution

Awardee: Baylor University

Amount: \$159,211.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). this project examines the roles of time and environment in the adaptive evolution of early

apes by advancing knowledge about the chronology, paleoecology, and species **diversity** for a set of geographically restricted fossil localities. the research design includes a series of fossil excavations to uncover new evidence of early apes and their habitats, combined with laboratory analyses designed to aid in synthesizing and interpreting these discoveries. the scientific importance of this project lies in documenting early ape adaptive **diversity** within specific, highly-resolved chronological and ecological contexts, with major downstream implications for interpreting the origin and diversification of later apes, including hominins. more broadly, this project expands participation in research through training opportunities targeted to underrepresented groups, enhances scientific infrastructure by digitizing invaluable but currently inaccessible field records, and increases public engagement with science through outreach activities aimed at museums and public schools. fossil and molecular evidence indicate that the major lineages of humans and apes diverged during the early miocene (ca. 23-16 ma). the **diversity** of ape species and adaptations during that time greatly exceeds modern variation in this group making it difficult to interpret the evolutionary sequence and ecological contexts in which the suite of features shared by living apes and humans appeared. this project is organized around the central question: are differences among early apes tied to differences in paleoenvironments, ages, or both? to clarify these relationships, researchers pursue three specific aims: (1) establishing a rigorous chronology of early ape fossil sites; (2) generating high-resolution paleoecological reconstructions for undersampled ape localities; and (3) documenting the **diversity** of ape species during the early miocene. fossil excavations are conducted at a series of outcrops to better document ape **diversity**, geological contexts, and habitat parameters. the project employs radiometric and magnetostratigraphy at correlated stratigraphic sections (aim 1); sedimentological, isotopic, and paleontological analyses (aim 2); and comparative, morphometric, and phylogenetic analyses of new fossil ape specimens (aim 3). integration of these study results can enable the researchers to contextualize the timing and ecological parameters associated with the emergence of key characteristics in the ape and human lineage, and to subsequently interpret how these early miocene primate communities contributed to

the distribution of primates across broad regions. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: PPOSS: Planning: A Disciplined Approach to Scaling in the Post-Moore's Law Era

Awardee: Princeton University

Amount: \$158,700.00

Abstract: general-purpose processor speeds have not increased at their historical rates for over 15 years. designers have instead offered scalable computing systems with additional barriers to realizing the performance gains that once came "for free" with each processor generation. this situation has slowed the progress of all endeavors that involve scalable computing. a disciplined approach to reversing this trend must start and end with a direct engagement with the scalable-system users and programmers faced with these barriers. with this goal, the investigators are performing in-depth face-to-face interviews with a broad set of users. in addition, with these users, the project team is also examining codes, exchanging ideas, and offering assistance. this is producing a deep understanding of how users are coping with their growing demands for computing while computing is placing more demands upon them. the project's novelties are this in-depth study and the resulting formulation of an approach to address the limitations of scalable computing based on real users' needs. the project's impacts are the dissemination of the survey results and a recommended approach forward that restores meaningful layers of abstraction to scalable systems, freeing programmers from being drawn deeper into the complexity of scalable computing while delivering higher performance to them. the investigators performed a similar study in 2011. with this planning grant: (1) they are conducting a more ambitious study with a greater **\*\*diversity\*\*** of subjects. by re-engaging as many 2011 subjects as possible, this becomes a longitudinal study

capable of revealing trends not visible in any single point-in-time study. (2) the investigators are using these interactions to explore transitioning their foundational work to practice, to build a larger team, and to expand the scope of future work. the results of the 2011 study inspired the investigators to produce breakthroughs in speculation, dependence handling, latency tolerance, and automatic parallelization. the 2021 study serves as a vehicle to explore ways to transition these results to practice. (3) the investigators believe that hardware can be more domain-adept without being domain-specific. using prior insights, they are exploring hardware/software concepts that deliver top performance levels without undue programmer burden. by testing these ideas in the context of the study, the investigators can best frame the problem, refine approaches, and test hypotheses in the context of actual needs, opportunities, and constraints. all of these activities ensure that future work in scalable systems will have greater impact. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: Quantum Transport in Self-Assembled Hybrid Superlattices



Awardee: Purdue University

Amount: \$158,534.00

Abstract: new phenomena emerge when two semiconductors are brought together in a periodic structure. such semiconducting superlattices have properties not observed in bulk semiconductor crystals. their unique properties have led to novel devices such as tunable optical filters, infrared photodetectors, and quantum cascade lasers. superlattices are expensive to make, requiring ultrahigh vacuum and meticulous layer by layer assembly. the project aims to discover a new type of superlattice based on hybrid perovskites, materials with both organic and inorganic components. hybrid perovskites can be solution processed, allowing for spontaneous assembly into layered nanostructures. their chemical **diversity** can revolutionize superlattice research with a vastly expanded range of materials with varied properties. this research will enable future superlattice devices that are scalable and cost-effective. this project will also provide interdisciplinary training to undergraduate and graduate students, providing them with critical-thinking and problem-solving skills needed for careers in stem and industry. semiconducting superlattices are quantum heterostructures important to condensed matter physics and with applications in advanced electronic technologies. the constituents of the superlattices to date have been limited to inorganic semiconductors, such as GaAs and AlGaAs. this project will investigate quantum transport in a new class of semiconducting superlattices based on Ruddlesden-Popper halide perovskites. the project will employ theoretical and experimental studies in an iterative manner so as to accelerate materials discovery. first principle density functional theory (DFT) calculations will be used to predict materials structures and the optical and electronic properties will be modeled by combining tight-binding models with the DFT calculations. superlattice structures will be prepared by solution processing and self-assembly, allowing for facile tuning of the electronic structure by varying constituents. the design strategy, using semiconducting organic ligands, will create new possibilities for band engineering. electrooptical measurements will be used to identify signatures of semiconducting superlattices such as electronic minibands. complementary electrical characterization will be used to

search for evidence of quantum transport, using optical excitation to generate charge carriers without unintended effects arising from doping. the project will elucidate the properties of 2d perovskite superlattices, differentiate their behaviors from conventional inorganic superlattices, and determine if their optical and electronic properties can be tailored in a controllable manner. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Mayo Clinic Rochester

Amount: \$158,333.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology,

engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Research Initiation: Social Engagement & Belonging in Academic Makerspaces

Awardee: Western Washington University

Amount: \$158,228.00

Abstract: academic makerspaces provide students with open access to resources that help them develop their problem solving skills, provide opportunities for collaboration, and encourage experimentation and discovery. however, recent research has shown that many makerspace environments do not readily support diverse populations, create tensions between different student groups, and can sometimes lead to a work environment that feels exclusive and unwelcoming. it is essential that our academic makerspaces are welcoming and that all students feel a sense of belonging and acceptance in these spaces. this project will use the flexible nature of an academic makerspace as the framework to provide students with the opportunity to connect socially in ways that have been shown to increase sense of belonging. this will be accomplished by integrating social engagement activities into a university affiliated makerspace. the engagement activities will be designed to support students' social and emotional development, which is an essential component to creating culturally competent, well-rounded engineers. due to the flexible and informal nature of the makerspace environment, it is an ideal place to build and create social connections between students. makerspaces provide a venue for informal learning and student connection that inspires

attributes associated with the professional formation of engineers: creativity, discovery, lifelong learning, teamwork, and critical thinking. this study will lay the foundation for future research that will inform strategies to create an equitable and inclusive makerspace culture with a focus on better supporting non-dominate students. this project aims to increase student sense of belonging in undergraduate engineering students through the integration of social engagement activities into an academic makerspace. the objectives of this project are to (1) strategically integrate social engagement activities that have been shown to contribute to increased sense of belonging and student persistence into an academic makerspace; (2) research the effects of the social engagement activities on student sense of belonging; and (3) increase engineering education research capacity at western washington university. the outcomes of this work will lead to identification of best practices for improving student sense of belonging in a makerspace environment. this research will investigate the impact of carefully designed social engagement activities on development of student sense of belonging. within the recent context of the covid-19 pandemic, social support and positive sense of belonging have been shown to counter the adverse social emotional effects of the experience. engagement activities will focus on supporting student social and emotional development, providing peer support, and building awareness of the importance of equity, inclusion, and **\*\*diversity\*\*** in engineering. the activities will be designed so that any student can participate regardless of ability level, time availability, or physical location. the research questions that will guide this work are (1) to what extent do students participate in the engagement activities within the makerspace and in which formats, and does this level of engagement vary based on student demographics? and (2) to what extent does participation in the engagement activities lead to an increased sense of belonging? these research questions will be investigated through a communities of practice theoretical framework using a two-year mixed methods research that includes survey development, analysis, student reflections, and focus groups. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: MRA: Distributions of Macrofungi: Quantifying Ecosystem and Climate Drivers of Fungal Reproduction

Awardee: University of New Hampshire

Amount: \$150,235.00

Abstract: fungi are essential components of terrestrial ecosystems worldwide. many fungi produce fruiting bodies in the form of mushrooms. these mushroom-forming fungi are key to forest nutrient cycling and, in association with plants, range from beneficial symbionts to pathogens. yet, we know very little about how regional, landscape, and local factors such as fire combine to affect the distributions of mushroom-forming species, nor how such distributions may be changing with a shifting climate. understanding mushroom distributions is particularly challenging because these fungi spend most of their lives as branching filaments of asexual cells (hyphae) below the soil, and their presence only becomes known if and when they produce a mushroom. recent work has shown that some fungi may occur as hyphae inside plants thousands of kilometers outside their known ranges, which are based on their sexual reproduction (i.e., mushrooms). these extended ranges of fungal hyphae suggest that different factors drive the distributions of life stages of these fungi, complicating efforts to forecast how fungi will respond to changing environments. this research will examine the distributions of mushroom-forming fungi across the united states by combining mushroom collections with sampling of fungal dna in soils, litter, plant tissues, and the air, at study locations in eight different states (ak, az, co, fl, ks, nh, mn, or). information at each site such as climate, plant communities, fire and soils will then be used to determine the conditions under which particular fungi are able to sexually reproduce and where they can only live as hyphae. the project will connect scientists with more than a thousand community members from mushroom clubs, local schools, and museums who will be involved in collecting mushrooms and working with fungal dna for scientific purposes. using the extensive climatic and geographic scope of the study, containing

diverse plant communities and fire disturbances, we will test how environmental variables at multiple scales influence distributions of sexual and asexual stages of fungi. we will also determine whether occurrence of a fungus in one stage (e.g., mushrooms) is predictive of its occurrence in other substrates at a site (e.g., soils, air, or plant tissues), allowing improved sampling schemes for fungi. together, this study will build the most complete picture to date of how macrofungal communities and their relationships change across climate gradients, thus building capacity to predict changes in fungal distributions and ecosystem processes under changing climate. further, unprecedented fires in recent years have placed fire ecology in the public eye like never before, such that expanding understanding of fire as a driver of cryptic aspects of bio\*\*diversity\*\* and ecosystem dynamics is timely and of broad interest. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SRS RN: Sustainable Transportation Electrification for an Equitable and Resilient Society (STEERS)

Awardee: Texas A&M Engineering Experiment Station

Amount: \$150,000.00

Abstract: the us is in the midst of a massive transformation as both the electric grid becomes much more renewable and transportation becomes much more electrified, a change that will touch just about everyone. this nsf project goals are to ensure that this change is done in a way that is fair and technically sound, considering the need and well-being of all, done in a way that ultimately provides a more resilient and equitable society. the project is transformative by bringing together a broad team of researchers from four universities, coupled with a diverse group of outside advisors, to focus on sustainable transportation electrification in texas, a state that is extremely diverse and has its own electric grid. the goals will be achieved by utilizing the team?s broad expertise in the many

different areas needed to ensure success. the intellectual merits include fostering a culture of **\*\*diversity\*\*** and inclusion, developing criteria for success, developing the required research and education agenda, and doing pilot studies. the broader impacts of the project include helping to guide the equitable, sustainable and resilient electrification of transportation by engaging with a wide variety of partners, including government, community organizations and the business community. the purpose of this project is to develop a convergent team and associated proposal focused on the sustainable, equitable and resilient electrification of transportation. this is needed because society is beginning a massive transformation as the electric grid becomes much more renewable and as transportation becomes much more electrified. the convergent work proposed here is to ensure that this transformation is done so as to benefit all members of society. the specific focus is the supra-aggregation associated with the connected urban-rural systems in the electric grid covering most of the state of texas, with results applicable to the rest of the country. the team has broad expertise in the many required areas including the electric grid, renewable generation, transportation, urban studies, community planning, sociology, risk analysis, large-scale computing and data analytics, demographics, and education. the portfolio of research and education will be broad, leveraging the strengths of the convergent team with key aspects including developing better modeling and simulation, developing theories of change and more generalization theories, broad stakeholder participation, and equity with the goal of advancing knowledge. the effort has a strong focus on education to all, and should result in overall societal benefit given its broad focus on the electric and transportation infrastructures. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SRS-RN: Planning for a Network to Address Pressures, Responses and Sustainability Intersections across a Growing, Innovative, and Dry State



Awardee: Colorado State University

Amount: \$150,000.00

Abstract: colorado, like many dry states in the western u.s., faces significant sustainability challenges from population growth, technological innovation, climate change, and competing development preferences and priorities. these challenges span the connected urban and rural areas within the region. while many researchers, practitioners, and communities in colorado are working to understand and address these challenges, efforts are fragmented. solving regional sustainability challenges requires an approach that understands regions as nested layers of natural, built, social, public, and government networks. the aim of this planning grant is to improve the ability to share knowledge, resources, and data across the public, private, and non-profit sectors in all phases of the research, leading to a more sustainable and regional system in colorado. a strong, connected, and coordinated cross-sector (university, government, industry, non-profit), and transdisciplinary network is needed to improve the capacity of groups already working on sustainability challenges in colorado. during the twelve-month planning period, the network will use a survey instrument to better understand the connectivity, collaboration, **\*\*diversity\*\***, inclusivity, perceived opportunities, barriers, and the range of sustainability work being done across colorado in the existing network. the second step will be to host workshops focused on understanding past and current sustainability activities, identifying which pressures are most important to different communities, and how these issues define relationships at various spatial scales. the cross-sector, interdisciplinary workshops aims to 1) expand existing network ties to include additional communities and minority serving institutions; 2) build knowledge and trust across diverse stakeholders; and 3) formulate a set of research objectives, methods, and scope for the development of a track 1 sustainable regional systems research networks (srs-rn) proposal. finally, researchers will conduct network and economic analyses designed to assess broad inequalities in resources and connections across the state to better understand barriers and inequities across various communities. network analyses will also examine how connections across disciplines, or lack thereof, are impeding development of a

transdisciplinary research agenda the workshops and analyses will focus scientific researchers and communities in conversations meant to identify the necessary social and technical platforms needed to break through these barriers, and to strengthen and empower the network. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: BPC-A: LEAP Alliance: Diversifying Future Leadership in the Professoriate

Awardee: Georgia Tech Research Corporation

Amount: \$150,000.00

Abstract: only 5.3% of the faculty at phd-granting universities are from the following underrepresented communities: black or african-american, hispanic, or american indian/alaska native. diversifying the computing professoriate is critical for providing excellent role models, shaping departmental programs and policies, and bringing diverse perspectives into research projects and programs. the leap alliance aims to increase the **\*\*diversity\*\*** of leadership in the computing professoriate by intentionally bringing together four cohorts of universities, each with common strengths and a common agenda. this work builds upon the lessons learned from a first cohort comprised of institutions producing a large percentage of computing faculty and adds three additional cohorts to further strengthen the pipeline to the computing professoriate. the goal of the leap alliance is to address the broadening participation challenge of increasing the **\*\*diversity\*\*** of the future leadership in the computing professoriate at research universities as a way to increase **\*\*diversity\*\*** across the field. key national leadership roles, such as serving on national committees that impact the field of computing, often come from research universities, making these institutions a critical point of focus. the alliance has previously piloted this effort in an initial cohort of 11 research universities who were found to produce over 50% of the faculty at the top 55 research institutions.

they will continue to bring together similar institutions in a second cohort, as well as cohorts that focus on institutions graduate a large percentage of computing phds and computing undergraduates, respectively. ultimately, the alliance aims to increase the **\*\*diversity\*\*** of phd graduates from the institutions that are the top producers of computing faculty, increase the exposure of academic careers at the institutions that already have good **\*\*diversity\*\*** in their phd graduates, and increase the retention of diverse undergraduate students at the institutions who send students to graduate school that go on to be faculty. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SCC-PG : Human-AI Teaming for Flood Evacuation Decision Making

Awardee: Clemson University

Amount: \$150,000.00

Abstract: evacuation of coastal communities, particularly in rural areas, can be a challenge due to the topography, dispersed residential and population patterns, and limited number of roadways that lead further inland. this smart and connected community planning project will assess the viability of leveraging human knowledge and social media data with an artificial intelligence (ai) system to create a human-ai teaming (hat) paradigm addressing flood evacuation decision making in isolated coastal rural communities. in the process of creating a hat paradigm, we will integrate transportation network data with river information as well as volunteers' observations and social media data to leverage the strengths of local members of a community emergency response team (cert) with ai. this planning project advances the field by conducting a feasibility study of this hat decision-making tool, which will be tested through real-world flood evacuation examples in charleston, berkeley, and dorchester counties located in the lowcountry region of south carolina (sc). additionally, we will determine the barriers and motivations for understanding the usability of the researched hat

decision-making tool using qualitative (interview) protocols. this project supports education and **\*\*diversity\*\*** by providing research experiences to diverse students, as well as focusing on vulnerable, rural communities. additionally, this planning project supports nsf's mission to promote the progress of science and to advance the nation's health, prosperity, and welfare by seeking to (i) enhance flood evacuation by automatic data-driven decision making and (ii) identify potential barriers to the adoption of technology in rural volunteer communities. this research will co-create and implement a pilot solution for flood evacuation decision making by including systems thinking, human-machine engagement, human development training, and ai-driven decision making. the focus is on the advancement of flood evacuation techniques by transferring the traditional determination techniques (the expert evaluation approach) toward new and coherent hat computing. by leveraging hat protocols and applying them to a flood evacuation decision-making tool, our project has the potential to be transformative. tackling these issues will enable us to harness the full potential of ai as a partner in emergency management and response. this planning project brings together researchers from water resources engineering, social sciences and communication, transportation engineering, disaster science, computer science, and numerous volunteers and stakeholders to co-create solutions, build/strengthen collaboration with key stakeholders and cert organizations and identify potential barriers to technology use in rural communities challenged by a higher incidence of flood hazards and substandard infrastructure. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SCC-PG: Preparing the Next-Generation Rural Workforce Through Inclusive and Place-Based Smart and Connected STEM Educational Delivery Models

Awardee: Iowa State University

Amount: \$150,000.00

Abstract: contrary to trends in most rural communities, which are shrinking and aging, many rural midwestern communities have experienced rapid population growth since the 1980s, as migrants and refugees have been moving there to meet growing labor demand in the agroindustrial sector such as meat and poultry processing. the school-aged residents of these growing midwestern communities, who are primarily the u.s.-born children of low-skilled workers, represent a significant untapped population of future stem workers and entrepreneurs who are growing up in, and want to stay in, rural america. there is a lack of research on workforce development in rural communities with large migrant and refugee populations. thus, there is a critical need to study strategies to both train, and also keep, this skilled workforce local to rural communities where expanded employment opportunities (e.g., industries building state-of-the-art factories) can limit out-migration of technical and entrepreneurial talent. the goal of this planning grant is to pilot new extended reality (xr)-enabled stem educational delivery models developed in collaboration with youth and adults in rural communities with large numbers of low-skilled workers. xr-enabled solutions can support active and experiential learning by enhancing hands-on activities, creating simulations of objects and experiences that may not be accessible in the physical world, and promoting learners' engagement with complex real-life problems. the planning research consists of three main activities: 1) identify stakeholder needs and aspirations for new place-based educational curricula in stem fields and entrepreneurship in partnership with the storm lake community via workshops, interviews, and focus groups; 2) use workshops to co-design (designing with as opposed to designing for) innovative xr-enabled technology delivery models to meet these needs; and 3) assess the outcomes of the pilot project via surveys. these activities will help address two research questions: 1) how can inclusive and place-based educational delivery models for rural workforce development benefit communities with large numbers of low-skilled workers? 2) which xr-enabled smart and connected technology solutions will improve inclusive and place-based stem educational delivery models in a rural community with a large number of low-skilled workers? this project is a partnership between iowa state university, iowa 4-h youth development, and the storm lake community school district. the city

of storm lake (pop. 10,600) was chosen as the site for these pilot activities because it is a rural iowa community with a large low-skilled workforce employed in the agroindustrial sector and a k-12 student population that is 64% english language learners and 85% students of color. the results of the planning grant will yield new insights into the educational needs of rural communities, and the opportunities and barriers that place-based technologies can offer for supporting those educational needs, which is an underexplored area in the literature. thus, this work is aligned with the smart and connected communities program, which endeavors to integrate community stakeholders into smart and connected community projects to co-create and pilot solutions that are directly informed by the needs, challenges, and opportunities of present and future communities. this project is also being funded via the nsf improving undergraduate stem education program, which seeks to support projects that have high potential for broader societal impacts, including improved **\*\*diversity\*\*** of students and instructors participating in stem education, professional development for instructors to ensure adoption of new and effective pedagogical techniques that meet the changing needs of students, and projects that promote institutional partnerships for collaborative research and development. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: FET: Medium: Robust Quantum Networks via Efficient Entanglement Distribution

Awardee: Duke University

Amount: \$150,000.00

Abstract: quantum computing has the potential, if realized, to significantly alter the computing landscape. however, building large-scale quantum computers is a key challenge. quantum networks (qns) enable the construction of large, robust, and more capable quantum-computing platforms by connecting smaller quantum computers. networked quantum systems have the potential to

significantly alter various activities in society by leading to faster development in medicine and engineering; more secure and privacy-preserving communication; and hitherto infeasible optimizations that leverage the immense computational power to identify efficiencies in manufacturing, logistics, finance, etc. this project is also using the potential and attractiveness of qns to design and offer a variety of educational programs, including a flexible post-baccalaureate program in quantum computing and networking to cater to non-traditional students, improve the **\*\*diversity\*\*** of undergraduate and graduate student body, and develop a quantum capable workforce.

building qns that support robust communication across nodes requires several fundamental scientific and technological advances, especially since classical techniques cannot be directly used in the quantum regime. qns can be used to build quantum computing systems that are more capable and more resilient than stand-alone quantum computers. this project is examining the design and implementation of qns from the ground up by developing an infrastructure for efficient communication and management of quantum entanglements in the network. in addition, the project is addressing specific challenges in two key applications of qns: (i) distributed quantum algorithms, and (ii) quantum sensor networks. the project is evaluating the developed techniques using large-scale simulations and over a 6-node qn testbed spread across long island, ny. the testbed is providing a high-fidelity platform to evaluate the effectiveness of our developed techniques. overall, the project has three research thrusts. in the first thrust, the project is developing an infrastructure to facilitate efficient communication and entanglement management. in particular, it is developing optimization techniques for (i) efficient generation of long-distance entanglement using multiple paths, and (ii) efficient distribution of pre-distributed entanglements. in addition, the project is developing efficient entanglement-distillation strategies in practical settings, and protocols for multicast primitives. in the second thrust, the project is addressing challenges in the context of two key qn applications to corroborate and validate the developed techniques. in particular, the project is developing optimization techniques for efficient distributed implementation of centralized quantum circuits; efficient distributed implementations are important for qn's computational success. in the

context of quantum sensor networks, it is designing efficient protocols for the estimation of binary parameter functions and investigating the benefit of entanglements in these settings. in the third thrust, the project is evaluating the above techniques using large-scale simulations and a small qn testbed. to evaluate qn performance effectively, the project is formulating novel performance metrics for qns; this requires non-trivial generalization of the classical network metrics. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Catalyst Project: Microbial trophic complexity in waterbodies: elucidating the role of algal-microbiome-nutrient interactions in harmful algal bloom formation

Awardee: Alabama State University

Amount: \$150,000.00

Abstract: catalyst projects provide support for historically black colleges and universities to work towards establishing the research capacity of faculty to strengthen science, technology, engineering, and mathematics undergraduate education and research. it is expected that the award will further the faculty member's research capability, improve research and teaching at the institution, and involve undergraduate students in research experiences. this project at alabama state university intends to investigate the role of microbial (bacteria, protists, algae) **diversity** and nutrient enrichment in the formation of harmful algal blooms (hab) in collaboration with researchers at auburn university. the project will contribute to efforts aimed at establishing an active research and training program in microbial ecology for educating and mentoring minority students. aquatic microbial **diversity** and trophic complexity represent a diverse set of prokaryotic and eukaryotic microbes. the role of aquatic microbes in reducing nutrient loads (via nutrient assimilation or cycling) and controlling other invasive or harmful microbial species such as microcystis spp., is acknowledged, though less explored. this project will mechanistically test the role of nutrient inputs and microbial **diversity** in the survival of microcystis spp., and hab formation in lab and field experiments using multi-omics approaches. the results from this project may contribute to a broader understanding of microbial factors underlying hab formation and control in waterbodies. overall, the proposed research may help us develop strategies aimed at predicting and controlling habs in the context of microbiome **diversity** and ecosystem functioning research. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: SRS RN: Convergent Innovations in Regional CirCULAR Economies (CIRCULAR)

Awardee: University of Illinois at Chicago

Amount: \$149,994.00

Abstract: a research network organized around the goal of creating and implementing circular economy solutions could address growing social, economic, and environmental impacts facing regional systems. using a case study based upon the city of chicago and its surrounding urban-rural linkages, research network planning will explore the underlying system structures and interactions that give rise to unsustainable resource consumption and waste generation. the planning will also identify potential solutions grounded in the emerging field of circular economy. the planning team will engage interdisciplinary researchers and non-academic partners in a process to co-create a research agenda for transforming regional systems towards circular economy. the group also will explore convergent research mechanisms for the deep integration of knowledge, methods, tools, and expertise from diverse perspectives that can advance the study of regional circular economies. finally, the team will devise a collaborative platform on which the scientific community and key stakeholders can share knowledge, translate findings, and enhance **\*\*diversity\*\*** and engagement. a planning activity will be undertaken to analyze how different actors in a regional circular economy affect the stocks, flows, depletion and regeneration of various types of capital, and how explicit identification of these flows might shape potential innovations. new thinking, technologies, and business models will be explored to tackle the circular economy challenge from the front end of the supply chain by re-designing products and developing resource sharing models and from the back end by closing material loops. the creation of circular economy business opportunities, especially in marginalized urban and rural communities, will be addressed through convergent approaches encompassing multi-capital flows, data science, and public policies with participatory co-design methods. this approach elevates the knowledge and experiences of diverse participants to that of subject matter experts so that any innovations developed will result in resource conservation and will meet community needs. the team's community partners are leaders in developing and implementing

new models that seek to broaden the influence of circular economy-based solutions. throughout the efforts of this planning activity, the importance of justice, equity, **\*\*diversity\*\*** and inclusion to the project's framing of circular economy will be emphasized. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: EAGER: Lip Reading by Unobtrusive Multimodal Sensors and Machine Learning Algorithms

Awardee: SUNY at Stony Brook

Amount: \$149,878.00

Abstract: the project aims to build an unobtrusive system to enable lip reading for patients with amyotrophic lateral sclerosis (als, also known as lou gehrig's diseases) and individuals with speech and hearing disorders. although there is rich literature on lip reading, the bulkiness, obtrusiveness, and/or immobility of these solutions impedes their applications in daily practice, especially for patients with neuromuscular disorders. there is an urgent need to develop novel lip-reading technologies to improve the communication capabilities of als patients with loved ones and healthcare providers. the proposed system can considerably improve on existing solutions for tracking and interpreting facial movements and more broadly, body movements, such as finger motions and body gestures. the ability to gather multimodal motion patterns from unobtrusive

sensors and apply machine learning (ml) to interpret the acquired data would greatly facilitate diagnosis, treatment, and rehabilitation of motion-related disorders, such as stroke and parkinson's disease. in addition, this work paves the way for the development of nonverbal communication interfaces enabled by facial/body gestures and opens new avenues for rehabilitation, robotics, and human-machine interfaces. this project presents an excellent opportunity for students to participate in cross-disciplinary research. part of the research will be integrated into the pi's courses and capstone design projects. the pis are committed to outreach activities and increasing the **\*\*diversity\*\*** through local minority organizations and the vertically integrated program at stony brook university.

the overarching goal of this project is to build an unobtrusive hardware-software platform for als patients that can capture speech-relevant lip gestures and decode lip movements for speech. first, a skin-like multimodal strain and electromyography (emg) sensing system will be designed to track both skin deformations and muscle activities associated with lip movements. self-assembled structures will be introduced to render the sensors ultrathin, breathable, and semi-transparent. second, the feasibility of converting the sensed lip signals to corresponding spoken words will be demonstrated. modern ml methods, and in particular, ensemble gaussian processes (gps) will be exploited for speech recognition. in the proposed scheme, each gp serves as a classifier and the final decision is made by fusing the results of all the gps by making use of methods within the bayesian framework. the potential contributions of the proposed work include: 1) design of skin-like strain and emg sensors with high sensitivity and good skin compatibility through a scalable self-assembly process. 2) integration of multimodal sensors for comprehensive in-vivo quantification of lip movements associated with speech. 3) development of ml algorithms that precisely convert lip movements to speech. 4) laying the grounds for developing a truly natural and unobtrusive hardware-software system for lip reading. our proposed work can fill the gaps in the existing solutions by an intuitive and unobtrusive technology for lip reading.

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Amount: \$149,878.00

Abstract: the project aims to build an unobtrusive system to enable lip reading for patients with amyotrophic lateral sclerosis (als, also known as lou gehrig's diseases) and individuals with speech and hearing disorders. although there is rich literature on lip reading, the bulkiness, obtrusiveness, and/or immobility of these solutions impedes their applications in daily practice, especially for patients with neuromuscular disorders. there is an urgent need to develop novel lip-reading technologies to improve the communication capabilities of als patients with loved ones and healthcare providers. the proposed system can considerably improve on existing solutions for tracking and interpreting facial movements and more broadly, body movements, such as finger motions and body gestures. the ability to gather multimodal motion patterns from unobtrusive sensors and apply machine learning (ml) to interpret the acquired data would greatly facilitate diagnosis, treatment, and rehabilitation of motion-related disorders, such as stroke and parkinson's disease. in addition, this work paves the way for the development of nonverbal communication interfaces enabled by facial/body gestures and opens new avenues for rehabilitation, robotics, and human-machine interfaces. this project presents an excellent opportunity for students to participate in cross-disciplinary research. part of the research will be integrated into the pi's courses and capstone design projects. the pis are committed to outreach activities and increasing the **\*\*diversity\*\*** through local minority organizations and the vertically integrated program at stony brook university. the overarching goal of this project is to build an unobtrusive hardware-software platform for als patients that can capture speech-relevant lip gestures and decode lip movements for speech. first, a skin-like multimodal strain and electromyography (emg) sensing system will be designed to track both skin deformations and muscle activities associated with lip movements.

self-assembled structures will be introduced to render the sensors ultrathin, breathable, and semi-transparent. second, the feasibility of converting the sensed lip signals to corresponding spoken words will be demonstrated. modern ml methods, and in particular, ensemble gaussian processes (gps) will be exploited for speech recognition. in the proposed scheme, each gp serves as a classifier and the final decision is made by fusing the results of all the gps by making use of methods within the bayesian framework. the potential contributions of the proposed work include: 1) design of skin-like strain and emg sensors with high sensitivity and good skin compatibility through a scalable self-assembly process. 2) integration of multimodal sensors for comprehensive in-vivo quantification of lip movements associated with speech. 3) development of ml algorithms that precisely convert lip movements to speech. 4) laying the grounds for developing a truly natural and unobtrusive hardware-software system for lip reading. our proposed work can fill the gaps in the existing solutions by an intuitive and unobtrusive technology for lip reading. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: High-throughput discovery of microbial genes conferring improved root colonization.

Awardee: North Carolina State University

Amount: \$149,858.00

Abstract: plant roots are surrounded by billions of microscopic organisms called bacteria. these bacteria help the plant obtain nutrients and grow. because of how important bacteria are, many people are interested in developing fertilizers containing bacteria to help plants grow better. however, it has become clear that while some bacteria, when added to a growing plant, can help them grow under artificial laboratory conditions, hardly any bacteria can help a plant grow when applied under realistic conditions. we would like to understand why some bacteria are able to help plants grow, while some bacteria cannot. to do this, we will study the genes that growth-promoting



bacteria have, and determine whether these genes can convert a non-growth-promoting bacteria into a growth-promoting one. this work will be performed in corn, and will train one graduate student. beneficial microorganisms can greatly improve crop plant performance, motivating their use as seed inoculants. however, exogenous microbes are often outcompeted in the field, which limits their utility and reveals fundamental gaps in our understanding of root colonization. the rationale for this proposal is that the genes that are most important for colonizing the root are largely unknown. recent work using comparative genomics and knockout mutants has provided the first insights into the genes involved in root colonization. however, a complete picture of colonization must include how to enhance it, an understanding that is not currently available. since root colonization is multifaceted (encompassing interactions with other microbes, the host, and abiotic soil conditions) it is expected that a **\*\*diversity\*\*** of microbial and plant genes will impact root colonization. to parse this complexity, we will use a functional metagenomics approach to screen for genes conferring improved colonization maize under three different nutrient conditions. this work will therefore advance our understanding of root colonization and our ability to identify microbes that exert beneficial effects for prolonged periods. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: FW-HTF-P: Office Work in the AI Age

Awardee: University of Iowa

Amount: \$149,675.00

Abstract: office work is an important part of the american workplace across sectors, involving tens of millions of workers. further, doing office work is not just about the processing of paperwork and information; it also involves organizational knowledge, communication and relationship building, and other interpersonal skills. these twin issues of job reliance and job complexity raise concerns for the

design of artificial intelligence-based office automation tools that use software agents, machine learning, and data analytics. many such tools are designed without workers' needs or organizational complexity in mind; mistakes here can lead to reduced quality of life and job loss for workers, and worse outcomes for firms and customers. this planning project will develop a multi-disciplinary research agenda toward the careful scientific study of both office work and the design of automation that affects it, with the goal of improving both office automation and training and outcomes for workers. the project involves three main activities. the first is a comprehensive literature review using a combination of the critical review method, the systematized review framework, and a review of state-of-the-art office automation systems. the second involves qualitative analysis of a series of focus groups conducted with a broad sample of office workers about their daily work practices and challenges, their professional development and training, and their perceptions about the future of their job and of office automation. the third main activity is a three-day ideation workshop that will build on the findings from the first two activities. the research team will convene multidisciplinary academic and industry experts from human factors, computer science and artificial intelligence, economics, labor and human resource management, public policy, and equity and **\*\*diversity\*\*** to identify domains of office work and research themes that look most interesting, promising, and impactful for future research. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: FW-HTF-P: Office Work in the AI Age

Awardee: University of Iowa

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Matched Words: diversity

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Title: Collaborative Research: LTREB Renewal: Long-Term Dynamics of Amphibian Populations Following Disease-Driven Declines

Awardee: University of California-Berkeley

Amount: \$149,431.00

Abstract: this project will examine the processes of invasion of a novel pathogen into a population for the case of a fungal pathogen that causes the disease chytridiomycosis in frogs and salamanders. outbreaks of emerging infectious diseases are increasingly recognized as major threats, not just to human populations but also to wildlife, and they increasingly threaten global bio\*\*diversity\*\*. the initial invasion of a novel pathogen into a susceptible host population can cause a disease outbreak resulting in high levels of mortality and declines in population size. when this happens, natural selection can occur for both the host and pathogen populations resulting in evolutionary changes in the host's susceptibility and tolerance to infection by the pathogen and the pathogen's ability to damage the host (virulence). these changes can in turn determine whether the host population can persist and recover from the disease. understanding these evolutionary processes is crucial in development of conservation strategies for threatened species. chytridiomycosis has had catastrophic effects on amphibians worldwide, and has been linked to numerous species extinctions in recent decades and many more species at risk. the researchers will investigate the patterns of evolutionary change in both the pathogen and the host (mountain yellow-legged frogs), following the invasion of the disease into hundreds of high elevation lakes in the california sierra nevada. this project will contribute to the understanding of the role of infectious diseases, such as chytridiomycosis, as agents of evolutionary change in natural populations. it will provide critical information to state and federal agencies, facilitating endangered species recovery and will train and educate undergraduates, graduate students, and the general public. this research builds on data from a long-term study of the population dynamics of mountain yellow-legged frogs (*rana sierrae* and *rana muscosa*) in the complex landscape of the california sierra nevada, and the affects of *batrachochytrium dendrobatidis* (bd) as it has invaded and spread through hundreds of frog populations. in most cases, invasion of bd results in outbreaks of the disease chytridiomycosis, rapid frog population declines, and local extinctions. in some cases, long-term persistence of frog populations occurs with bd in an enzootic state in which the impact of

the pathogen is greatly reduced. the research will extend and leverage 25 years of host population and disease data and archived genetic samples from *r. sierrae*/*r. muscosa* and *bd*. these resources will provide insight into how populations of both host and pathogen change during the transition from pre-pathogen arrival, to disease outbreak, to enzootic disease, to potential recovery of the pre-disease host population abundances. this dataset will be used to investigate the genetic basis for differences in host resistance/tolerance and pathogen virulence. cutting-edge genomic analysis of existing frog and fungal samples will complement laboratory experiments on *bd* virulence and frog susceptibility using *bd* cultures and frog mucosal samples from wild host populations. continued surveys of wild host populations will identify new disease outbreaks and describe the transition from initial outbreak to persistent enzootic state. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: IRES Track II: Rivers of the Andes Field Training

Awardee: University of Montana

Amount: \$145,456.00

Abstract: this project will train students in interdisciplinary, international river sciences and prepare them for the stem workforce, for their research, and for applying river science toward developing sustainable solutions to the human-induced stresses on rivers in the andes and globally. the proposed 12-day advanced studies institute will immerse 14 us-based graduate students in innovative field training in hydrology, geomorphology, and ecology for, in each of two years. working in the magdalena river basin, colombia, students will learn cutting-edge field, remote sensing, and computational tools, develop critical and systems thinking, and complete team-based research projects. students will work with instructors from university of montana, university of colorado, and colombia, taking advantage of long-term research sites in the magdalena river basin and broad

expertise. the rivers of the andes field training course will recruit a diverse group of students that broadens participation in sciences, and course materials and lessons learned will be shared openly and widely. river systems are under stress from climate change and growing demands for water, energy, and food. there is a strong disconnect, however, between where research and teaching about fluvial processes is concentrated, and where stresses on river systems such as new dam construction and associated impacts on humans and bio\*\*diversity\*\* are more recently evolving, such as in the andes. moreover, innovative and interdisciplinary approaches are needed to address challenges such as those surrounding river systems and to prepare students for the 21st century workforce. to address these challenges, we propose rivers of the andes field training (raft), a course to be taught in colombia that will provide field-based training in river sciences. course content will focus on hydrology and fluvial geomorphology, especially river mechanics, floods, and sediment regimes, and complementary content in tropical fish ecology and basin-scale, cumulative-impact and decision-support analysis. raft will use the magdalena river and its tributaries as a field site to illustrate broader content about river processes and andean rivers. the course will augment field training with classroom teaching about fluvial processes and observational, measurement and modeling approaches for understanding river processes. raft will provide a transformative experience for graduate student participants by combining innovative approaches and technologies with evidence-based best practices to not only advance knowledge of river sciences and associated tools, but also to promote critical and systems thinking and observational, interdisciplinary, and teamwork skills. raft will include international and multicultural experience, interdisciplinary teaching on cutting-edge process knowledge and tools, training in cross-scale and systems thinking, team-based projects, and practice in science communication. participants will be equipped to tackle wicked problems at the nexus of water, energy, and food systems and to apply science toward sustainable solutions to the challenges surrounding rivers in the andes and in the anthropocene. this project is jointly funded by the nsf office of international science and engineering (oise) and the established program to stimulate competitive research (epscor). this award reflects nsf's statutory

mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: A Data-Driven Employer-Academia Partnership for Continual Computing Curricular Change

Awardee: University of Illinois at Urbana-Champaign

Amount: \$144,647.00

Abstract: this project aims to serve the national interest by improving the supply of well-prepared computer science professionals capable of addressing the needs of american employers in the public and private sectors. this project intends to build a national partnership between employers and academia to help identify and mitigate gaps between the competencies of computing graduates and the expectations of potential employers. the project will survey computer science educators and practitioners to develop a model that defines the competencies expected by potential employers. the project team then plans to test the model at three institutions of higher education in alabama ? the university of alabama, tuscaloosa, tuskegee university, and shelton state community college. finally, the project team intends to develop tools and methods for institutions to identify and implement competency-based educational approaches for computer science across the nation. the project plans to use three interconnected strands of evidence-based activities to institute transformational change in the involved communities. first, a national strand will engage u.s. faculty in developing competency-based curricula informed by industry practitioner feedback. second, a local pilot strand intends to create transformative curricular change based on student competencies using an evidence-based change model in the three alabama institutions. sociologists and computing faculty on the team will help to understand, predict, and reduce barriers to competency-based employment of computing graduates from marginalized communities in the heart of the impoverished alabama black belt. the unique perspective relative to **\*\*diversity\*\***, equity, and

inclusion needs should serve as a model for other computing departments. the third strand will develop competency-based surveys for practitioners and academics to identify and refine specific competencies that are hoped to drive continual curricular change. outcomes, including the change process, national workshops, and experiences from the local process will help with transferability in the computing education community. in addition to informing curricula, the project will provide valuable data for educational researchers to help close the gap between employers and higher education. finally, as the competency approach to curricular design is relatively new in computing and engineering disciplines, lessons from this project will have the potential to transform curricular review and design in other stem disciplines. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the institutional and community transformation track, the program supports efforts to transform and improve stem education across institutions of higher education and disciplinary communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: A Data-Driven Employer-Academia Partnership for Continual Computing Curricular Change

Awardee: Mississippi State University

Amount: \$142,587.00

Abstract: this project aims to serve the national interest by improving the supply of well-prepared computer science professionals capable of addressing the needs of american employers in the public and private sectors. this project intends to build a national partnership between employers and academia to help identify and mitigate gaps between the competencies of computing graduates and the expectations of potential employers. the project will survey computer science educators and practitioners to develop a model that defines the competencies expected by potential employers.



the project team then plans to test the model at three institutions of higher education in alabama ? the university of alabama, tuscaloosa, tuskegee university, and shelton state community college. finally, the project team intends to develop tools and methods for institutions to identify and implement competency-based educational approaches for computer science across the nation.

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Matched Words: diversity

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Title: Collaborative Research: IRES: Tropical Research Experience in Ecological Science (TREES):  
Regeneration dynamics in a hyper-diverse tropical forest

Awardee: Yale University

Amount: \$142,309.00

Abstract: the number and severity of abnormal weather events, such as storms and droughts, have increased in recent decades all over the world. in the tropical forests of south america, two large drought events occurred in 2005 and 2010, and more will likely happen in the future. although most tropical forests have a regular and predictable dry season that lasts several months, those that lie in the northwestern corner of the amazon region do not. here, high rainfall occurs in every month of the year, and researchers think that these forests may be hit particularly hard by lower rainfall. no one knows if these trees have had any previous experience of drought conditions. if they do grow poorly or die when there is no rain, then the kinds of trees that make up these forests may be quite different in future, leading to changes in how the forest works, as well as in the availability of food for animals and resources for people. this international research experiences for students (ires) project will carry out experiments to look at how tree seedlings of this area respond to drought, and how drought affects the other animals that interact with trees. the award addresses a critical scientific challenge while building capacity and experience in field and lab techniques among u.s. graduate and undergraduate students. to this end, we will mentor six u.s. students every year during the spring semester before, and fall semester after, they embark on an overseas research experience in ecuador, working with long-term collaborators of pis queenborough and metz at pontificia universidad catolica del ecuador, as well as with ecuadorian students. masters? and undergraduate students from yale university will be paired with undergraduates from lewis & clark college, a primarily undergraduate institution, to develop and conduct ecological research in a remote field station in the amazon rain forest: yasuni national park. this project will address a key knowledge

gap in forest ecology and climate change science: how do aseasonal ever-wet tropical forests respond to drought and natural enemies? the answer has clear implications for theoretical ecology (how infrequent disturbance, i.e., drought, affects the dynamics and composition of diverse ecological communities), climate change ecology (how forest structure, composition and distribution will likely change in the future), and policy (whether tropical forests remain a net carbon sink, or switch to a net carbon source thereby accelerating climate change). tropical aseasonal ever-wet rain forests are characterized by high rainfall and no dry season, as well as high biological **diversity** and globally significant carbon stocks. however, anthropogenic climate change is predicted to lead to increases in the frequency and severity of droughts in south america. drought is expected to act synergistically with other abiotic and biotic factors such as the pests and pathogens that drive the negative density-dependence that helps maintain the high **diversity** found in the tropics. recent work has focused on the impacts of drought on tropical seasonal forests, yet virtually nothing is known about how pest and pathogen pressure varies with water availability in the aseasonal ever-wet tropics nor how increasing drying may change the structure and function of these forests. this project, therefore, will investigate the interaction between climate and natural enemies on the performance of trees in a hyper-diverse, aseasonal tropical rain forest in the northwestern amazon. specifically, the research team will use experiments to test the effect of variation in water availability on pest and pathogen attack on young seedlings and how these effects will likely alter the strength and direction of negative density dependence; this information will transform current theoretical understanding of how these two factors affect tree performance, **diversity**, and distributions. results will also provide key information on how these economically and ecologically valuable, yet largely unknown, forests will change in a future of increasing drought. the prime goal of this project is to build capacity and experience in field and lab techniques among u.s. graduate and undergraduate students. to this end, the pis will mentor six u.s. students every year during the spring semester before, and fall semester after, they embark on an overseas research experience in ecuador, working with long-term collaborators of pis queenborough and metz at pontificia

universidad catolica del ecuador, as well as with ecuadorian students. masters and undergraduate students from yale university will be paired with undergraduates from lewis & clark college, a primarily undergraduate institution, to develop and conduct ecological research in a remote field station in the amazon rain forest: yasuni national park. yasuni national park and the associated forest dynamics plot are unique scientific resources. exposing u.s. students to the incredible richness of the most diverse forest in the world is an inspiring and humbling experience. students will be involved in meaningful research that is directly contributing to a broad understanding of the fundamental mechanisms that structure ecosystems and communities. ensuring that students understand how such science is conducted and how they can contribute is essential for how future generations decide to manage the world they inherit. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Mississippi Medical Center

Amount: \$141,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the

foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Mississippi Medical Center

Amount: \$141,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Massachusetts Lowell

Amount: \$141,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides

three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Massachusetts Lowell

Amount: \$141,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: South Dakota School of Mines and Technology

Amount: \$141,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a

highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Central Michigan University

Amount: \$141,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: South Dakota School of Mines and Technology

Amount: \$141,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Central Michigan University

Amount: \$141,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award



reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Idaho State University

Amount: \$141,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: California State University-Long Beach Foundation

Amount: \$141,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in

science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Integrative ecological perspectives on extinction processes - a multi-proxy case study of Hispaniolan subfossil and extant rodents

Awardee: Pennsylvania State Univ University Park

Amount: \$140,941.00

Abstract: this project brings together researchers and educators specializing in genetics, anatomy, and ecology to explore the factors that led to the recent extinction of endemic rodents on hispaniola. hispaniolan rodents provide an exceptional case study for examining the triggers and timeline of island extinction events. bio\*\*diversity\*\* loss is a global concern, and over 70% of mammalian extinctions in the last 500 years have occurred on islands. the caribbean has suffered the greatest species loss of any region in the world. fossil data generated from this project have the potential to contribute to conservation policy by clarifying which factors most contributed to extinction events, and will be helpful for understanding the disappearance of species on other islands. this project will contribute to education by providing mentorship to young scientists at multiple levels, including caribbean and caribbean-american undergraduates and by developing teaching modules for k-12 students. finally, a database of extinct hispaniolan mammals will provide better public access to scientific information both in haiti and the usa. this project will use morphometrics, stable isotope ecology, and ancient dna to (1) identify the ecological relationships among hispaniola's extinct endemic rodents, (2) determine the timing of species loss, (3) resolve phylogenetic relationships

among extinct taxa, and (4) clarify extinction triggers. the research team will rely on previously collected fossil material from three paleontologically-rich caves on the tiburon peninsula in southwestern haiti. the data generated will allow a more nuanced understanding of the roles that human behavior, climate, and individual species characteristics (e.g., body size, habitat, genetic **diversity**) have played in extinctions on hispaniola. the data generated can be leveraged by conservation biologists to inform conservation policy aimed at preserving the remaining biological **diversity** on hispaniola and in island systems more generally. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Characterizing Inclusive Strategies that Retain Black Students in Computer Science to Graduation and Beyond

Awardee: Howard University

Amount: \$139,407.00

Abstract: this iuse project aims to serve the national interest by identifying factors that lead to the lack of **diversity** in computing professions. research has shown that the first two years of science, technology, engineering, and mathematics (stem) majors are often where students are lost in the pipeline. this project will identify factors that affect the retention and graduation of under-represented minority students in the computing major. the goals are to identify inclusive strategies for success in computing programs and investigate ways to increase the retention and post-graduation success of black students in computing. of particular interest are strategies that are transferable to different types of institutions and stem fields in general. this project features a collaboration between two historically black colleges/universities and a primarily white institution that will work together to understand the challenges facing each institution and the strengths each institution brings to addressing this problem. through detailed transcript analysis, this research will take an

asset-based approach, focusing on the strengths of students succeeding in the major. two cohorts of lower division (freshman and sophomore) black cs students from two historically black colleges/universities (hbcus) and one primarily white institution (pwi) will be studied to measure perceived societal impacts and their understanding of content through conceptual assessment instruments. a cohort of upper division students will be studied to measure the factors that led to their success using surveys, a content assessment, and interviews. using a mixed methods analysis approach, white students will be compared to black students at the research intensive pwi and then the principal investigators will compare black students at the pwi to black students at the two hbcus. the goal is to expand knowledge of inclusive teaching strategies and provide institutional awareness of factors that can go beyond recruiting urms to focus on retention in the major and student success post-graduation. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through its engaged student learning track, the program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: BCSER: Using Virtual Reality to Train Geo-Spatial Reasoning

Awardee: Juniata College

Amount: \$138,607.00

Abstract: spatial reasoning skills include the abilities to visualize, interpret, and manipulate information in two dimensions (2d) and three dimensions (3d). these skills predict students' persistence and success in stem fields and are recognized as crucial aspects of geoscience education. thus, teaching undergraduate students spatial reasoning skills is expected to enhance their retention in stem fields and ultimately increase the number and **\*\*diversity\*\*** of stem professionals nationally. this project will study the effects of virtual reality (vr) training on students' spatial reasoning in geoscience contexts and, in the process, develop the principal investigator's (pi's) stem education research expertise. the project is supported by nsf's ehr core research building capacity in stem education research (ecr bcser) program, which is designed to build individuals' capacity to carry out high quality fundamental stem education research in the core areas of stem learning and learning environments, broadening participation in stem fields, and stem workforce development. stem professionals tend to have strong spatial reasoning abilities, and spatial abilities in adolescence correlate with persistence in stem fields. decades of research indicate that these skills can be significantly improved with training, which presents an opportunity to improve student retention in stem fields. the specific objectives of the project are (1) to develop the pi's stem education research skills and expertise; and (2) to design, implement, and disseminate the findings from a pilot study of the efficacy of vr training modules at juniata college and the university of south carolina at columbia. the pilot study will measure geoscience students' spatial reasoning skills before and after participating in either a vr training module or a more traditional training activity. the pi will work with an advisory board to evaluate the success of the professional development activities and pilot research project. the research, associated presentations, and interaction with the advisory board will contribute to the growth of the geoscience education research community through numerous new collaborations and related projects, as well as stimulate interest in education research among students and faculty members at the pi's home campus. improved training in spatial reasoning also has the potential to promote broader participation, retention and inclusion in stem fields. this award reflects nsf's statutory mission and has been

deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Ecological drivers of chemosensory gene family evolution

Awardee: Quinteros, Kevin

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, broadening participation of groups under-represented in biology. the fellowship supports a research and training plan for the fellow that will increase the participation of groups underrepresented in biology. a principal difficulty in biology is understanding how complex traits in an organism diversify, since complex traits can serve numerous functions and are controlled by multiple genes. plants and insects are the two most diverse groups on earth and are important to multiple ecosystems. the ability to detect floral scents by insects affects many plant-insect interactions. this project will investigate the genetic evolution of insect smell (olfaction). this research will combine gene-level data with the knowledge of a panamanian insect communities and plant-insect associations. integrating these biological scales can help our understanding of how and why environmental and ecological variation generates and maintains variation in complex traits. the fellow will develop a science communication workshop to foster a collaborative mentoring environment between college students and scientists. insect chemosensory gene families on the antennae participate in the olfactory recognition of floral scents. this project will unravel ecological factors contributing to the genomic evolution of floral scent detection in the highly co-evolved symbiosis between figs (genus ficus) and fig wasps (superfamily chalcidoidea). by addressing three questions: (1) does pollinating and non-pollinating fig wasp attraction to the same fig host result in convergent evolutionary patterns at the genomic level? (2) is greater host breadth and attraction to a larger **\*\*diversity\*\*** of floral scents

associated with greater chemosensory gene family variation? (3) is a larger effective population size also associated with greater chemosensory gene family variation? to answer the aforementioned questions, the fellow will use next-generation sequencing to construct de novo genomic references. furthermore, the fellow will incorporate comparative genomics with fig wasp community composition, estimates of effective population size, and plant-host association. this project will provide opportunities for the fellow to gain new skills in genomics, de novo genome assembly, and wet lab techniques. the broader impacts of this project include the development of a grant writing and science communication workshops with the goals to (1) disseminate tips and information on grant writing, (2) foster a mentoring environment in which participants can share their research, and (3) help establish professional connections and mentoring relationships among participants. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Towards an integrative understanding of conspicuous signals: phenotype, genotype, and adaptive function of a selected trait

Awardee: Khalil, Sarah

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2020, broadening participation of groups under-represented in biology. the fellowship supports a research and training plan for the fellow that will increase the participation of groups underrepresented in biology. this project aims to broaden participation of groups underrepresented in biology in two ways: (1) by implementing a program that will directly increase the **diversity** of postdoctoral scientists and (2) by funding the fellow to engage in novel research in functional genomics. this research investigates how red-backed fairywrens, a small australian bird, produce their red feathers, and how this individual redness may affect male reproductive success. connecting how a signal is produced to the associated reproductive outcomes is a fundamental question in evolution, yet these components are often studied independently. this research will characterize how red feathers are produced by identifying the genes underlying red pigmentation and will use long-term breeding data to track the reproductive success of red-backed fairywren males that vary in plumage color. showy male traits have long captured the imagination of evolutionary biologists. however, insular approaches to studying these mechanisms can hinder an integrated understanding of these traits. the proposed research spans different levels of inquiry to investigate the evolution of the sexually-selected, red plumage in the red-backed fairywren (*malurus melanocephalus*). the fellow proposes to explore the proximate and ultimate mechanisms responsible for the production and maintenance of hue variation, which varies extensively across the species' range. the fellow will collect samples in australia and use genomic and transcriptomic tools to identify candidate loci associated with color production. in addition, this work will identify the direction and strength of selection on loci in response to the observed female preference for redder plumage. the fellow will leverage demographic data from two populations and use quantitative modeling to quantify the adaptive function of plumage and its relationship to reproductive success. the integration of an ecologically relevant trait that influences fitness with species-wide genomic data will prove critical in

understanding phenotypic evolution. the project's broader impacts are designed to close a gap for underrepresented minority scientists by developing a program to target and support graduate students from underrepresented backgrounds when they are at the critical career stage of applying to postdoctoral positions. the proposed research will further broaden **\*\*diversity\*\*** by providing opportunities for underrepresented minority students to gain research experience at the high school and undergraduate level. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Determining the functional and physiological tradeoffs of thermal plasticity on ectotherm hosts combatting a novel pathogen

Awardee: Claunch, Natalie M

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. the united states is home to the highest **\*\*diversity\*\*** of salamanders in the world, but these amphibians are at risk of contracting an invasive fungal pathogen (called batrachochytrium salamandrivorans, or bsal for short) that is responsible for local extinctions of salamanders in europe. this research investigates how environmental temperature affect different salamander species? ability to manipulate body temperature and metabolism to influence immune function and combat bsal. in addition to providing information about management of an emerging disease in salamanders, this project supports the development of salamander-focused education and outreach materials. the fellow will create and disseminate early education lesson plans, host draw-to-learn events, and create informational posters and brochures

on the **diversity** and ecology of salamanders, which will all be made free and available for public use. the fellow will gain training in mentorship of students underrepresented in stem fields and in laboratory and analytical techniques for application in disease ecology research. bsal infects salamanders? major respiratory organ (skin), presenting a clear trade-off between upregulating immune processes at high temperatures while simultaneously increasing demands for oxygen. through experimental infection trials of desmognathus salamanders with and without thermal gradients and integrated assessment of functional genomics, behavior, and physiology, this project will 1) reveal if interspecific differences in disease susceptibility and functional responses are exacerbated by thermal environments; 2) quantify the trade-offs and influence of thermal environment on physiological responses during infection; and 3) provide predictions of the adaptive value of thermal plasticity in limiting disease risk. in addition to training in functional genomics and infection trials, the fellow will gain training in niche modeling to project bsal susceptibility risk across the landscape using information about plethodontid salamander species? thermal preferences. the data generated by this project can later be applied to answer ecological and evolutionary questions in ectotherms such as how phylogeny and local environment influence thermal preferences and tolerance, or how within-species variation may influence the capacity to respond to thermal constraints imposed by climate change. the project supports the fellow?s training in development and subsequent evaluation of educational materials for broad segments of the public. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Macrophysiological patterns in the thermal and optical properties of ant cuticular structures

Awardee: Barrett, Meghan

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, broadening participation of groups underrepresented in biology. the fellowship supports a research and training plan for the fellow that will increase the participation of groups underrepresented in biology. the project seeks to understand the connection between the structure of ant hairs and cuticles and their thermal and optical properties in variable environmental conditions. variation in the thermal properties of ant cuticles and hairs may allow them to heat up in cool environments and stay cool in hot environments. patterns in thermal and optical properties will be analyzed across species along an elevational gradient in the chiricahua mountains in arizona, and within species across latitudinal gradients in north america (from canada to mexico). as the first survey of bio\*\*diversity\*\* in cuticular structures with unique thermal/optical properties, this project will inspire engineering applications for global thermal and energy challenges (solar energy capture, radiative cooling, biomimetic materials, etc.). the fellow will also develop curricular materials about thermal properties of living organisms to be used in high-need los angeles schools and published in peer-reviewed education journals as well as hosting culturally responsive mentoring and grant writing workshops for minoritized students at the host institutions and national conferences. the fellow will use scanning electron microscopy to analyze the microstructure of ant cuticles and hairs, using both existing museum collections of widespread north american ant species and specimens collected by the fellow along an elevational gradient at the southwestern research station in arizona. fourier-transform infrared thermography, reflectance spectrophotometry (from ultraviolet to mid-infrared), and finite element method modeling will be used to analyze the thermal and optical properties of ant cuticular structures. environmental data collected using local weather stations will be used to understand if solar radiation and temperature can predict the optical/thermal properties of ant cuticular structures. the research is integrated with an education plan aimed at increasing participation of underrepresented groups by 1) developing k-12 lesson plans in partnership with noyce scholars and master teacher fellows to be used in high-need los angeles schools, and 2) publishing these plans in peer-reviewed and open access education journals. in addition, the fellow will expand culturally responsive mentoring

programs for minoritized postdocs and students at california state university dominguez hills and university of southern california. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Integrating microbial dynamics into methane models for northern peatland and post-glacial lakes

Awardee: Kuhn, McKenzie Ann

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. northern lakes are important sources of the greenhouse gas, methane ( $\text{CH}_4$ ) into the atmosphere. methane emissions from lakes are expected to increase as the arctic warms, leading to the thaw of ground that has been frozen for hundreds to thousands of years (permafrost) and releasing organic material into lakes, where it can be consumed by microbes and transformed into methane. microbes are the key drivers of methane emissions from lakes. different microbes leave distinct "fingerprints," (isotopic signatures) on methane. these fingerprints are crucial components of global methane models and are used to trace methane in the atmosphere back to its source. however, little is known about which microbes live in northern lake sediments or how microbial activity (methane production) and related methane emissions and fingerprints will change with warming and permafrost thaw. this project will identify microbes present in lake sediments in northern sweden and measure how actively microbes produce methane under different thaw and temperature conditions. this research represents a crucial step towards improving global methane models, which predict annual emissions and help inform policy decisions. the fellow will

also strive to increase **diversity** in stem by mentoring undergraduate students in the field and engaging in k-12 educational activities in new hampshire and northern sweden. the fellow will measure ch4 emissions/signatures, abiotic conditions, and sample sediment from two lakes in northern sweden with contrasting permafrost conditions and potentially different ch4-producing microbes (methanogens). the fellow will analyze sediments for microbial composition (genes) and abundance using 16s rna gene amplicon sequencing. with sediment incubations, the fellow will assess the metabolic activity (phenotype expression) of methanogens under warming conditions using metatranscriptome sequencing. the fellow will leverage a library of metagenome-assembled genomes from environments in northern sweden to map metabolic pathway activity and target specific metabolic genes in methanogens. ultimately, the fellow will build a statistical ch4 model that links microbial dynamics to ch4 emissions and associated isotopic signatures. the fellow will develop mentoring, professional, and research skills through the nsf bii emerge project summer institute for early career researchers and will mentor students in the emerge research experience for undergraduates program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Investigating evolutionary mechanisms that facilitate local adaptation via inversions in the Atlantic silverside

Awardee: rick, Jessica A

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. natural environments are often heterogeneous, with strong

spatial variation in conditions within a species' range. populations within a species gain an advantage by adapting to these differing environments, and such local adaptation can be facilitated by structural variation within an organism's genome. the fellow will investigate how structural genomic variation allows populations to adapt to their environments, as well as how these types of variation enable population divergence and speciation. this research is important to understanding the mechanisms involved in the origin and maintenance of bio\*\*diversity\*\*, and how species may adapt to changing climatic conditions. through this research, the fellow will also broaden participation in stem through mentoring undergraduate students in independent research projects, advocating for open science and reproducible research practices, and training early-career students in open science principles and tools. this research will integrate data from common garden experiments, genomic analyses, and evolutionary modeling to investigate how structural genomic variation?specifically, inversions?facilitate local adaptation in wild populations. it will use the large inversion regions associated with locally adapted phenotypes in the atlantic silverside (*menidia menidia*) as a model system. key outcomes of this project will include: (1) identifying regions within inversions associated with local adaptation phenotypes using a common garden framework; (2) a population-wide selection scan to determine whether differentiation is greatest at inversion breakpoints or at candidate loci within inversions; and (3) simulations to quantify the conditions within which recombination suppression within inversions is a viable evolutionary mechanism for maintaining local adaptation. to achieve these outcomes, atlantic silversides will be collected and raised in a common garden experiment, and phenotypic and whole genome data from these individuals will be collected for analyses. the fellow will additionally facilitate two workshops on the topic of reproducible research, with a focus on bioinformatic workflows, targeted at upper division undergraduate and early career graduate students from historically underrepresented backgrounds in stem fields. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity



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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Investigating evolutionary mechanisms that facilitate local adaptation via inversions in the Atlantic silverside

Awardee: Rick, Jessica A

Amount: \$138,000.00

Abstract: This action funds an NSF postdoctoral research fellowship in biology for FY 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. The fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. Natural environments are often heterogeneous, with strong spatial variation in conditions within a species' range. Populations within a species gain an advantage by adapting to these differing environments, and such local adaptation can be facilitated by structural variation within an organism's genome. The fellow will investigate how structural genomic variation allows populations to adapt to their environments, as well as how these types of variation enable population divergence and speciation. This research is important to understanding the mechanisms involved in the origin and maintenance of biodiversity, and how species may adapt to changing climatic conditions. Through this research, the fellow will also broaden participation in STEM through mentoring undergraduate students in independent research projects, advocating for open science and reproducible research practices, and training early-career students in open science principles and tools. This research will integrate data from common garden experiments, genomic analyses, and evolutionary modeling to investigate how structural genomic variation specifically, inversions facilitate local adaptation in wild populations. It will use the large inversion regions associated with locally adapted phenotypes in the Atlantic silverside (*Menidia menidia*) as a model system. Key outcomes of this project will include: (1) identifying regions within inversions associated with local adaptation phenotypes using a common garden framework; (2) a population-wide selection scan to determine whether differentiation is greatest at inversion breakpoints or at candidate loci within inversions; and (3) simulations to quantify the conditions

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Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: An integrative investigation of host-parasite coevolution across heterogeneous environments

Awardee: Salter, Jessie Frances

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. host-parasite interactions provide a window into how environmental conditions shape traits of interest, which is a key process in evolution that generates biological **\*\*diversity\*\***. this research aims to understand these processes using the northern bobwhite quail (*colinus virginianus*, which display impressive geographic variation in feather color) and their parasitic feather lice as a model system. understanding how environmental change induces changes in traits provides insight into how species evolved and may respond to climate change. bobwhites are a commercially important game species that have experienced population declines of >70% over the past forty years. the interactions between bobwhites and their feather lice are poorly known; this research will provide insight into how feather lice impact bobwhite populations

and may contribute to conservation strategy for this species, which is actively managed in 25 states. to increase broader participation in science, the fellow will develop public exhibits and educational activities based on this research through the natural history museum of los angeles county. parasitism is the predominant life history strategy on earth, yet we have a limited understanding of how host-parasite interactions shape the coevolution of traits in wild populations. bobwhites and their feather lice are a tractable wild system for testing current evolutionary theory and developing new models of host-parasite coevolution across heterogeneous environments. the fellow will analyze phenotypic and ecological data, including parasite abundance, to assess whether feather lice are associated with plumage phenotypes in bobwhites. the fellow will quantify phenotypic and genetic data from lice collected from bobwhite specimens to assess the effects of plumage variation on the phenotypes and genotypes of coadapted lice. finally, the fellow will use cophylogenetic analyses and whole-genome sequence data from range-wide pairs of coadapted bobwhites and lice to test current theories of coevolution and identify regions of the genomes of both species that are under selection due to environmental variation and host-parasite interactions. through these activities, the fellow will support the mentorship and training of two students from underrepresented stem groups. additionally, this research will be conducted in a museum setting, and will develop and improve methods for collecting phenotypic and genomic data from museum specimens. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Integrating genetic-morphologic concepts of diversity in ecological and environmental context

Awardee: Trubovitz, Sarah

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative

research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. currently, we have a limited understanding of how **diversity** is expressed in one of the largest and most critical ecosystems on the planet: marine plankton. this makes it difficult to predict the impacts of climate change and imminent **diversity** loss on key ecosystem functions that society relies on such as primary production and food web interactions between organisms. in order to understand plankton **diversity** and its importance, this project will investigate how **diversity** is expressed in an abundant group of marine protists, the polycystine radiolarians. research will center on the systematic integration of genetic, morphologic, and ecologic information to improve our knowledge of different scales of radiolarian **diversity** and its environmental context. to achieve broader participation, the fellow will mentor undergraduate students at the host institution, and engage the public in locally relevant marine science through outreach programs at the wrigley marine science center. recent surveys of molecular **diversity** have revealed over an order of magnitude more radiolarian species than morphology-based studies. poor harmonization between molecular and morphological taxonomy has made it impossible to pinpoint the reasons for this discrepancy, demanding a reevaluation of classic species concepts and molecular methods. to address this, the fellow will investigate relationships and differences between genetic and morphological concepts of **diversity**. radiolarian samples will be collected from multiple depths at station aloha (hawaii) and classified based on skeletal morphology as well as sequencing analysis of the v4 region of the 18s rna gene. patterns of genetic variation paired with observations of physical specimens and their ecological niche information will be used to determine how genetic **diversity** is expressed both morphologically and ecologically. environmental and biological metadata available for station aloha will be used to interpret the function of hierarchical levels of radiolarian **diversity** in environmental context. research products will include new radiolarian genetic barcodes, which will improve the accuracy of ongoing efforts to monitor global plankton **diversity** dynamics in a changing climate.

the fellow will undergo training in live plankton sampling and molecular analytical methods, as well as gain vital experience in academic mentoring and outreach. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Are variants under selection for disease resistance predictive of disease susceptibility across taxa?

Awardee: Sharo, Andrew George

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. since the 1970's, 3 billion birds have disappeared from north america. infectious disease is an important cause of bird mortality. beginning in 1999, west nile virus rapidly spread across north america, primarily infecting birds and sometimes leading to their death. over the past two decades, house sparrows have evolved resistance to west nile virus, but the mechanism is unknown. this project will identify the genetic mechanisms through which house sparrows have evolved resistance to west nile virus. birds are important vectors for many diseases, and this will be the first project to characterize how birds adapt to west nile virus. the fellow will use this information to predict whether other species of birds are susceptible to west nile virus. the fellow will recruit and train underrepresented minority students at uc santa cruz, a hispanic serving institute, to work on this project. the fellow will also volunteer outreach and teach to diverse undergraduate and k-12 students, inspiring them to pursue stem careers. this project will first generate rna-seq from house sparrows previously infected by west nile virus. these data will be used to identify candidate genes where expression or splicing is associated with west nile viral load. next,

the fellow will identify genetic variants that are under selection in wild house sparrow populations through dna-seq of museum specimens. specifically, the fellow will sequence samples from multiple house sparrow populations before and after the introduction of west nile virus and determine whether adaptation is parallel in response to west nile virus. by limiting our scope to the candidate genes identified previously, this project will identify variants that are likely to mediate west nile resistance. finally, the fellow will develop a west nile virus susceptibility predictor based on these variants and assess its ability to predict susceptibility across avian taxa. the fellow will be trained in state-of-the-art techniques to isolate dna from museum samples and will develop a strong understanding of disease ecology. the fellow will also lead sampling field trips of underrepresented minority students through caledna, a community science initiative to monitor ecological \*\*diversity\*\* through environmental dna. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Mechanisms and consequences of thermal stress effects on cognitive performance

Awardee: Proffitt, Melissa R

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, broadening participation of groups under-represented in biology. the fellowship supports a research and training plan for the fellow that will increase the participation of groups underrepresented in biology. the project will address the need to understand how organisms respond to rising temperatures by measuring the organism's behavior and physiology in response to temperature in two closely related songbirds. these songbirds vary in their ability to tolerate hot temperatures, which will allow the fellow to directly test this question. this research will advance scientific knowledge by providing

insight into how and why different populations of birds vary in their response to heat in a changing climate. the project benefits society by taking a 4-tiered approach to address the need to develop a sense of community to support the recruitment and retention of underrepresented groups at the postdoctoral level. many species are shifting their range in response to changes in climatic conditions that are altering selective pressures. behavior can buffer these effects and facilitate survival. cognitive traits, such as learning, can be particularly vital to survival when facing new challenges and could mean the difference between a species persisting and going extinct in an area. however, not much is known about how variation in thermal tolerance affects behavioral performance, particularly of cognitive traits. the project includes a set of integrative, experimental studies to fill this gap in knowledge by experimentally manipulating air temperature to quantify effects of learning on a spatial foraging task. critically, the approach uses individuals from multiple populations across a latitudinal gradient spanning the shifting range limit of two species of songbird who vary in thermal tolerance, to ask how variation in thermal tolerance affects variation in cognitive performance under thermal stress. overall, the research aims to use thermal stress as a biologically relevant tool to understand connections between behavioral responses to an organisms' environment and underlying physiological mechanisms over different scales from neurons to individuals to populations and species. the project will expand the evolutionary framework of the fellow's research program and her training in designing and analyzing behavioral assays. broadening participation activities focus on building community for postdocs from under-represented groups by organizing career development workshops, a lightning talk series, formalization of postdoctoral committees, and a postdoc run outreach event to provide an opportunity for the younger generation to see **\*\*diversity\*\*** in scientists. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Deciphering the epigenetic signatures associated with invasive capacity in mixed seagrass communities

Awardee: Chiquillo, Kelcie Lorena

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, broadening participation of groups under-represented in biology. the fellowship supports a research and training plan for the fellow that will increase the participation of groups underrepresented in biology. the proposed research addresses the great debate of whether nature (genetics) or nurture (environment) drive biological invasions, i.e., the process where introduced species become harmful, threatening bio\*\*diversity\*\* and natural ecosystems outside their normal range. it is known that nature and nurture work in conjunction to produce biological traits. traits are controlled by genes, and the expression of these genes (or how much these genes are turned on) will change depending on the environment that they are in. not all introduced species become invasive, and this research will help understand how environmental changes are linked to invasions for conservation biology. the outcomes of this research will be to determine which factors and habitat characteristics modify gene expression and promote invasion success. this is particularly important as invasive species can be global threats to local ecosystems, like seagrass meadows, which support a wide variety of life (e.g. fish, sea turtles, manatees and birds); thus, it can have implications on society by altering ecosystem services that people depend on. this project will provide high quality research opportunities to traditionally excluded groups, and indirectly help management in recovery of seagrass communities. the fellow will use both field work and epigenetic technologies to understand the function and modifications of anthropogenic stressors in seagrass meadows and determine what role epigenetic mechanisms play in biological invasions. the fellow will test the hypotheses of whether species interactions, epigenetics, and microbial communities induce the epigenetic signatures of the seagrass invasion and determine the physiological mechanisms that promote an invasive phenotype. for that purpose, this work will characterize epigenetic



modifications, microbial populations, and their interaction with energetic networks (e.g. nutrient acquisition) to promote induced competitive phenotypes linked to acclimatization. in doing so, the fellow will broaden participation by developing a culture-based support program called ?salti: science acceleration and learning techniques inclusivity? week, where nsf research experience for undergraduates students and their families learn hands-on approaches to conducting marine science in south florida. the proposed program will produce engaging science-communication films. by facilitating family support, the **\*\*diversity\*\*** of people who are engaged in science will strengthen, and they and others can gain a deeper understanding of its ecological importance and feel empowered to protect the marine environment. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Habitat suitability: ecocultural restoration in the Klamath Basin

Awardee: Yazzie, Kimberly

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, broadening participation of groups underrepresented in biology. the fellowship supports a research and training plan for the fellow that will increase the participation of groups underrepresented in biology, particularly karuk youth and indigenous students at the university of washington. the fellow will utilize habitat suitability models to characterize the abundance and distribution of cultural keystone species, willow and salmon, in response to ecocultural restoration and ecological disturbance. the project will assess the effects of indigenous fire stewardship on climate adaptation to understand how fire promotes diverse landscape values (e.g., cultural foods and basketry) and restores ecological function (e.g., stream temperature). this research will provide insight to ecological

resilience and ascertain the effects of disturbance on the landscape, including floods and fire. with the largest dam removal project in u.s. history slated to begin on the klamath river in 2023, this research is timely. the fellow will survey pre-dam removal conditions that tribes can use to prioritize and identify optimal pathways for ecocultural restoration across co-managed landscapes. the fellow will assess a habitat suitability model framework coupled with place-based science to characterize habitat loss and species **diversity** of cultural keystone species, plants and salmon, within selected habitat zones identified by the karuk tribe in the mid-klamath basin, california. spatially explicit data and known occurrences of focal species will be used in the model, including a combination of fine-scale and broad-scale ecologically relevant variables (e.g., topography, soils, geology, climate). the fellow will use geospatial methods, aerial imagery and drone footage to quantify standing forest composition. species occurrences will be confirmed with field surveys and independent test locations at different resolutions will determine local-scale model accuracy. the fellow will assess a) the utility of habitat suitability models to determine that ecocultural restoration activities, cultural burns, increase habitat **diversity** of focal species, and b) explore the influence of grain and extent in local to broad-scale model predictions of environmental suitability at different site locations. an intergenerational knowledge exchange, co-mentorship and community participation will enhance research interpretation and outcomes. the fellow will serve as a mentor to tribal youth through a summer internship program and co-develop research materials and publications from this research with the karuk tribe. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Oviposition-relevant gustatory receptor evolution as a missing link governing insect-host plant specialization

Awardee: Godfrey, Rebekah Keating

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. identifying a cohesive theory of insect-host plant associations has proved one of the most challenging biological questions. while the ecological and evolutionary relationships between insects and their host plants often hinge on variation in a few key genes, we know relatively little about which genes drive host plant associations and how variation in these genes affects host plant selection or use. where an insect lays her eggs has very real fitness consequences, making oviposition a strong candidate behavior to connect genetic variation and host plant use. this research will identify taste receptor genes involved specifically in oviposition and quantify variation in these genes within and across species of closely related hawkmoths that vary in host plant use. the fellow will work within the mcguire center for lepidoptera **\*\*diversity\*\*** to directly mentor scientists at the undergraduate and graduate level and to broaden knowledge of and interest in insect neuroscience both in students underrepresented in stem and the general public. this project tests the hypothesis that selection on oviposition-related sensory receptors acts as a primary driver in host breadth in lepidoptera. the project focuses on gustatory receptors (grs) because they are the primary sensory receptors used to sense plant surface compounds and elicit or deter oviposition. the fellow will (1) test whether variation in gustatory receptor genes is associated with host use in species that vary in host breadth, (2) identify gustatory receptor genes involved in host selection by comparing sex-specific gene expression, and (3) test whether variation in receptor gene sequences and gene expression across populations are associated with population-specific host use. this fellowship will provide the fellow with training in collecting and analyzing molecular data from an evolutionary perspective. furthermore, the project will provide functionally relevant targets for gene editing in future neuroethology experiments and will serve as a model for studying natural selection on the nervous system; the fellow's museum outreach activities and involvement of

students in research ensures these ideas and training will reach a diverse, public audience. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Identifying high-risk bioregions and predicting the impact of climate change on the distribution of genetic diversity

Awardee: Boria, Robert A

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. forecasting how bio\*\*diversity\*\* will change in the future due to natural and human impacts is a primary focus of both ecology and evolutionary biology. one factor important to the geographic distribution of \*\*diversity\*\* at multiple levels - genes, species, and morphology - is climate. this proposal will study how populations have responded to past climate change, and how these responses could influence future climate change responses. this research will generate maps of future genetic \*\*diversity\*\* to identify potential areas where climate change could have a significant impact on species \*\*diversity\*\*. understanding the spatial distributions of intraspecific genetic \*\*diversity\*\* and the role of climate refugia in evolutionary and ecological processes is important because it likely determines their potential for persistence in the face of future climate change. determining how the distribution of intraspecific \*\*diversity\*\* of north american taxa was directly influenced by climate and landscape changes may illuminate broad-scale patterns of species? responses to other climatic events, or more generally, to barriers impeding or constraining gene flow. this research will study how populations have responded to past climate change and how the historical distributions and past areas of climate refugia for four small mammals

will influence future climate change responses. this study will utilize an interdisciplinary approach ? three different data types and/or tools (next generation sequencing; gis; bioinformatics) ? to understand how historical events have shaped the current distribution of genetic \*\*diversity\*\* within a widespread species in north america and the impacts on future genetic \*\*diversity\*\*. to broaden participation, the fellow will recruit five high school students from underrepresented groups to help facilitate the research. the fellow will mentor them through their high school education and the college application process. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: The buried solution for agricultural resilience: arbuscular mycorrhizal fungi

Awardee: Guzman, Aidee

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, broadening participation of groups under-represented in biology. the fellowship supports a research and training plan for the fellow that will increase the participation of groups underrepresented in biology. longer and more extreme drought periods pose a substantial challenge for agriculture globally. at the same time, the dominant farming model has dramatically reduced crop \*\*diversity\*\* leading to a decline in soil bio\*\*diversity\*\*, especially in an important group of fungi called arbuscular mycorrhizal fungi (amf). these organisms are known for alleviating plant drought stress. therefore, the goal of the proposed research is to (1) determine the mechanisms by which crop \*\*diversity\*\* and soil fungi are connected, and in turn, (2) understand the functional mechanisms by which plant-fungi interactions buffer crops against drought stress. this research will engage underrepresented students in the local rural communities and at the sponsoring institution. specifically, the fellow will develop a novel and

integrative approach to simultaneously support future stem educators in rural high schools and develop an experiential learning program for high school students in minority-majority rural communities in california's san joaquin valley. crop diversification has emerged as a strategy to harness the potential benefits of soil bio\*\*diversity\*\*, especially amf, to buffer crops against drought, a current and growing threat to agricultural productivity. however, while greater crop \*\*diversity\*\* can enrich amf communities, linking soil bio\*\*diversity\*\* to ecosystem functions in the contexts of agricultural systems remains a fundamental challenge. therefore, more studies are needed to understand how agricultural management may alter fungal community composition and select for fungal traits may or may not alleviate drought stress. this research seeks to fill this knowledge gap by using a novel approach that integrates soil fungal ecology, functional genomics, and plant ecophysiology to test whether crop diversification can positively alter the functional composition of fungi and plant-fungal interactions to alleviate drought stress. by comparing fields with varying levels of crop \*\*diversity\*\* (monoculture versus polyculture) and manipulating water availability, this research will examine the contribution of mycorrhizal fungi (versus non-mycorrhizal fungi) to crop productivity under drought directly in the field. the fellow will also develop an experiential learning program for rural minority-majority high schools to empower underrepresented high school students to pursue stem careers and support future stem educators in rural high schools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: The buried solution for agricultural resilience: arbuscular mycorrhizal fungi

Awardee: Guzman, Aidee

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high school students to pursue stem careers and support future stem educators in rural high schools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Hybridization on the adaptive landscape

Awardee: Patton, Austin H

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. how do new species arise? do they arise in isolation? or can hybridization, the exchange of genetic material between species, instead facilitate adaptation, and speed up the speciation process? recently, there has been growing support for the latter hypothesis but, to date, few studies have experimentally demonstrated that hybridization influences aspects of evolutionary fitness, such as survival, in vertebrate species. this project will address this by combining laboratory studies of feeding performance, fitness experiments in the field, and genetic sequencing of three species of bahamian pupfish. this research will provide insight into the capacity of hybridization to facilitate adaptation to climate-change associated environmental shifts. the fellow will expand participation by involving the bahamian community both in educational and collaborative opportunities, as well as by conducting outreach involving local public schools and community colleges within the bay area. can gene flow promote adaptive radiation? to address this question, the fellow will conduct a comprehensive field fitness experiment, integrating genomic, morphological, environmental, and feeding performance data. the fellow will also quantify the extent to which the visual environment modulates the phenotype-performance-fitness map. using 4,000 experimental hybrids and purebred species, the fellow will measure fitness in high- and low-turbidity lakes and



feeding performance of hundreds of these fish will be assessed in similar environments pre- and post-experiment. these data will be used to construct a genome-phenotype-performance-fitness map, demonstrate the functional consequences of adaptive introgression, and test the hypothesis that environment modulates the phenotype-performance-fitness map. with this experiment, the fellow will quantify the sensitivity of the relationship between morphology, performance, and fitness to a hurricane-induced environmental perturbation of lake turbidity. gaining this understanding is critical to predicting the sensitivity of san salvador island's micro-endemic pupfish **\*\*diversity\*\*** to increased hurricane activity in coming years. this research will provide the fellow with a **\*\*diversity\*\*** of training, from fish care to performance assays, field experiments, selection and genomic analyses. the fellow will establish a collaboration at the university of the bahamas, providing training to their students, and offer lessons on evolution to students at the san salvador island high school. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: : Investigating how neopolyploidy affects the core microbiome and how the extended phenotype can facilitate ecological establishment

Awardee: Anneberg, Thomas

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. polyploidy, or whole-genome duplication, has frequently acted as a mechanism of generating new species. however, first-generation polyploids, or neopolyploids, are expected to suffer from a high risk of local extinction shortly after they arise due to competition with their diploid parents for limited space and resources. despite the expectation that

neopolyploids should go locally extinct shortly after they arise, we see a disproportionately high number of established polyploids in nature. this research will address this apparent gap in knowledge by investigating what factors can drive the establishment of neopolyploid populations. the project will specifically characterize how environmental resource supply and microbial interactions affect the ability of neopolyploids to persist in the presence of their diploid parents and become established. the goal of this research is to understand the ecological drivers of neopolyploid establishment by testing two hypotheses: that neopolyploid establishment is 1) dependent on the external environment, and 2) is facilitated by the extended phenotype: neopolyploid genotypes and their microbiomes. the approach to testing these hypotheses is to first characterize how neopolyploidy affects the microbiome community and shapes host phenotypes. second, to predict the outcome of competition between diploids and their neopolyploid descendants and whether it differs given the extended phenotype, multigenerational competition experiments will be combined with modern coexistence theory. the expected outcomes of this research are to understand 1) how neotetraploidy affects the microbiome composition and **diversity** and 2) how the microbiome affects the competitive ability of neotetraploids against their diploid ancestors, and 3) whether these patterns vary with the genotype of a lineage or across environmental resource gradients. the fellow will use diploid and synthetic neotetraploid duckweeds, which is a uniquely well-suited system for this research since they have rapid generation times and are compact enough to allow high replication across various environmental conditions. additionally, this research will incorporate the mentorship of high school and undergraduate students from under-represented groups to carry out independent research projects, as well as facilitating outreach activities with local intercity classrooms on ecological principles. " this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: How does arbuscular mycorrhizal fungi impact pollination and plant fitness in an anthropogenically disturbed environment?

Awardee: Feters, Andrea Marie

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment, and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. the research will focus on mutualistic interactions between plants, pollinators, and soil-dwelling arbuscular mycorrhizal fungi. the plant-pollinator mutualism may be altered decades after anthropogenic disturbances, like surface mining. plants growing in soils contaminated by mining may lack the resources needed to invest in floral traits attractive to pollinators. however, the presence of arbuscular mycorrhizal fungi could lessen the negative effects of soil contamination on attractive traits. interactions between the plant-arbuscular mycorrhizal fungi and plant-pollinator mutualisms in reclaimed surface mines remain largely unexplored. this research will illuminate how arbuscular mycorrhizal fungi promote attractive floral traits and pollinator visitation, which in turn contribute to plant persistence. the fellow will disseminate the outcomes in many venues, from national meetings to student-led science clubs at the ohio state university. additionally, the outcomes will be used to design guest lectures and a lab module with quantitative and active learning components for undergraduate biology courses; through the research, the fellow will mentor undergraduate students from underrepresented groups. given the extensive impacts of anthropogenic disturbances on natural environments, understanding the role that mutualists play in alleviating the negative effects of these disturbances is a key lesson for researchers and students of ecology alike. the research has two aims. the first is to characterize the arbuscular mycorrhizal fungal mutualists of ten plant species reflective of the plant **diversity** at the wilds, a conservation park with a history of surface mining in cumberland, ohio. the second aim is to determine: 1) whether arbuscular mycorrhizal fungi promote attractive floral traits of one of the focal plant species and

subsequently increase pollinator visitation and plant fitness and 2) whether the fungi mitigate the negative effect of anthropogenic disturbance on the plant-pollinator mutualism via the promotion of floral traits like phenology, color, scent, and nectar quantity. it is hypothesized that plants growing with arbuscular mycorrhizal fungi will have more attractive floral traits, higher pollinator visitation, and higher fitness such that the effect will be greatest when soil contamination is also present. in addition, the guest lectures and lab module will be planned with the best pedagogical practices for increasing equity and inclusion in the classroom. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: How does arbuscular mycorrhizal fungi impact pollination and plant fitness in an anthropogenically disturbed environment?

Awardee: Fetters, Andrea Marie

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment, and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. the research will focus on mutualistic interactions between plants, pollinators, and soil-dwelling arbuscular mycorrhizal fungi. the plant-pollinator mutualism may be altered decades after anthropogenic disturbances, like surface mining. plants growing in soils contaminated by mining may lack the resources needed to invest in floral traits attractive to pollinators. however, the presence of arbuscular mycorrhizal fungi could lessen the negative effects of soil contamination on attractive traits. interactions between the plant-arbuscular mycorrhizal fungi and plant-pollinator mutualisms in reclaimed surface mines remain largely unexplored. this research will illuminate how arbuscular mycorrhizal fungi promote attractive floral traits and pollinator

visitation, which in turn contribute to plant persistence. the fellow will disseminate the outcomes in many venues, from national meetings to student-led science clubs at the ohio state university. additionally, the outcomes will be used to design guest lectures and a lab module with quantitative and active learning components for undergraduate biology courses; through the research, the fellow will mentor undergraduate students from underrepresented groups. given the extensive impacts of anthropogenic disturbances on natural environments, understanding the role that mutualists play in alleviating the negative effects of these disturbances is a key lesson for researchers and students of ecology alike. the research has two aims. the first is to characterize the arbuscular mycorrhizal fungal mutualists of ten plant species reflective of the plant **\*\*diversity\*\*** at the wilds, a conservation park with a history of surface mining in cumberland, ohio. the second aim is to determine: 1) whether arbuscular mycorrhizal fungi promote attractive floral traits of one of the focal plant species and subsequently increase pollinator visitation and plant fitness and 2) whether the fungi mitigate the negative effect of anthropogenic disturbance on the plant-pollinator mutualism via the promotion of floral traits like phenology, color, scent, and nectar quantity. it is hypothesized that plants growing with arbuscular mycorrhizal fungi will have more attractive floral traits, higher pollinator visitation, and higher fitness such that the effect will be greatest when soil contamination is also present. in addition, the guest lectures and lab module will be planned with the best pedagogical practices for increasing equity and inclusion in the classroom. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Comparative methods and model clades for evolutionary developmental biology

Awardee: Church, Samuel H

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. the funded research will use large datasets to investigate how evolution leads to bio\*\*diversity\*\*. methods for collecting large amounts of data with thousands of measured biological traits are becoming increasingly common and inexpensive to generate. examples of such data include developmental assays of gene expression. as this data becomes more common, so do comparisons of these data across species. however, evolutionary biologists have warned for years that comparisons across species must be performed using mathematical models that account for how related species are, or they risk misidentifying patterns across species. this fellowship will focus on developing new methods for comparing data across species. this research is important given that, in this era of rapid global change, robust models of evolution are needed to accurately predict how bio\*\*diversity\*\* is likely to change in the future. furthermore, this research will broaden participation in science by recruiting and mentoring undergraduate students from underrepresented groups in computational biological analysis. this research project will result in a new comparative framework for analyzing high-dimensional data on gene expression across species. gene expression data are common in assays of developmental biology, yet current comparisons of these data across taxa often fail to consider the evolutionary non-independence of observations. there exists a rich literature of comparative methods designed to statistically compare traits across taxa, but their implementation for high-dimensional continuous traits faces technical limitations. to overcome these limitations, first the fellow will identify and extend evolutionary models to describe the distribution of expression data across taxa. this analysis will require the fellow to achieve specific training objectives, including seeking out advanced knowledge in mathematical modeling, to overcome common challenges in analyzing datasets that have many thousands of parameters. second, the fellow will apply these methods to real-world data on gene expression across tissues and species, testing hypotheses about the degree to which phylogeny, gene

pathway, and gene product type explain variation. the results of this study will be a comparative framework that can be immediately applied to datasets of gene expression across species, which will be released as free, publicly accessible, open-source software. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Evolution of the extended floral phenotype

Awardee: Freundlich, Grace

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. the fellow will investigate the effect of biotic interactions on the expression and evolution of floral traits. pollinators are a significant force of selection on floral traits, including size, color, and scent. floral tissues frequently harbor a **\*\*diversity\*\*** of microbes, however, which impact cues important for pollinator attraction, with consequences for host reproduction. despite the potential for such effects, it remains unclear whether microbes can modify pollinator-mediated selection on floral traits. after manipulating interactions among a flowering host, pollinator, and microbes the fellow will use chemical and molecular techniques to assess the strength and direction of selection exerted on floral traits by these biotic interactions. such research will advance pollination biology and inform understanding of factors promoting floral diversification. the fellow will also collaborate with local institutions and programs to broaden participation of underrepresented groups at the middle school, high school, and undergraduate levels through providing opportunities for learning and research. the fellow will test the hypothesis that floral microbes and pollinators jointly shape selection on floral phenotype. using fast-cycling brassica rapa

plants and an experimental evolution framework, the fellow will manipulate interactions among host plant, bumble bee (*bombus impatiens*), bacterium (*bacillus subtilis*), and/or yeast (*metschnikowia reukaufii*) to dissect biotic drivers of floral phenotypic evolution. more specifically, the fellow will address the following three objectives: 1) examination of interactive effects of microbes and pollinators on floral evolution, 2) characterization of molecular mechanisms underlying shifts in floral phenotype, and 3) assessment of reciprocal selection on microbial inhabitants of flowers. by considering such eco-evolutionary dynamics among interacting partners, and taking a multi-level selection approach that employs genomic, transcriptomic, and metabolomic approaches, this study will address an important but understudied component of pollination mutualism and the sources of variation upon which natural selection can act. in performing the research, the fellow will acquire new skills in genomics, transcriptomics, and metabolomics. finally, middle school, high school, and college students from groups underrepresented in the sciences will be included in the research, with the fellow also giving guest lectures in plant science courses and at outreach events. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Fluid homeostasis in the evolution of frog breeding phenology

Awardee: Juarez, Bryan H

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, broadening participation of groups underrepresented in biology. the fellowship supports a research and training plan for the fellow that will increase the participation of groups underrepresented in biology. the goal of this research is to understand the role of aquaporin proteins in allowing frogs to overcome harsh environments, and how this may be related to climate and breeding behaviors. aquaporins allow



water to move across cell membranes and therefore allow frogs to maintain water balance in many different environments. frogs might encounter harsh weather conditions during their reproductive period and must overcome them in order to reproduce and survive. the fellow will obtain data on the genetic **diversity** of aquaporins and other relevant traits from various species of frogs living in different habitats. laboratory experiments will be used to determine how different species may adapt to hot, cold, or dry conditions and eventually inform amphibian conservation efforts. if differences across species are observed, it is implied that aquaporins are important in allowing frogs to survive changing climates and are related to breeding behaviors in frogs. additionally, the fellow will design and implement free public workshops for graduate students providing practical guides for reporting statistical results and enhancing scientific reproducibility, with the goal of promoting the participation of historically underrepresented groups at the postdoctoral level. this research will test three hypotheses to determine the evolutionary relationship between behavior, climate, and genetic and functional **diversity** in aquaporin proteins: h1) breeding period duration across anurans is related to climate, h2) **diversity** in aquaporin sequences is influenced by climate, and h3) aquaporin gene expression is related to temperature/water availability. h1 and h2 will be analyzed using phylogenetic generalized least squares (pgls) regression while accounting for relevant traits such as body size or habitat preference. for h2, pairwise genetic distances will be obtained via generalized time-reversible models and then projected into a euclidean space (required for pgls regression) using multidimensional scaling. h3 will be analyzed using a phylogenetic multivariate analysis of variance model. it is expected that temperature will be one of the major factors influencing sequence **diversity**, gene expression, and breeding period duration. this research is important for understanding past biogeography and future conservation prospects in anurans. training objectives for the fellow include developing mentorship skills and learning to obtain and analyze data on climate, molecular sequences, and gene expression. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Social Preferences Among Transgender, Gender Nonconforming, and Gender Typical Children

Awardee: Jordan, Ashley Eliza

Amount: \$138,000.00

Abstract: this award was provided as part of nsf's social, behavioral and economic sciences postdoctoral research fellowships (sprf) program. the goal of the sprf program is to prepare promising, early career doctoral-level scientists for scientific careers in academia, industry or private sector, and government. sprf awards involve two years of training under the sponsorship of established scientists and encourage postdoctoral fellows to perform independent research. nsf seeks to promote the participation of scientists from all segments of the scientific community, including those from underrepresented groups, in its research programs and activities; the postdoctoral period is considered to be an important level of professional development in attaining this goal. each postdoctoral fellow must address important scientific questions that advance their respective disciplinary fields. under the sponsorship of dr. kristina olson at princeton university, this postdoctoral fellowship award supports an early career scientist investigating how gender diverse youth and teens reason about the social world. the transyouth project at princeton is a national, longitudinal study of the largest sample of prepubescent transgender and gender nonconforming youth and their siblings. this project addresses a longstanding issue in the field of gender development research. namely, that virtually all theorizing and empirical approaches to date assume that the sex a child is assigned at birth matches their lived gender identity. although this is true for many, in recent years transgender individuals?those who identify with the gender opposite their natal sex?have gained more visibility. thus, the time is ripe for developmental researchers to broaden the scope of their theorizing to include gender diverse youth. self-disclosure of one's identity is a precursor to many benefits, such as receiving social affirmation and building community

around one's identity. however, transgender youth must take into consideration the potential for discrimination and bullying that may follow. how transgender youth adjudicate between the option to disclose rather than conceal their identity is important, but not well understood. the goal of the project, entitled "social preferences among transgender, gender nonconforming, and gender typical children" is twofold. first the project assesses how transgender teenagers (13-18 years) evaluate those whom they have disclosed their gender identity to (aim 1). this aim employs a mixed-methods approach using thematic analysis to identify themes associated with teens' successful disclosure experiences, as measured by the teens' ratings of their chosen confidants' levels of support. second, the project empirically assesses how young children reason about disclosure decisions in a third-person context based on the characteristics of potential confidants, including the composition of their friend groups with respect to gender **\*\*diversity\*\*** (aim 2a). finally, this work will examine whether transgender teens' evaluations of their confidants is consistent with younger transgender children's reasoning about others' disclosure decisions (aim 2b). this project advances scientific knowledge that has the potential to support better outcomes for gender diverse individuals. further, this work will provide an empirical basis for how to better support gender diverse individuals by assessing how children across the gender identity spectrum reason about the benefits and burdens of gender identity disclosure. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Biophotonics, Species, and Relationships

Awardee: McCoy, Dakota E

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and

phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. coral reefs, essential elements of the global ecosystem, depend on solar-powered symbioses: algae live inside marine reef animals, such as coral and giant clams, and photosynthesize to provide ready energy. however, increasingly environmental changes jeopardize the balance that maintains these animal-algal symbioses. to protect critically-threatened reefs worldwide, we face a powerful imperative to (i) explore how reef animals harness solar power so efficiently and (ii) understand threats to their intricate solar. in this project, the fellow will research optical adaptations and evolution in reef-dwelling symbiotic animals. the results will help us understand why corals bleach so severely while other symbiotic marine animals do not. along the way, the innate creativity of nature may inspire sustainable technologies for solar power. through three projects, the fellow will explore the following rule of life: how do animal hosts and their symbionts partner together to harness solar energy? in project 1, the fellow will research whether photosymbiotic acoels and anemones have adaptations to channel light toward their symbionts, and if so whether these adaptations resemble light-harnessing structures seen in other organisms (such as plants). as a result, this work will set the stage for comparative evolutionary analyses as well as, potentially, inspiring new solar panel research. in project 2, the fellow will test hypotheses about what selective forces drive **diversity** in biophotonic structures (from project 1) and colors across acoels and anemones. for example, are environmental influences? such as depth? less important than symbiotic pressures? such as species of symbiont? in project 3, the fellow will analyze why some animals are so susceptible to bleaching while others are resistant. specifically, i will assess whether certain biophotonic adaptations that concentrate light for photosynthesis could actually exacerbate bleaching ? potentially by causing organisms to heat up, or experience light shock, amidst warming waters. the fellow will learn and apply cutting-edge microscopy, applied physics, and materials science methods to marine biology (including hyperspectral imaging, transmission electron microscopy, and finite-difference time-domain simulations). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's

intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: General plasticity kinetics: developing a universal framework of developmental plasticity

Awardee: Jung, Julie

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. all multicellular organisms develop according to a body plan defined by their genes. however, developmental trajectories must also be flexible enough to respond to different environmental conditions. plastic traits can persist through a process known as genetic accommodation, which has been increasingly discussed as a major facilitator of novelty and divergence. this project aims to demonstrate developmental plasticity's value and prominence in evolutionary theory and to elucidate how phenotypes arise from the interplay between genotypes and the environment. to promote broad dissemination, the fellow will create an interactive web interface to visualize the parameters of any plastic trait and teaching modules for undergraduate courses in mathematics modeling and developmental biology. to promote retention and inclusion of historically excluded students in biology graduate programs, the fellow will develop workshop materials and establish a mentorship program for the **\*\*diversity\*\*** fellows program at the university of utah. the project will introduce a general framework for studying plasticity, drawing from principles of theoretical ecological and mathematical modeling (aim i) and then apply that universal model to a laboratory case study of mouth-form plasticity in the pristionchus genus of diplogastrid nematodes (aim ii). this research will span several scales in the hierarchy of life and use diverse methodologies to reveal three predicted outcomes: changes in plasticity, corresponding changes in

trait evolution, and the underlying molecular mechanisms of both. this work identifying the process of genetic accommodation in real time will tie developmental plasticity in response to environmental perturbations to rigorous theoretical and empirical laboratory approaches in an emerging model study system. this research has the potential to revise mainstream evolutionary biology to include a mature theory of how the environment and genes determine phenotypes during development. the fellow will experience training on mathematical modeling, functional genomics, and mentorship practices; these skills are required to tackle many of the most important modern problems in ecology and evolutionary biology. outreach activities include organizing a local peer-to-peer learning community to promote the practice of openscience and reproducibility in r. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Using a protoendothermic mammal to understand how body temperature influences nutrient absorption.

Awardee: Conner, Justin L

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, broadening participation of groups under-represented in biology. the fellowship supports a research and training plan for the fellow that will increase the participation of groups underrepresented in biology. the ability to generate a high internal body temperature independent of environmental temperature, has independently evolved twice in vertebrate animals, in mammals and in birds. however, there is a high cost (in terms of energy) to maintaining a high body temperature. this project focuses on understanding why there is increased body temperatures in modern mammals. to answer this question, the pi will use the tenrec as a model system. tenrecs are mammals from madagascar with a body temperature more variable than any other known mammal, and are an excellent model for

understanding the advantages of having a warmer body temperature. more specifically this project will focus on how body temperature influences digestion, which is connected to energy generation. to broaden participation, the fellow will set up two independent outreach events at the university of nevada las vegas aimed at increasing minority engagement within the department of life sciences. tenrecs have the remarkable ability to partially disconnect body temperature and metabolism. for instance, when maintained at 12°C, the body temperature of active tenrecs can range from ~13 to 32°C but resting metabolism of active tenrecs at 12°C may vary by 25-fold and is only partially dependent on body temperature. the fellow will exploit a unique mammalian system in order to understand how body temperature influences the nutrient extraction from food. this model will directly test the hypothesis that warmer body temperatures allow for greater nutrient extraction from foods. to test this nutrient extraction model for the evolution of endothermy (increased body temperature), an integrative approach will be used. utilizing whole animal, ex vivo, and in vitro 3d cell culture approaches to develop a multi-level approach the exploits whole animal, organ, and even cellular level investigation. fewer than 2% of all post-docs in stem fields are black/african american, which is an over 6-fold underrepresentation of the population as a whole. **\*\*diversity\*\*** within biological sciences will not increase unless underrepresented individuals are elevated thus, becoming an example of opportunities within this field. to broaden participation, the fellow will establish outreach events at the university of nevada las vegas, leveraging the Isamp program there. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Modeling the singular and additive effects of various anthropogenic disturbances using genomics

Awardee: Aviles-Rodriguez, Kevin J

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2020, broadening participation of groups under-represented in biology. the fellowship supports a research and training plan for the fellow that will increase the participation of groups underrepresented in biology. species are often affected by multiple human-created stressors simultaneously. however, disentangling the singular and additive effects of these human made stressors remains challenging. the fellow will use a technique called landscape genomics, which allows you to identify relationships between the environment and genetics of organisms, to build a model to understand the effect of human induced environmental change (urbanization, climate change) on a freshwater turtle, the puerto rican slider, in puerto rico. this species is impacted by both habitat loss to urbanization and the spread of an invasive species, the red eared slider. additionally, the fellow will facilitate community engagement at various levels. firstly, the fellow will work with puerto rican science educators to facilitate the use of inaturalist, which is an app used to discover, identify and report local bio\*\*diversity\*\*. secondly, the fellow will facilitate training in molecular laboratory techniques for underrepresented high school students near the sponsoring institution in new york. thirdly, the fellow will help connect students to graduate programs, fellowships, and professional opportunities through a facebook group called jicoteando created for this fellowship and also via various oral presentations. this research will require the application of population genomics, spatial analyses, and ecological studies. thus, the fellow will be provided training in many new skills and in interdisciplinary work. the landscape genomics models will test the singular and additive contributions of biotic and abiotic factors in relation to the species? functional genetic connectivity. to accomplish this, the fellow will first sequence genomic dna and then sample relevant landscape and ecological covariates across the study area. covariates will then be transformed into resistance surfaces characterizing their permeability or resistance to the movement of genetic variation. this transformation will be used to contrast singular and additive resistances arising from the measured covariates. the fellow will build important collaborations with conservation agencies with the goal of writing a management plan for the species informed by the impacts of landscape features and hybridization. the fellow will also gain



outreach experience working with students at various career stages. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Ecological and genetic structuring of a pathogen microbiome and its effect on virulence

Awardee: Kolp, Matthew Robert

Amount: \$138,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. infectious fungal pathogens are capable of hosting their own microbes, and these microbes can affect the relationship between the fungus and the plants and animals. the project goals are to develop general rules to better understand the relationship between these microbes and their pathogenic hosts, and how these relationships evolve. these goals are relevant to threats that pathogens pose to humans, agriculture, and bio\*\*diversity\*\*. the fellow will engage in a series of activities designed to highlight how basic discovery informs applied research for a broad audience. the fellow will hold a series of seminars for extension agents and agricultural stakeholders, highlighting the impacts of crop pest and pathogen life cycle on crop management strategies. further, the fellow will implement interactive lessons for elementary students in underserved schools in rural tn, using aphids, fungal pathogens, and other microbes. these lessons will expose students to beneficial impacts of microbes on human life. the fungal pathogen pandora neoaphidis is an important natural microbial enemy of aphids. the proposed work develops this pathogen as a tractable system for studying microbiome effects on host-pathogen interactions. the pathogen's microbiome of endosymbiotic bacteria is hypothesized to explain pea aphid epidemics.

the project will test whether endosymbiont **diversity** in *p. neoaphidis* from infected aphids collected from semi-natural areas recapitulates pathogen genetic **diversity** or ecological factors. the fellow will use metagenomics to determine the functional capacity of various endosymbiont taxa, with the goal of testing if *p. neoaphidis* endosymbionts correlate with difference in virulence among strains. this work will broaden understanding of how ecology and evolution shape pathogen associations with microbes. aphids are invasive agricultural pests, and fungal pathogens are used as a biological control of aphid populations. developing an understanding of how agricultural pests resist biocontrol agents is critical in integrated pest management. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Dimensions US-China: Collaborative Research: Consequences of diversity in Asian and American oak syngameons for functional variation, adaptation and symbiont biodiversity

Awardee: University of Oklahoma Norman Campus

Amount: \$136,646.00

Abstract: the world's approximately 425 oak species maintain species identity even while exchanging genes with their close relatives through hybridization. this history of evolution and genetic exchange has shaped the bio**diversity** of northern hemisphere ecosystems. oaks are ecologically diverse, with related species often growing in close proximity but specializing on areas of the forest landscape that differ in soil texture and moisture level or in the frequency of natural fires. gene exchange can move such ecological specializations between oak species, broadening their ranges and ability to respond to climate change. the impacts of these genetic exchanges may extend beyond the oaks themselves. oaks host an estimated 1000 gall wasp species worldwide and highly diverse communities of fungi associated with their roots (as mycorrhizae) and inside their leaves (as endophytes). using paired field surveys and common garden experiments the pis will

evaluate the effects of hybridization and introgression on the genetic, phylogenetic, and functional **diversity** of focal oak species and their symbionts in the us and china. this work will also provide inquiry-based k-12, undergraduate, and graduate education; critical natural history training to the public through a community-science initiative in oak phenology; and publications that will bring research to public audiences. two interdisciplinary teams of researchers, one based in the us and one in china, will investigate how genomic, functional, and phylogenetic **diversity** of oak trees shape the mycorrhizal fungi, endophytic fungi, and gall wasp and other insect communities that associate with them. research will focus on two related groups of interbreeding species: bur oak (*quercus macrocarpa*) and relatives in the us and bao li (*quercus serrata*) and relatives in china. the project has three objectives, each conducted in parallel in china and the u.s. in objective 1 the teams will perform range-wide phylogenomic surveys of natural populations to reconstruct genomic mosaics, characterize geographic patterns of leaf functional traits, and characterize functional and phylogenetic **diversity** of associated mycorrhizal fungi, leaf endophytic fungi, and gall wasps. in objective 2 common gardens will be planted across climatic gradients to evaluate the effects of genetic variation and population differentiation on oak functional and spectral traits and relative fitness in different climates, and how these influence the phylogenetic and functional **diversity** of oak-associated fungal and insect communities. in objective 3 the teams will use a second set of common garden experiments to evaluate how plant community and phylogenetic **diversity** affects focal oak species genetic, phylogenetic, and functional **diversity**. the project will provide an integrative perspective on how oak **diversity** within and among species impacts the broad **diversity** of oak-dominated ecosystems across the northern hemisphere. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Workshop on Leadership: Increasing Leaders from Historically Under-Represented Groups

Awardee: Pennsylvania State Univ University Park

Amount: \$135,177.00

Abstract: in this increasing complex world, stem leaders must have a broader education than science, technology, and engineering to be successful in addressing the leadership challenges required to solve the technological challenges facing the world. rising leaders need to have a grounding in the social and behavioral sciences and an appreciation for the cultural, economic, political, and educational differences of the people and communities who will use and/or be affected by the stem approaches they will be developing. additionally, addressing the underrepresentation of marginalized groups in leadership positions within the us stem enterprise is vital to ensuring that the nation has a robust and diverse stem workforce. this conference proposal will deliver a three-day workshop to document and learn from a multidecadal perspective the following: 1) characteristics of leaders from underrepresented groups in stem, 2) transformative efforts that increased representation of diverse stem leaders across various institutions (academia, public sector, non-profit sector, and private sector), 3) innovative **\*\*diversity\*\*** and inclusion perspectives from current leaders, 4) effective/emerging strategies regarding the development of next-generation leaders from underrepresented groups, and 5) approaches for the integration of stem with social sciences to facilitate processes for a **\*\*diversity\*\*** of early and mid-career scientists and engineers to gain leadership positions. while the number of leaders from underrepresented groups (urgs) has increased modestly over time, this increase has lagged the increase of individuals from urg in stem workplaces, which themselves do not yet reflect the demographics of the nation. this workshop has the potential of affecting various types of institutions that have lagged in utilizing fully the repository of national talent by involving policy makers at the highest level as well as strong leaders who can speak not only to the value of **\*\*diversity\*\*** but can also articulate the work and the processes behind their stories of success, thereby illuminating possible paths forward. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CIF: An Ice Nucleation Cold-Stage for Research and Teaching

Awardee: North Carolina State University

Amount: \$132,755.00

Abstract: this community instruments and facilities (cif) award makes the north carolina state ice nucleation cold stage (nc state cs) freezing assay available as a community instrument facility. the instrument consists of a machine vision optical system to observe a thermally controlled surface. the main purpose of the instrument is to observe the freezing nucleation process of supercooled water droplets. the instrument is suitable for studying ambient ice nucleating particle concentrations and laboratory-based process-level studies of the nucleation process. the facility will be advertised at conferences, including conferences that exclusively target professional societies focused on fostering enhanced **\*\*diversity\*\*** in science. interactive educational content will be created and disseminated using a multi-user web-interface that can be used by instructors to supplement instruction in a wide range of undergraduate and graduate courses. this project contributes instrumentation and educational resources to tackle the problem of characterizing the abundance of ice nucleating particles in the atmosphere. by becoming a community instrument facility, the cold-stage technique will become more widely available to groups that do not specialize in instrument design. funds for the award will also yield a public design of a low-cost version of the instrument that can be self-manufactured. this award will enhance the ability of the broader scientific community to use the nc state ice nucleation cold stage freezing assay through the atmospheric and geospace sciences facility and instrument request process. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: STEPP-NET: Steppe Parasite Networks

Awardee: Georgia Southern University Research and Service Foundation, Inc

Amount: \$131,319.00

Abstract: this project focuses on collecting and describing mammals and their tapeworm and flea parasites from the grasslands of central asia. these parasites are highly diverse and ecologically important groups, and many are sensitive indicators of ecosystem quality; further, the parasitic infections they cause can have major negative impacts on wildlife. they also can play an important role in transmitting diseases from wild to domesticated species, and also to humans. however, knowledge of the **diversity** of parasite species, their geographic distributions, and the precise hosts they occur on and in remains highly fragmentary for much of the world. central asian mammals and their associated parasites are particularly highly imperiled but also little studied. this project will collect new material and study how tapeworm and flea parasites from the region evolve in conjunction with their mammalian hosts; it will also consider how the hosts and parasites have responded to various ecological changes across the region. this work is extremely time-sensitive, with many central asian ecosystems on the cusp of major land use change as economies shift and major construction occurs in the region. numerous specimens will be collected, and these will serve as a repository of parasite **diversity** useful for assessing how future global change influences the distribution of parasites and their hosts. this may ultimately improve public health outcomes. the work will also involve training the next generation of early-career stem researchers for careers in bio**diversity** science. the stepp-net project will rapidly advance discovery and description of species **diversity**, host associations, and community assembly, in two mammal-associated macroparasite clades - fleas and cestodes - across the vast grasslands of central asia. this region is a prototype for exploring host-parasite dynamics and spillover in response to human activity; historically, as a conduit for ancient silk road trade routes, and, currently, from intensifying land use changes and construction. stepp-net leverages existing museum specimens, new expeditionary collections in mongolia and kazakhstan, and genomic analyses of hosts and parasites to advance

knowledge of species boundaries, environmental and host niche breadth, and the exploration of novel host interfaces by focal parasite clades in response to global change pressures. a key outcome of stepp-net will be an extended specimen network for central asia, in which mammal and parasite specimens are durably linked to derived data and immediately useful in global bio\*\*diversity\*\* studies and public health initiatives. the project also creates opportunities for stem graduate and undergraduate students to participate across the spectrum of modern bio\*\*diversity\*\* science, from international fieldwork to specimen curation and digitization, genomics, and integrative taxonomy. it will build out this community of early-career stem researchers even further by developing undergraduate and graduate educational modules that are implemented across our institutions and hosted online for broader bio\*\*diversity\*\* literacy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Redefining the footprint of deep ocean methane seepage for benthic ecosystems

Awardee: Occidental College

Amount: \$128,827.00

Abstract: this research examines the role of deep-sea organisms in determining the fate and footprint of methane, a potent greenhouse gas, on pacific continental margins. the investigators are evaluating the deep ocean methanosphere defined by the microbial communities that consume methane and the animals that directly feed on or form symbioses with methane-consuming microbes. they are also investigating animal communities that gain energy indirectly from methane, as well as those that take advantage of carbonate rocks, the physical manifestation of methane consumption in seafloor sediments. the study of methane seeps in the deep waters of both alaska (4400-5500 meters) and southern california (450-1040 meters) is enabling comparisons of the

methanosphere under different food-limitation and oxygen regimes. by applying diverse chemical, isotopic, microscopy, and genetic-based analyses to seep microbes and fauna, this study is advancing understanding of the contribution of methane to deep-sea bio\*\*diversity\*\* and ecosystem function, information that can inform management and conservation actions in us waters. in addition to training for graduate and undergraduate students at their home institutions, the investigators are collaborating with the alaska native science and engineering program (ansep). they are recruiting alaskan undergraduates to participate in the research, contributing to ansep?s online resources that promote interaction between scientists and middle and high school students, and participating in ansep?s annual residential career exploration in marine science programs to engage middle school students in learning about deep-sea ecosystems and the variety of career pathways available in marine related fields.

microbial production and consumption of methane is dynamic and widespread along continental margins, and some animals within deep-sea methane seeps rely on the oxidation and sequestration of methane for nutrition. at the same time, understanding of methane-dependent processes and symbioses in the deep-sea environment is still rudimentary. the goals of this study are to 1) examine the \*\*diversity\*\* of animals involved in methane-based symbioses and heterotrophic consumption of methane-oxidizing microbes and how these symbioses extend the periphery of seeps, contributing to non-seep, continental slope food webs; and 2) determine whether carbonates on the seep periphery sustain active methanotrophic microbial assemblages, providing a localized food source or chemical fuel for thiotrophic symbioses, via anaerobic oxidation of methane, or free-living, sulfide-oxidizing bacteria consumed by animals. the investigators are addressing these goals by surveying, sampling, and characterizing microbes, water, sediments, carbonates and animals at a deep seep site on the aleutian margin and a shallow site off southern california. shipboard experiments and laboratory analyses are using molecular, isotopic, geochemical, and radiotracer tools to understand transfer of methane-sourced carbon from aerobic methanotrophs under multiple oxygen levels, pressures, and photosynthetic food inputs. this approach offers a wide lens by which to examine the methane seep footprint, allow reinterpretation



of past observations, and identify new scientific areas for future study. improved characterization of the deep continental margin methanosphere informs climate science, bio\*\*diversity\*\* conservation, and resource management. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: A Data-Driven Employer-Academia Partnership for Continual Computing Curricular Change

Awardee: Rochester Institute of Tech

Amount: \$125,694.00

Abstract: this project aims to serve the national interest by improving the supply of well-prepared computer science professionals capable of addressing the needs of american employers in the public and private sectors. this project intends to build a national partnership between employers and academia to help identify and mitigate gaps between the competencies of computing graduates and the expectations of potential employers. the project will survey computer science educators and practitioners to develop a model that defines the competencies expected by potential employers. the project team then plans to test the model at three institutions of higher education in alabama ? the university of alabama, tuscaloosa, tuskegee university, and shelton state community college. finally, the project team intends to develop tools and methods for institutions to identify and implement competency-based educational approaches for computer science across the nation. the project plans to use three interconnected strands of evidence-based activities to institute transformational change in the involved communities. first, a national strand will engage u.s. faculty in developing competency-based curricula informed by industry practitioner feedback. second, a local pilot strand intends to create transformative curricular change based on student competencies using an evidence-based change model in the three alabama institutions. sociologists and

computing faculty on the team will help to understand, predict, and reduce barriers to competency-based employment of computing graduates from marginalized communities in the heart of the impoverished alabama black belt. the unique perspective relative to **\*\*diversity\*\***, equity, and inclusion needs should serve as a model for other computing departments. the third strand will develop competency-based surveys for practitioners and academics to identify and refine specific competencies that are hoped to drive continual curricular change. outcomes, including the change process, national workshops, and experiences from the local process will help with transferability in the computing education community. in addition to informing curricula, the project will provide valuable data for educational researchers to help close the gap between employers and higher education. finally, as the competency approach to curricular design is relatively new in computing and engineering disciplines, lessons from this project will have the potential to transform curricular review and design in other stem disciplines. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the institutional and community transformation track, the program supports efforts to transform and improve stem education across institutions of higher education and disciplinary communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MRI: Acquisition of a Broad-Energy Germanium Detector at Western Washington University

Awardee: Western Washington University

Amount: \$124,892.00

Abstract: this award is made to western washington university (wwu) to purchase a broad-energy germanium gamma ray detector to expand research and education programs in environmental science and geology. the earth possesses many naturally occurring radioactive elements that emit gamma radiation. by measuring the quantity and distribution of these elements, researchers can

estimate the rates of important processes, such as the burial of sediment and organic carbon, removal of contaminants from seawater, and the mixing and transport of important particulate materials including carbon, metals, and organic contaminants. the instrument will allow students and faculty at wwu to quantify sedimentary processes, characterize past environments, and to assess changes in land use, pollution, and other natural conditions over time. the research community's interest in the use of our existing gamma detector and our associated expertise has now exceeded our ability to accommodate the demand. the expanded capabilities of this instrument will enable wwu students and faculty to address new environmental problems, take on additional research projects, improve the design of existing projects, and expand our network of collaborators at the global scale. the new broad-energy germanium detector (mirion be3825) will support the research and teaching programs of eight senior personnel and their associated students at wwu. these users all have research questions that can be addressed using gamma-emitting radionuclides, with applications ranging from bioturbation and sediment accumulation to tribal coastal clam gardens and estuarine carbon burial, to lake paleo-genetics and riparian geomorphological development. while our existing detector is in continuous use measuring low-energy gamma emitters such as pb-210 and th-234, the new broad-energy germanium detector will also enable the measurement of higher-energy gamma emitters such as cs-137, be-7, zn-65, and fe-59, allowing for a much greater number of users, more educational opportunities, and a greater **\*\*diversity\*\*** of instrument applications. as a non-phd granting institution, wwu places a strong emphasis on undergraduate and masters-level research and education. the new instrument at wwu will be made available not only for faculty-driven research but also for student-led thesis research and class projects to train the next generation of scientists. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: MRI: Acquisition of an Inductively Coupled Plasma-Mass Spectrometer for Quantitative Elemental Analysis of Natural and Engineered Materials

Awardee: University of Oregon Eugene

Amount: \$122,856.00

Abstract: this award is supported by the major research instrumentation and the chemistry research instrumentation programs. the university of oregon at eugene is acquiring an ion chromatograph, inductively coupled plasma-mass spectrometer (ic-icp-ms) to support professor shannon boettcher and colleagues krista mcguire and matthew polizzotto. in general, mass spectrometry (ms) is one of the key analytical methods used to identify and characterize small quantities of chemical species in complex matrices. in a typical experiment, the components flow into a mass spectrometer where they are ionized, and the ion masses are measured. this highly sensitive technique allows detection and determination of the structure of molecules in a complex mixture. the ionization using the inductively coupled plasma allows detection of metal ions and several non-metals present in very small concentrations. the ion chromatograph component allows separation of metal ions from mixtures, thus improving the characterization of the various components. the acquisition strengthens the research infrastructure at the university and regional area since this technology is accessible to students, faculty and researchers throughout several departments such as chemistry, biochemistry, materials science institute, earth sciences, biological sciences and anthropological sciences. the team is designing a research program to train new phd students to be mentors to k-12 students, by

showing them how to quantify metal ion content in soil and water sources and a plan to support academic and industrial partnerships through the facility denominated center for advanced material characterization at oregon (camcor) where the instrument is located. the award of the ic-icp-mass spectrometer is aimed at enhancing research and education at all levels. it is especially useful to determine species that function as electrocatalysts and for the study of aquifer mineral complexity and redox reactivity. the instrumentation is also used to investigate processes underlying biotransformation of arsenic and other contaminants in aquifers as well as plant-soil-microbial associations contributing to maintenance of tree **\*\*diversity\*\*** and nutrient cycling in tropical forests. the instrument also serves researchers assessing interactions of metal ions with nucleic-acid biomolecules and the preparation of precision-engineered nanoparticles. the mass spectrometer aids characterization of trace elements in volcanic and hydrothermal minerals. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: MRI: Acquisition of an Inductively Coupled Plasma-Mass Spectrometer for Quantitative Elemental Analysis of Natural and Engineered Materials

Awardee: University of Oregon Eugene

Amount: \$122,856.00

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Matched Words: diversity

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Title: Workshop: ProVis-EER: Developing Professional Vision into Empirical Practices within Engineering Education Research (EER) though Digital Apprenticeship

Awardee: George Mason University

Amount: \$119,505.00

Abstract: the preparation of a future engineering workforce depends critically on our ability to provide excellence in training and through our efforts to train a diverse range of stakeholders for the engineering profession. increasingly within the united states institutions are creating programs, courses, and centers to support the preparation of the future engineer. this institutional and education infrastructure depends on a better and deeper understanding of how engineering education works best in order to support their efforts and initiatives. this project will contribute to this mission by increasing and improving the capacity of engineering educators to undertake research on engineering education. through this series of workshops newcomers to the field will be able to learn first-hand from scholar-experts in the field. the online nature of the workshops will ensure that a large number of participants are able to undergo the sessions. furthermore, the resources created as part of this project will be available for future training purposes. overall, this work is crucial for the growing field of engineering education and the ability of future engineering educators to learn from a diverse set of scholar-experts will broaden the kinds of research that are done as well as the outcomes of the research. this project aligns with nsf's investment in the research in formation of engineers (rfe) program by creating better engineering education researchers that can support the training of future engineers and who can undertake better research for us to know how to create a more inclusive engineering workforce for the future. building capacity for engineering education research (eer) is a core goal of nsf and organizations such as the american society for engineering education (asee) and the national academies of sciences, engineering, and medicine (nasem). over the past decade the community has made significant gains towards achieving this objective as evidenced by increasing number of departments and centers directed towards engineering education across institutions. propagation of eer practices has largely been through face-to-face interactions, including doctoral programs, working in research laboratories, and workshops and tutorials at professional development meetings. these in person engagements and events are prohibitive for many who would benefit from developing a better understanding of how research is



conducted. they also limit new researchers in exposure to a broader **\*\*diversity\*\*** of views and research practices. this proposed series of digital workshops are designed as a ?swift apprenticeship? experiences to increase the formation of eer practitioners by creating exemplars of engineering education research practices that take the learner through the entire lifecycle of a project and provide an avenue for learning by example, scaffolded by experts. experts will focus on one of their exemplary published research papers and deconstruct/reconstruct how that research was done and the paper produced including matters of theory, methods, and review. the reconstruction will take place as a conversation with the pi/s which will be captured on video and audio and drafts of papers and other relevant artifacts will be collected and shared. it will also invite questions from a set of novice participants and commentary from other experts to provide another viewpoint and additional context on research practices. this project will benefit engineering education graduate students, engineering graduate students and faculty in other disciplines interested in engineering education research, and postdoctoral scholars. this work will contribute to research on engineering education, especially the use of professional vision and scaffolding for novices, and on transfer learning for research practices. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Examining the Vulnerability and Recovery of Small Farms to Natural Hazards and the Impact to Rural Community Resilience

Awardee: Texas A&M University

Amount: \$118,102.00

Abstract: this disaster resilience research grant (drrg) project contributes to the advancement of national health, prosperity and welfare by creating new knowledge on disaster recovery for the agricultural industry. despite the criticality of agriculture to u.s. and global food production, the lack

of economic **diversity** and prevalence of agriculture in many rural areas, particularly in the central us, is theorized to be a major contributor to low disaster resilience. resilience is a complex function of socio-economic dimensions and the built environment; and the population, economics, and physical infrastructure that comprise agricultural regions are distinct from the urban and suburban areas that are the common focus of most disaster and community resilience studies. this research generates a fundamental understanding of the resilience of farms and agriculture-prevalent rural communities in the face of severe windstorms, which will be of broad benefit to society and to national resilience. the research team will identify, evaluate, and recommend actions to enhance resilience of farms. to maximize the impact of these findings, the team will partner with the extension disaster education network for outreach and technology transfer. implementation of these mitigation measures can transform the disaster resilience of rural and agricultural regions, safeguarding the lives of citizens, regional and national economies, and global food production. the long-term goal of this research is to enhance the resilience of rural communities to natural hazards, which requires state-of-the-art research on the infrastructure that support farm operations, the recovery processes of individual farms, and the interaction of individual farms within the regional agricultural economy. as a first step towards enhancing rural resilience, the interdisciplinary team will conduct a three-year research project carefully tracking resilience from hazards to structures to farms to communities. the project is characterized by two primary goals. the first goal is to generate a fundamental understanding of the vulnerability and recovery of farms following windstorms through longitudinal reconnaissance of impacted agricultural communities, surveys of impacted farmers, correlation of hazard intensity with infrastructure response, and the examination of the linkages between recovery of individual infrastructure with farm-level recovery. the second goal is to develop and validate a risk-informed resilience assessment framework comprised of a farm-level resilience factors and community-level economic analyses to support decisions on business continuity and infrastructure investment for farms and the broader agriculture-prevalent rural communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the

foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Digitization TCN: Extending Anthophila research through image and trait digitization (Big-Bee)

Awardee: University of New Hampshire

Amount: \$117,425.00

Abstract: declining populations of bees impact plant-pollinator interactions in both natural and agricultural systems. while bees and other insects pollinate most wild plants, and are critical to sustain a large proportion of global food production, they are decreasing in both numbers and **\*\*diversity\*\***. our understanding of the factors driving these declines is limited because we lack sufficient data on the distribution of bee species, and on the behavioral and anatomical traits that may make them either vulnerable or resilient to human-induced environmental changes, such as habitat loss and climate change. fortunately, wild bees have been collected by researchers and deposited in natural history collections for over 100 years, retaining a wealth of associated attributes that can be extracted from specimen images. this project will digitally capture data and images from these historic specimens, develop tools to measure bee traits from these images, and generate a comprehensive bee trait and image dataset to measure changes through time. this will increase our understanding of specific traits that put bee species at risk of decline - a critical need for both sustaining our agricultural economy and the conservation of our natural resources. in addition, the large image datasets created by this project can be used for new artificial intelligence identification tools that will help improve our future pollinator observation and monitoring efforts. the big-bee thematic collection network (big-bee tcn) will create over one million high-resolution 2d and 3d images of bee specimens, representing over 5,000 worldwide bee species, including all of the major pollinating species of the united states. the big-bee network includes 13 institutions and partnerships with us government agencies. novel mechanisms for sharing image datasets will be developed and

datasets of bee traits will be available through an open data portal, the bee library, for research and education. the big-bee project will engage the general public in research through community science via crowdsourcing trait measurements and data transcription from images. in addition, training and professional development for natural history collection staff, researchers, and university students in data science will be provided through the creation and implementation of workshops focusing on bee traits and species identification. all data resulting from this award will be shared with and publicly available through the national digitized biocollections resource, [idigbio.org](http://idigbio.org). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Examining the Vulnerability and Recovery of Small Farms to Natural Hazards and the Impact to Rural Community Resilience

Awardee: Texas A&M AgriLife Extension Service

Amount: \$115,213.00

Abstract: this disaster resilience research grant (drrg) project contributes to the advancement of national health, prosperity and welfare by creating new knowledge on disaster recovery for the agricultural industry. despite the criticality of agriculture to u.s. and global food production, the lack of economic **\*\*diversity\*\*** and prevalence of agriculture in many rural areas, particularly in the central us, is theorized to be a major contributor to low disaster resilience. resilience is a complex function of socio-economic dimensions and the built environment; and the population, economics, and physical infrastructure that comprise agricultural regions are distinct from the urban and suburban areas that are the common focus of most disaster and community resilience studies. this research generates a fundamental understanding of the resilience of farms and agriculture-prevalent rural communities in the face of severe windstorms, which will be of broad benefit to society and to national resilience. the research team will identify, evaluate, and recommend actions to enhance

resilience of farms. to maximize the impact of these findings, the team will partner with the extension disaster education network for outreach and technology transfer. implementation of these mitigation measures can transform the disaster resilience of rural and agricultural regions, safeguarding the lives of citizens, regional and national economies, and global food production. the long-term goal of this research is to enhance the resilience of rural communities to natural hazards, which requires state-of-the-art research on the infrastructure that support farm operations, the recovery processes of individual farms, and the interaction of individual farms within the regional agricultural economy. as a first step towards enhancing rural resilience, the interdisciplinary team will conduct a three-year research project carefully tracking resilience from hazards to structures to farms to communities. the project is characterized by two primary goals. the first goal is to generate a fundamental understanding of the vulnerability and recovery of farms following windstorms through longitudinal reconnaissance of impacted agricultural communities, surveys of impacted farmers, correlation of hazard intensity with infrastructure response, and the examination of the linkages between recovery of individual infrastructure with farm-level recovery. the second goal is to develop and validate a risk-informed resilience assessment framework comprised of a farm-level resilience factors and community-level economic analyses to support decisions on business continuity and infrastructure investment for farms and the broader agriculture-prevalent rural communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity  
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Title: Collaborative Research: Reproductive heterogeneity in the structured coalescent framework

Awardee: Kennesaw State University Research and Service Foundation

Amount: \$112,256.00

Abstract: curbing the effects of pathogens and securing the survival of endangered or commercially exploited species is a matter of national interest. while collecting genetic data on these pathogens

and endangered species has become standard over the last decade, the data requires translation and analysis to be useful for policy decisions. these data are commonly used in models that describe both the recent and ancient history of the species. these models are founded on theoretical population genetics and are often not very flexible. this research addresses the assumption that the populations that are being studied have a relatively constant number of offspring per generation. scientific observation has shown that this assumption is incorrect. for example, some sars-cov-2 strains are more successful in infecting people than others, suggesting that the ancestor with a new mutation has many more 'offspring' than others. this research generalizes the common assumption and constructs a framework that allows for the improvement of these population models by offering an increase in accuracy and a decrease in bias. this research will result in the creation of a software tool that will benefit the research community and train the next generation researchers. accurate estimates of population size and genetic **diversity** will lead to better control of pathogen outbreaks, regulation of catch quota for commercial fishing, and maintenance of endangered species. this research explores the effect of heterogeneity of offspring production on the genealogy of a population using (1) a theoretical framework that can handle heterogeneity and the development of software to infer this heterogeneity from genomic data. this framework is based on the fractional coalescent expanded to multiple, structured populations. the research extends a single-population derivation of the fractional coalescent that incorporates offspring variability as a random variable. these new methods will be incorporated into the widely-used open-source computer software migrate. the new approach will then be compared with multi-merger coalescent methods using artificial data. these data are generated using (2) a simulator taking into account environmental quality changes within and among populations affecting the number of offspring an individual can have. (3) analyses of the effect of heterogeneity for many biological datasets over a broad range of species with different life histories: from viruses to humpback whales and from small geographic scale to large scales. these biological datasets will be analyzed in collaboration with practical scientists. software and tutorials will be reported on <http://popgen.sc.fsu.edu> and

<https://peterbeerli.com>. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Collaborative Research: LightningBug, An Integrated Pipeline to Overcome The Biodiversity Digitization Gap

Awardee: Harvard University

Amount: \$111,116.00

Abstract: insects are the largest and most diverse class of animals on our planet where they play essential roles in ecosystems and the services those provide to society. entomologists have long been engaged in collecting, preserving and depositing nearly one billion insect specimens at natural history museums around the globe. these collections form the basis for much of our knowledge about insects and provide critical information about the past from which scientists can assess current and future global change impacts. to fully realize the value of these collections, data from insect specimens must first be digitized. however, their small size, delicate structures, and traditional



storage and labeling methods creates enormous challenges for large-scale digitization. consequently, at present, only 5% of specimens have transcribed labels and less than 1% of specimens are imaged. the lightningbug project will break through this digitization bottleneck by establishing a semi-automated workflow involving advancements in robotic multi-view imaging, information extraction and 3d reconstruction. results from this work will provide researchers with the unprecedented capability to capture specimen metadata representing time, place and taxonomic identity along with accurate three-dimensional surface morphology representing color and shape. these investigators expect lightningbug and related technologies will promote ecomorphological studies at a scale that has not been possible to date. the lightningbug project seeks to create an end-to-end pipeline for high-throughput data acquisition from pinned insects in entomological collections. to accomplish this goal, it will: (1) further develop an existing hardware and software platform to capture multi-view imagery of both labels and specimens; (2) build robust algorithms to automatically process fragmentary views of multiple labels into separate integrated "virtual labels;" (3) connect virtual labels to structured text extraction services; and (4) apply photogrammetric analysis to assemble the 3d shape and structure of specimens. guided by real-world science use cases that highlight the use of specimen-based multi-view imaging in studies of global change and functional morphology, the entomological collections of the yale peabody museum and the harvard museum of comparative zoology will be used in rigorous test-case implementations. results will include robust sets of annotated multi-view images, 3d models of specimens (point clouds, textured meshes), 2d reconstructed "virtual labels" and digitized specimen metadata generated from those labels. these digital specimens will present new challenges for data preservation and access, but they will also catalyze new solutions for large-scale storage and delivery of research imagery. this challenge will be addressed via a partnership with morphosource to develop a linked institutional repository model for data access to large digital assets such as those produced by multi-view imaging. ultimately, the ability to capture multi-view image suites and generate virtual specimens at scale will permit new avenues for remote access to research resources, and enable the application

of computer vision and machine learning to trait identification and evolution, species recognition and new species discovery. label data from pinned insects will give researchers access to critical temporal and geospatial information necessary for relating changes in bio\*\*diversity\*\* to other biotic and environmental variables. it will also provide collections staff with a complete digital portrait of their holdings, which can enable historical research, streamline collections use and tracking, and improve data quality control. results from this project will also have applications beyond the natural history collections and research communities, such as computer graphics, product imaging, motion pictures, 3d animation, virtual and augmented realities, and education. more information and results from this project can be found at <http://lightningbug.tech> this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Digitization TCN: Collaborative Research: Bringing Asia to digital life: mobilizing underrepresented Asian herbarium collections in the US to propel biodiversity discovery

Awardee: Bernice P Bishop Museum

Amount: \$109,530.00

Abstract: asia is the largest continent on earth, and includes the world's tallest mountains, lowest landscapes, and habitats ranging from arctic tundra to tropical rainforests and mangroves to deserts. the plants of this region are incredibly diverse in their identities and functions. more than one-third of the world's 350,000 plant species grow in asia and include tiny alpine cushion plants, medicinal herbs, ancient crops, and some of the planet's tallest rainforest trees. but documentation of this \*\*diversity\*\* remains inaccessible and research about it is difficult because most herbarium specimens of asian plants have not been digitized. the all asia thematic collections network (tcn) will mobilize online 15 million specimens of asian plants currently housed in the us and around the world. the project will especially focus on digitizing specimens from the unique and critically

endangered bio\*\*diversity\*\* hotspots of southeast asia and the himalaya-hengduan region. these mobilized digital data will accelerate research to conserve endangered plant species and understand the interacting effects of evolution and global environmental change on plant species \*\*diversity\*\*. the project will apply state-of-the-art informatics tools and high-throughput digitization methods to efficiently and affordably digitize an unprecedented number of herbarium collections. this effort will connect and build long-lasting relationships among 25 large and small consortium institutions in the u.s., europe, and asia. the focal areas from which specimens will be digitized encompass five bio\*\*diversity\*\* hotspots that include ~20% of the world's vascular plant flora and historically spanned 3 million km<sup>2</sup> of primary vegetation that now covers less than 300,000 km<sup>2</sup>. fundamental bio\*\*diversity\*\* data for these bio\*\*diversity\*\* hotspots are lacking, along with the necessary baselines required to characterize species' identity, range, and responses to ongoing climatic change. the overall goals of the all asia tcn are to rapidly digitize herbarium specimens of asian plants to advance bio\*\*diversity\*\* discovery and provide critical baseline assessments essential for establishing floristic change in the anthropocene. the project will accomplish this by (1) digitizing 3 million asian vascular plant specimens from u.s. herbaria; (2) developing and applying novel informatics tools and high-throughput digitization methods to massively scale herbarium digitization; (3) aggregating and mobilizing the digitized records from the project with those by international partners in china, france, the netherlands, and russia to establish a single online all asia portal of ca. 15 million specimens; and (4) enhancing opportunities for early career learners in science, technology, engineering, and mathematics by stimulating synergies between bio\*\*diversity\*\* and computer scientists who will use design thinking principles to create real-world informatics solutions to bio\*\*diversity\*\* challenges. to stimulate curiosity in plant \*\*diversity\*\* and botanical exploration among the general public, the consortium members will host several asia-themed notes from nature virtual expeditions to facilitate additional specimen digitization by citizen-scientists. digitized specimen data mobilized through this project will be shared and made available through idigbio.org. this award reflects nsf's statutory mission and has been deemed

worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: LEAPS-MPS: The representation theory of combinatorial categories

Awardee: Bowdoin College

Amount: \$105,432.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). in mathematics, a finite graph refers to a finite collection of points with line segments, called edges, connecting them. for example, a triangle is a graph with three points and three edges, while the letter "h" could be viewed as a graph with 6 points and 5 edges. despite the simplicity of this description, graphs have proven themselves to be one of the most important tools in the modern mathematical toolkit, being critical in applications to, for instance, large networks and robotics. the projects of the current award seek to further the state of the art in the study of graphs in key ways related with the two aforementioned applications. in particular, one project seeks to understand the sizes of large independent (without a single edge connecting them) collections of points within the graph, whereas another relates to ways in which large networks expand over time. the final project considers scenarios of a collection of robots randomly moving on the graph as if it were a track, while not being allowed to collide, and showing the extremely interesting behavior that can result from this. in addition to these research concerns, this grant will be used in furthering educational standards for students of various backgrounds and skill levels. this includes attaching a "growing up in science" series to existing student seminars, supplying funding for the local awm chapter, using funds to send students to national conferences which specialize in **\*\*diversity\*\*** in research, and funding for summer research opportunities. this project builds on previous work, which developed a framework for studying families of highly symmetric graphs using combinatorial categories. this work lends itself to a variety of natural conjectures, including one that would imply certain regular

behaviors in the independence numbers of graphs in these families. these conjectures comprise the first proposed project. the second project applies a similar categorical framework to families of discrete groups, including automorphism groups of free groups and integral special linear groups. it has been observed that various group theoretic properties, such as kazhdan's property (t), seem to behave stably in these families. it is our belief that this framework can illuminate and expand upon our understanding of groups with property (t) and thereby our understanding of expander graphs. finally, recent work has presented a model for random braiding in the configuration space of a tree. this model has an associated covariance matrix, which has been conjectured to uniquely identify the tree; a feature which the topology of the configuration space lacks. furthermore, the pi has also devised a random model for graph configuration spaces that may be used to detect the presence of exotic torsions in homology. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Awardee: Bowdoin College

Amount: \$105,432.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). in mathematics, a finite graph refers to a finite collection of points with line segments, called edges, connecting them. for example, a triangle is a graph with three points and three edges, while the letter "h" could be viewed as a graph with 6 points and 5 edges. despite the simplicity of this description, graphs have proven themselves to be one of the most important tools in the modern mathematical toolkit, being critical in applications to, for instance, large networks and robotics. the projects of the current award seek to further the state of the art in the study of graphs in key ways related with the two aforementioned applications. in particular, one project seeks to understand the

sizes of large independent (without a single edge connecting them) collections of points within the graph, whereas another relates to ways in which large networks expand over time. the final project considers scenarios of a collection of robots randomly moving on the graph as if it were a track, while not being allowed to collide, and showing the extremely interesting behavior that can result from this. in addition to these research concerns, this grant will be used in furthering educational standards for students of various backgrounds and skill levels. this includes attaching a "growing up in science" series to existing student seminars, supplying funding for the local awm chapter, using funds to send students to national conferences which specialize in **\*\*diversity\*\*** in research, and funding for summer research opportunities. this project builds on previous work, which developed a framework for studying families of highly symmetric graphs using combinatorial categories. this work lends itself to a variety of natural conjectures, including one that would imply certain regular behaviors in the independence numbers of graphs in these families. these conjectures comprise the first proposed project. the second project applies a similar categorical framework to families of discrete groups, including automorphism groups of free groups and integral special linear groups. it has been observed that various group theoretic properties, such as kazhdan's property (t), seem to behave stably in these families. it is our belief that this framework can illuminate and expand upon our understanding of groups with property (t) and thereby our understanding of expander graphs. finally, recent work has presented a model for random braiding in the configuration space of a tree. this model has an associated covariance matrix, which has been conjectured to uniquely identify the tree; a feature which the topology of the configuration space lacks. furthermore, the pi has also devised a random model for graph configuration spaces that may be used to detect the presence of exotic torsions in homology. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: STEPP-NET: Steppe Parasite Networks

Awardee: Northern Michigan University

Amount: \$105,402.00

Abstract: this project focuses on collecting and describing mammals and their tapeworm and flea parasites from the grasslands of central asia. these parasites are highly diverse and ecologically important groups, and many are sensitive indicators of ecosystem quality; further, the parasitic infections they cause can have major negative impacts on wildlife. they also can play an important role in transmitting diseases from wild to domesticated species, and also to humans. however, knowledge of the **diversity** of parasite species, their geographic distributions, and the precise hosts they occur on and in remains highly fragmentary for much of the world. central asian mammals and their associated parasites are particularly highly imperiled but also little studied. this project will collect new material and study how tapeworm and flea parasites from the region evolve in conjunction with their mammalian hosts; it will also consider how the hosts and parasites have responded to various ecological changes across the region. this work is extremely time-sensitive, with many central asian ecosystems on the cusp of major land use change as economies shift and major construction occurs in the region. numerous specimens will be collected, and these will serve as a repository of parasite **diversity** useful for assessing how future global change influences the distribution of parasites and their hosts. this may ultimately improve public health outcomes. the work will also involve training the next generation of early-career stem researchers for careers in bio**diversity** science. the stepp-net project will rapidly advance discovery and description of species **diversity**, host associations, and community assembly, in two mammal-associated macroparasite clades - fleas and cestodes - across the vast grasslands of central asia. this region is a prototype for exploring host-parasite dynamics and spillover in response to human activity; historically, as a conduit for ancient silk road trade routes, and, currently, from intensifying land use changes and construction. stepp-net leverages existing museum specimens, new expeditionary collections in mongolia and kazakhstan, and genomic analyses of hosts and parasites to advance

knowledge of species boundaries, environmental and host niche breadth, and the exploration of novel host interfaces by focal parasite clades in response to global change pressures. a key outcome of stepp-net will be an extended specimen network for central asia, in which mammal and parasite specimens are durably linked to derived data and immediately useful in global bio\*\*diversity\*\* studies and public health initiatives. the project also creates opportunities for stem graduate and undergraduate students to participate across the spectrum of modern bio\*\*diversity\*\* science, from international fieldwork to specimen curation and digitization, genomics, and integrative taxonomy. it will build out this community of early-career stem researchers even further by developing undergraduate and graduate educational modules that are implemented across our institutions and hosted online for broader bio\*\*diversity\*\* literacy. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Contribution of mafic magmatism to upper crustal batholiths: A case study of the Sierra Nevada batholith

Awardee: Pomona College

Amount: \$104,344.00

Abstract: the dense crust beneath earth's oceans is regularly driven beneath the continents in a tectonic process called subduction, which results in the formation of magmas. such magmas ascend and create long chains of volcanoes like the cascades of the northwest united states or the andes in south america. over time, magmatism at subduction zones has helped build earth's continents. these magmatic processes concentrate silica to create thick and buoyant continents that stand higher than surrounding oceans and oceanic crust, which is a unique feature of our planet. this continental crust is an important source for resources essential to human existence, but the processes that concentrate silica in magmas are not fully understood. this research will study



magmatic processes in the sierra nevada mountain range of california, which is the ancient ?plumbing system? from the insides of subduction zone volcanoes from hundreds of millions of years ago, now exposed at earth?s surface. this work will study the chemistry of mafic (more magnesium and iron-rich, lower silica) rocks that represent an important compositional ingredient to create the high-silica rocks that form the bulk of the continents. extensive existing work on the high-silica rocks at this location will provide context for new measurements of the mafic end-member composition to understand the magmatic processes that build continents. the research will support collaboration between caltech and pomona college, including the mentoring of a female graduate student (caltech) and multiple undergraduate/post-baccalaureate students (pomona), as well as early career support for a female faculty member (caltech). in addition, earth science classroom lessons and field trips for middle and high school students from the big pine unified school district (bpusd) in owens valley, located within study area will be developed and conducted. bpusd serves a student population that is ~50% native american and >40% latinx, two under-represented groups in geosciences. the ultimate goal is to increase participation and interest of under-represented students in geosciences through place-based and culturally appropriate lessons that successfully aligned indigenous ways of knowing and scientific practices with western science models the formation of high-silica arc batholiths is an enduring petrologic problem. during flux-melting of the mantle wedge at subduction zones primitive basalts are produced. upon ascent into the crust, further differentiation of these basalts is required to form more silicic derivative melts. although field and experimental studies highlight the importance of lower crustal (>0.7 gpa) fractional crystallization of primitive basalts in generating high-silica melts, this process in detail cannot produce the composition of arc batholiths. in particular, deep crustal fractional crystallization generates peraluminous intermediate and silicic melts, compositions that are not widely observed in arc batholiths. to reconcile these observations, this research will test the following hypothesis: deep crustal differentiation produces high-al, low-mg basalts, as well as, evolved mildly peraluminous granitic melts. these melts represent endmembers that can mix to form the compositional

**\*\*diversity\*\*** of granitoids observed in arc batholith. testing this mixing-model hypothesis has been limited due to the relative lack of studies focusing on the mafic endmember. although volumetrically minor and relatively less-studied compared to high-silica granodiorites to granites that dominate batholiths, mafic plutons (non-primitive gabbros and diorites) are widely present in the upper crust of accreted arc sections. through a collaboration between caltech and pomona college this research will investigate the bulk-rock and mineral major/trace element chemistry, geochronology, and oxygen & strontium isotopic compositions mafic plutonic bodies across a transect from a classic continental arc locality, the sierra nevada batholith. this data will be placed in the context of both existing and new granitoid data, as well as, quantitative geochemical and rheologic models to understand whether these mafic plutonic bodies represent suitable mixing endmembers in the production of batholithic granitoids. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Explaining Differential Success in Biodiversity Knowledge Commons

Awardee: Purdue University

Amount: \$103,752.00

Abstract: scientists increasingly rely on community-governed digital portals to store and access open data. while these digital portals have improved access to data and other scientific products, portals are expensive to implement, challenging to maintain, and often fail to have uptake among key stakeholders. like those working in other areas of the digital economy, scientists have increasingly adopted platforms to implement and tailor portals to particular communities and needs, a model that lowers infrastructure costs and enables benefits of scale across networked portals. yet portals built from the same platform nonetheless show a large variation in their outcomes. participation in any particular portal is often short-lived and the impacts of data portals on the scientific process are

challenging to evaluate; portal usage typically fails to map onto traditional measures of research productivity such as publications and citation counts. this project is the first to systematically investigate scientific data portals built from a common platform in order to understand portal communities and outcomes. the research design, which compares bio\*\*diversity\*\* data portals, will inform studies of other platforms and digital knowledge commons, such as open source software and peer-production communities. specific findings and recommendations will be shared with bio\*\*diversity\*\* portal stakeholders regarding the effective design and use of these portals in order to improve uptake and access to these important species data and facilitate science and decision making around environmental change. this project uses fuzzy set qualitative comparative analysis (fsqca) to analyze open data portals as a kind of knowledge commons that impose minimal restrictions on access or reuse. the study sample comprises the 37 active and 4 inactive bio\*\*diversity\*\* data portals built from the symbiota platform, one of the largest and earliest scientific data platforms still under continual development, with hundreds of participating bio\*\*diversity\*\* collections and several dozen individually managed portals. in 2020, symbiota portals collectively provided access to over 60 million bio\*\*diversity\*\* data records and accounted for 90% of web traffic accessing specimens digitized through the nsf's advanced digitization of bio\*\*diversity\*\* collections (adbc) program, which has invested over \$50 million in this area to date. the project synthesizes across multiple types and sources of quantitative and qualitative data to identify why some of these portals achieve sustained growth and others do not. to do so, the project collects and analyzes up to ten years of analytics and other information from the portals, including tracked usage data, community building activities, features of portal governance, and resource inputs, as well as observation data collected during portal site visits and interviews with a stratified sample of portal managers. the fsqca approach enables comparative inferences about those portal features most likely to foster productive and sustained outcomes, including collective benefit and building inclusive scientific communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review

criteria.

Matched Words: diversity

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Title: Collaborative Research: A Data-Driven Employer-Academia Partnership for Continual Computing Curricular Change

Awardee: University of New Hampshire

Amount: \$101,794.00

Abstract: this project aims to serve the national interest by improving the supply of well-prepared computer science professionals capable of addressing the needs of american employers in the public and private sectors. this project intends to build a national partnership between employers and academia to help identify and mitigate gaps between the competencies of computing graduates and the expectations of potential employers. the project will survey computer science educators and practitioners to develop a model that defines the competencies expected by potential employers. the project team then plans to test the model at three institutions of higher education in alabama ? the university of alabama, tuscaloosa, tuskegee university, and shelton state community college. finally, the project team intends to develop tools and methods for institutions to identify and implement competency-based educational approaches for computer science across the nation. the project plans to use three interconnected strands of evidence-based activities to institute transformational change in the involved communities. first, a national strand will engage u.s. faculty in developing competency-based curricula informed by industry practitioner feedback. second, a local pilot strand intends to create transformative curricular change based on student competencies using an evidence-based change model in the three alabama institutions. sociologists and computing faculty on the team will help to understand, predict, and reduce barriers to competency-based employment of computing graduates from marginalized communities in the heart of the impoverished alabama black belt. the unique perspective relative to **\*\*diversity\*\***, equity, and inclusion needs should serve as a model for other computing departments. the third strand will

develop competency-based surveys for practitioners and academics to identify and refine specific competencies that are hoped to drive continual curricular change. outcomes, including the change process, national workshops, and experiences from the local process will help with transferability in the computing education community. in addition to informing curricula, the project will provide valuable data for educational researchers to help close the gap between employers and higher education. finally, as the competency approach to curricular design is relatively new in computing and engineering disciplines, lessons from this project will have the potential to transform curricular review and design in other stem disciplines. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the institutional and community transformation track, the program supports efforts to transform and improve stem education across institutions of higher education and disciplinary communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: SPARC: Facilitating Research, Experimentation, and Education in Spatial Archaeometry

Awardee: Dartmouth College

Amount: \$101,572.00

Abstract: the spatial archaeometry research collaborations (sparc) program promotes the use of spatial analysis, 3d modeling, as well as satellite, aerial, and terrestrial remote sensing in archaeological research projects. the things archaeologists study?from artifacts to sites to landscapes?almost always have a spatial component and spatial analysis is therefore central to contemporary archaeological investigations. today, the increasing availability and sophistication of geospatial technologies is not merely generating new data but is facilitating entirely novel means of engaging with the archaeological record and exploring the human past. however, the high costs of

instrumentation and software, combined with the expertise they require, create hurdles for many archaeologists who aim to deploy geospatial technologies in research projects. sparc 1) facilitates high-impact spatial archaeometric research, 2) advances emerging methodologies towards greater community use, 3) promotes this new knowledge across the discipline, and 4) promotes inclusion of junior and underrepresented scholars and institutions in leadership roles and in its training schema. through its innovative approach to supporting collaborative archaeological research, the sparc program makes costly geospatial technologies and specialized domain expertise available to researchers from a wide range of backgrounds, including early career scholars and those at minority serving institutions, enhancing **\*\*diversity\*\***, equity, and inclusion within archaeological research. the program also provides education and training opportunities for students and professionals seeking to use geospatial techniques in their own research, broadening the impact of the program far beyond individual supported projects. the sparc program supports archaeological researchers seeking to integrate geospatial technologies and methods into their investigations by facilitating collaborations with research faculty and staff and the technological infrastructure from the university of arkansas' center for advanced spatial technologies (cast), dartmouth college's spatial archaeometry lab (sparcl), and the university of arkansas' microct imaging consortium for research and outreach (micro). researchers apply to the program through a competitive, peer-reviewed process, and successful proposals receive support from geospatial technologies experts in both field and lab settings, access to specialized equipment and software, and intensive training opportunities.

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Planning Grant: Engineering Research Center for Green and Climate Resilient Built Environments (Green CRiB)

Awardee: North Carolina State University

Amount: \$100,000.00

Abstract: the vision of the proposed ERC for green and climate resilient built environments (green cribs) is to enhance the climate-resilience of our society by improving indoor temperature stability as a means of dramatically increasing passive survivability, environmental justice, and providing a pathway to accelerate energy system decarbonization. The Green Cribs ERC planning grant activities will focus on identifying cutting-edge, sustainable, engineering-based innovations in transparent envelope materials and enabling smart manufacturing technologies that will transform how natural and artificial light, heat and energy are managed in the built environment. Window and transparent envelope technologies leveraging innovations in super-insulating materials and novel light management paradigms will enable dramatic reduction of the overall need for active cooling/heating in buildings and agricultural greenhouses, while maximizing access to safe temperatures for both human living and economic activity, including food production. Green Cribs is envisioned as an essential strategy for addressing climate change and environmental equity through energy savings and grid protection, while catalyzing innovation in the \$0.42 trillion glass/window industry and multiple sectors it serves, and training the next generation of diverse, convergence- and innovation-minded engineers to solve complex societal problems. In this ERC, we aim to dramatically improve indoor temperature stabilization against outdoor temperature variations, which will lead to residual load reductions essential for grid decarbonization using an entirely new approach predicated on dynamical management of heat, light and energy at the level of the built environment. A diverse ERC team in terms of expertise, gender, race, geographic location, and career stage will be formed to establish an integrated research, innovation, learning, and mentoring environment with broad participation to produce a highly diverse group of convergent thinkers and problem solvers that reflect the increasing **diversity** of our society. System-level implications on safety, climate resilience, environmental equity and justice, reduction in greenhouse gas emissions and grid decarbonization will be sought and enabled through enabling technologies, fundamental research, smart manufacturing innovations and stakeholder engagement. Intellectual merit

outcomes of this planning grant are to: i) establish linkages between how multi-functional and dynamic transparent envelope technologies and innovations therein will impact climate resilience, energy equity, and grid decarbonization, ii) identify system-level and technology-level testbeds (residential and commercial buildings, greenhouse agriculture, etc.) that will maximize system-level benefits and societal impacts, iii) chart a path towards developing enabling technologies that advance thermal and light management properties well beyond the current state-of-the-art to become responsive to system-level needs, iv) identify critical pathways for advancement of aerogel thermal insulating windows, macroelectronic devices in fundamental areas of reversible electrodeposition, light energy modulation required for optimal plant growth and human comfort, on-glass energy harvesting and storage, and v) improve sustainable, low-cost and large scale manufacturing of advanced technologies on glass and other envelopes. system-level evaluations in primary testbeds in conjunction with stakeholders will be identified to guide research with an eye on minimizing cost and maximizing acceptance, adoption and societal impact. the green cribs planning activities will also seek to identify the broadest possible stakeholder community and foster convergence of diverse disciplines related to systems, technologies and fundamental knowledge. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Planning Grant: Engineering Research Center for Electrosymbiotic Engineering, Design, and Technology (CEED-TECH)

Awardee: Washington State University

Amount: \$100,000.00

Abstract: the center for electrosymbiotic engineering, design, and technology (ceed-tech) will investigate the design rules of recognition, organization, and performance that allow electrochemically active microorganisms to interact with inert electronic materials through a process



called electrosymbiotics. the center seeks to harness bioprocesses through technologies designed to address pressing issues in water security, renewable energy, and green manufacturing. currently, there are knowledge, training, and technical gaps that limit our ability to diversify and scale up these technologies for industrial applications. without multidisciplinary efforts, the field has lagged in the workforce training and diversification that is critical for building productive partnerships, collaborative infrastructure, and large-scale networks between academia and industry that are needed for technology development. this engineering research center (erc) planning grant will bring together a diverse team of scientists, engineers, and relevant stakeholders (academia, industry, and policymakers) and prioritize efforts through in-person and remote planning meetings to develop a full erc proposal. specifically, we will (1) identify key stakeholders for pressing sustainability issues in electrosymbiotic engineering, (2) reach consensus on the significant bottlenecks in advancing electrosymbiotic technologies, (3) refine proposed solutions for developing large-scale electrosymbiotic technologies, (4) build technical and administrative teams, and (5) develop a shared vision across all center participants with a commitment to **\*\*diversity\*\***, equity, and inclusion.

electrosymbiotic engineering is a new field of science that integrates many stem disciplines in engineering and life sciences to actualize technologies critical for economic integration and growth. advancing technology transfer in the field requires a convergent and innovative research and education plan across all science and engineering areas influencing electrosymbiotics and between academia and industry. the center will leverage the **\*\*diversity\*\*** required by this field to create engineering platform designs for market-ready technologies modeled as integrated systems for stable performance and scalability. overcoming the scalability bottleneck will bring transformative electrosymbiotic platforms to the testbed stage. the testbeds will provide integrated environments for problem-solving and new product development. the planned research efforts will be sustained by the targeted and inclusive training program that is needed to develop a workforce with the core competencies, intellectual versatility, and industry knowledge required for long-term professional success and technology implementation. this dynamic and integrated approach will diversify the

economic technology portfolio, promoting growth in 1) sustainable manufacturing, 2) greenhouse gas sequestration, 3) cost-effective wastewater treatment, 4) reclamation of strategically important metals, 5) sensors innovation, and 6) enhanced methods for contaminant removal. industries built on this new center-created knowledge will contribute to our shared economic prosperity and security. this planning grant will allow us to bring together a team of scientists, engineers, and stakeholders to strategically integrate center-driven activities for sustained growth and innovation within the emerging field of electrosymbiotic engineering. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Planning Grant: Engineering Research Center for Electrosymbiotic Engineering, Design, and Technology (CEED-TECH)

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Matched Words: diversity

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Title: EVO-LTER: Building collaborations to investigate the effects of urbanization on eco-evolutionary dynamics across the LTER network

Awardee: Rutgers University Camden

Amount: \$99,969.00

Abstract: living organisms are strongly shaped by both ecological and evolutionary forces. because ecological and evolutionary processes are constantly interacting, it can be difficult to fully understand their effects on the biology of organisms. eco-evolutionary dynamics theory provides a powerful framework for understanding interactions between ecology and evolution on contemporary time scales. the long-term ecological research (lter) network, which was launched in 1980 and has over two dozen geographic research sites, has rich historical and contemporary data for many species across a **\*\*diversity\*\*** of biomes. importantly, many lter sites are embedded in urbanizing landscapes, where eco-evolutionary dynamics may be particularly strong. there is a need to bring together scholars with research expertise in urban eco-evolutionary dynamics and lter researchers to (i) integrate lter approaches and the eco-evolutionary dynamics framework in an explicitly urban context, and (ii) train future lter eco-evolutionary dynamics researchers in an integrative science approach. the intention of this project is to develop research initiatives that promote inclusion and equity while advancing the science of ecology and evolutionary biology. two workshops will be hosted to meet these goals. anticipated outcomes include the preparation of several manuscripts that summarize data synthesis activities and outline the future of eco-evolutionary research at lter sites. another outcome is the formation of new hypotheses about the effects of urbanization on eco-evolutionary dynamics across the lter network to stimulate plans for future collaborative and transformative research. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review

criteria.

Matched Words: diversity

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Title: Planning Grant: Engineering Research Center for Employment of Persons with Disabilities through Inclusion Engineering (EDIE)

Awardee: Vanderbilt University

Amount: \$99,910.00

Abstract: adults with neurodevelopmental disabilities (e.g., autism spectrum disorder; asd) and/or motor impairments (e.g., multiple sclerosis; ms) have the lowest rates of any type of employment in the us (unemployment rate of 63-68%). the potential economic benefits of improving employment outcomes for these individuals are enormous. for example, the current economic opportunity cost to the us economy of unemployed individuals with asd is estimated at \$90 billion per year, to say nothing of the immeasurable human costs; for individuals with ms, the estimated loss to the economy is approximately \$25 billion per year. this national science foundation engineering research center (erc) planning grant award to vanderbilt university will address this potential by creating the capacity for a future nsf erc for the employment of persons with disabilities through inclusion engineering (edie). edie would seek to create engineered systems to lower barriers to employment for neurodiverse and motor-impaired individuals, such that they can more readily maintain or pursue meaningful employment. to be fully ready for erc scale, we need to more fully develop a number of critical elements through this planning grant, specifically: (1) an erc work plan guided by a 5-year timeline for deliverables that emphasizes (a) stakeholder engagement and assessment of user needs, (b) pilot testing of technologies with and through partner organizations, (c) development of technologies to minimum viable product (mvp) stage, (d) testing through large-scale deployment, and (e) sustainability through commercialization of the technologies. (2) commercialization strategies (e.g., start-ups and licensing agreements) that would create a self-sustained innovation ecosystem. (3) a plan to gradually expand the center's scope to include a

wider range of both technologies and disabilities, consistent with the mission of creating a more inclusive workforce. the proposed vision of the planned edie erc is to create intelligent, adaptive technologies that enable employment and workplace success for individuals with neurodevelopmental and/or motor disabilities, increasing human productivity and economic impact, and leading to a more fully inclusive workforce and society. guiding these engineered systems would be the enabling idea of inclusion engineering, an emerging research paradigm representing the convergence of engineering with implementation science, labor and economic policy, and commercial innovation, toward enabling full societal inclusion of all individuals. multiple technological innovations will need to be pursued in concert toward a truly systems-level solution for full inclusion of motor-impaired and neurodiverse individuals for the future of work. thus, we envision that surrounding and supporting edie's core research thrusts will be an innovation ecosystem that includes commercialization efforts coupled to key stakeholder needs and feedback, a culture of **\*\*diversity\*\*** and inclusion with regards both to center personnel and end-users, and a multi-pronged effort toward developing a future engineering workforce that is trained, equipped, and inspired to advance the future of inclusion engineering. the preliminary convergent research thrusts that we have identified are: (1) workplace disability inclusion and employment nondiscrimination policy to ensure these individual technologies and the resulting engineering systems are based on participatory action research (par) to have real-world uptake and societal impact; (2) social human-machine interaction (shmi) to support neurodiverse individuals; and (3) physical human-machine interaction (phmi) to support motor-impaired individuals. the second and third thrusts map directly into engineered systems, while the first guides them and also addresses issues that are not directly addressable via technological solutions. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Defining research and educational priorities in Near-Surface Geophysics: a workshop and survey in light of the Vision for NSF 2020-2030 Earth in Time report

Awardee: American Geophysical Union

Amount: \$99,892.00

Abstract: human society, and all life of earth, depends on earth's near-surface environment. the soils, water, ground water, microbes, and rock provide resources, allow construction, and shape local environments and their resilience. this is the locus of diverse natural hazards, such as landslides, volcanic hazards, earthquakes, and floods, and persistent soil and water pollution. geoscientists have recently developed a diverse range of techniques to probe and study this environment in increasing detail, to help understand it and improve responses to these hazards and challenges. there is huge potential benefit in integrating these approaches and standardizing and sharing broadly and collectively the diverse data and observations of these studies both for advancing science questions and for immediate societal uses and benefits, for example in planning and resilience to climate change. this proposal will survey the full near-surface research community and support a workshop to plan and develop this integration of approaches, data, and training for the future. this proposal will thus support a recommendation from the national academies on future earth science priorities for nsf outlined in the earth-in time consensus report. high-priority questions about the shallow subsurface (or uppermost ~100 m) of the earth, where lithosphere, hydrosphere, biosphere, and atmosphere meet, could be addressed with integrated near-surface geophysics instrumentation, data, and training. we propose to survey diverse scientists and bring them together in a town hall discussion and virtual workshop series to create and disseminate such an inventory and plan for future integration of diverse approaches and data, including around training to address scientific targets as well as societal needs and challenges while stressing **diversity** and equity broadly. the products of this work would help define the merits, and roadmap, of this integration, including the recommendation of the national academies report earth-in-time for a near surface geophysical center to facilitate integrated near-surface studies. a

goal of the workshop's outcomes is to identify what the near-surface earth science community considers the highest-value scientific research targets as well as provide recommendations to improve education and outreach on near-surface geophysics topics to the geoscience community and related communities such as engineering and those involved in natural hazard mitigation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Awardee: American Geophysical Union

Amount: \$99,892.00

Abstract: human society, and all life of earth, depends on earth's near-surface environment. the soils, water, ground water, microbes, and rock provide resources, allow construction, and shape local environments and their resilience. this is the locus of diverse natural hazards, such as landslides, volcanic hazards, earthquakes, and floods, and persistent soil and water pollution. geoscientists have recently developed a diverse range of techniques to probe and study this environment in increasing detail, to help understand it and improve responses to these hazards and challenges. there is huge potential benefit in integrating these approaches and standardizing and sharing broadly and collectively the diverse data and observations of these studies both for advancing science questions and for immediate societal uses and benefits, for example in planning and resilience to climate change. this proposal will survey the full near-surface research community and support a workshop to plan and develop this integration of approaches, data, and training for the future. this proposal will thus support a recommendation from the national academies on future earth science priorities for nsf outlined in the earth-in time consensus report. high-priority questions about the shallow subsurface (or uppermost ~100 m) of the earth, where lithosphere,



hydrosphere, biosphere, and atmosphere meet, could be addressed with integrated near- surface geophysics instrumentation, data, and training. we propose to survey diverse scientists and bring them together in a town hall discussion and virtual workshop series to create and disseminate such an inventory and plan for future integration of diverse approaches and data, including around training to address scientific targets as well as societal needs and challenges while stressing **\*\*diversity\*\*** and equity broadly. the products of this work would help define the merits, and roadmap, of this integration, including the recommendation of the national academies report earth-in-time for a near surface geophysical center to facilitate integrated near-surface studies. a goal of the workshop's outcomes is to identify what the near-surface earth science community considers the highest-value scientific research targets as well as provide recommendations to improve education and outreach on near-surface geophysics topics to the geoscience community and related communities such as engineering and those involved in natural hazard mitigation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Workshops: Broadening Participation of Historically Black Colleges and Universities in the NSF Research Traineeship and Innovations in Graduate Education Programs

Awardee: Jackson State University

Amount: \$99,879.00

Abstract: this award to jackson state university is supported by the national science foundation research traineeship (nrt) and innovations in graduate education (ige) programs. the project team will bring together members of the carnegie doctoral universities high research (r2) historically black colleges and universities (hbcus), experts in graduate education, graduate students, other hbcus, and nsf program officers. two workshops will be organized to address challenges related to increasing the number of stem ph.ds. from underserved populations and providing support and

training to investigators from the participating institutions to generate creative proposals for the nrt and ige programs. the workshops are intended to provide information, understanding, and training on how new graduate models can be created to increase the recruitment, retention, and graduation of minority ph.d. students. this project endeavors to develop strategies and critical recommendations that will address growing national concerns about the number of african americans applying to ph.d. programs in stem. by promoting the close interaction of nsf program officers with a coalition of r2 hbcu graduate education stakeholders, the workshops are intended to increase interest in and awareness of the nrt and ige programs and the number of proposals submitted by r2 hbcu institutions. the specific goals of the workshops are to 1) understand and investigate how to leverage relationships between r2 hbcu institutions and the nrt and ige programs; 2) investigate current models and best practices between the coalition of r2 hbcus that may support recruitment, retention, and positioning of ph.d. stem students into the u.s. workforce, and 3) provide proposal writing training to support the production of competitive proposals to the nrt and ige programs to support these models. additionally, this project will be a path forward to filling in the gaps in outreach to and communications with r2 hbcus by the nsf, which can lead to greater **\*\*diversity\*\*** in the stem fields. the model that results from this project can then be tested and applied to other nsf programs where r2 hbcus are underrepresented in funding. the nsf research traineeship (nrt) program is designed to encourage the development and implementation of bold, new potentially transformative models for stem graduate education training. the program is dedicated to effective training of stem graduate students in high priority interdisciplinary or convergent research areas through comprehensive traineeship models that are innovative, evidence-based, and aligned with changing workforce and research needs. the innovations in graduate education (ige) program is focused on research in graduate education. the goals of ige are to pilot, test, and validate innovative approaches to graduate education and to generate the knowledge required to move these approaches into the broader community. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the

foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Creating inclusive workspaces that foster and support BAJEDI leaders in the Big Ten Academic Alliance of geoscientists

Awardee: Ohio State University

Amount: \$99,806.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). this project will advance knowledge of the barriers within geoscience academia that prevent the development of \*\*diversity\*\* champions, and help identify strategies to create and sustain cohorts of \*\*diversity\*\* leaders in geoscience at the ohio state university and the wider big ten academic alliance (btaa). the pi will organize a set of convenings of geoscientists with strong engagement from social and behavioral science experts to create and administer institutional climate surveys with an eye towards results-based action plans, developing bajedi faculty leaders in the geosciences, and providing professional development training in bajedi for graduate students and postdocs who will soon be on the job market. studies have demonstrated that \*\*diversity\*\* sparks innovation with underrepresented groups producing higher rates of scientific novelty. yet, there is an innovation-\*\*diversity\*\* paradox because the underrepresented groups that diversify scientific organizations have less successful careers within academia (hofstra et al. 2020). geoscience in particular continues to lag behind other stem fields in creating an inclusive community of diverse scholars. the main objective of this project is the creation of results-based implementation that focuses on training and support of bajedi (belonging access justice equity \*\*diversity\*\* inclusion) leaders at ohio state and the broader big ten academic alliance (btaa). the activities outlined in this project will address two key questions. (1) what barriers exist within geoscience academia that prevent the development of \*\*diversity\*\* champions? (2) what strategies could be employed to create and sustain cohorts of \*\*diversity\*\* leaders to maximize collective impact? this award

reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Planning Grant: Engineering Research Center for Symbiotic Systems

Awardee: Carnegie-Mellon University

Amount: \$99,481.00

Abstract: this planning grant will support efforts to create a new nsf engineering research center on symbiotic systems. symbiotic systems are machines and robotic systems that assist humans with daily tasks in a harmonious manner that does not create unnecessary physical impediments, constraints, or distractions. the purpose of these systems is to improve productivity, mobility, health, and quality of life through the aid of assistive robotics and wearable technologies. an important scientific challenge in developing these technologies is to introduce new types of soft material motors, sensors, and electronics that mimic the properties of natural muscle, skin, and nervous tissue. another challenge is to introduce integrated material architectures, models, and data-driven algorithms that allow these robotic systems to provide active support and motor assistance only when intended by the human user. beyond its potential impact on human well-being, the intelligent symbiotic systems developed by this center also represent opportunities for interdisciplinary scientific education and workforce training as well as broadened inclusion. such opportunities leverage the rich **\*\*diversity\*\*** of stakeholders, societal endeavors, and technical disciplines that relate to human-centered wearable technologies. the proposed erc will establish a scientific and technological framework for creating assistive robotic technologies that will be personalized, dynamically responsive and reconfigurable, and compatible with daily human activity outside of a laboratory or clinical setting. such systems will be *?symbiotic,?* engaging in intimate physical interaction with the body and assisting in rehabilitation, neuromuscular function, disease screening and diagnostics, and therapy without impairing natural bodily function. this will be achieved through

the use of soft material architectures that allow for selective mechanical impedance and actuation along with shape reconfigurability and reversible stiffness tuning. achieving these goals requires the convergence of several disciplines, including materials science and engineering, robotics, medicine, biomechanics, mechanical engineering, human-computer interaction, electrical and computer engineering, human psychology, and artificial intelligence. during the planning phase of this effort, we will pursue the following objectives: (i) identify and engage with stakeholders in research, healthcare, industry, and society to refine the erc vision; (ii) establish partnerships to create a diverse, interdisciplinary team of experts to tackle the various facets of scientific challenges and discovery, technology translation, and societal impact; and (iii) create a framework for workforce training, entrepreneurial activity, and educational outreach to ensure comprehensive and sustainable impact. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: RAPID: Impacts of high magnitude wildfire on volcanic (lava tube) cave water chemistry, nutrient transport, activity and diversity of cave microbiome

Awardee: University of Texas at San Antonio

Amount: \$99,394.00

Abstract: wildfires of high magnitude are known to cause destruction of surface vegetation, soil sterilization, and alteration of soil chemical and hydraulic properties; whereas their effects on subsurface environments are relatively unknown. recent caldwell and antelope wildfires in northern california burnt over hundreds of acres of landscape which included 97% of the area in lava beds national monument (lava beds) that protects volcanic (lava) caves. the volcanic caves provide a unique habitat for bacteria and archaea, and morphologically diverse secondary mineral features (speleothems) in the presence of water. this study investigates the impacts of intense wildfires on volcanic cave ecosystems by sampling cave water and microbial mats, and analyzing them for detailed inorganic and organic chemistry, microbial **\*\*diversity\*\*** and activity. this data from fire-affected caves will be compared with pre-fire data from earlier studies, and the control caves from the unburnt areas, to quantify the changes occurred within the caves due to wildfires. this rapid project supports one minority graduate student at the university of texas at san antonio, a leading hispanic serving institution (hsi) and several undergraduate students (hispanic, minorities, women and first generation). in collaboration with the national park service, the findings of this study will help inform protection of the sensitive natural heritage at lava beds national monument, and important scientific findings will be made available to the visitors of the park. impacts of high magnitude wildfires on surface environments are well documented such as complete destruction of vegetation, soil sterilization, and alteration of physical, chemical and hydraulic soil properties. however, their effects on subsurface environments like vadose zones, shallow aquifers, and caves are relatively understudied. the caldwell fire in 2020 and antelope fire in 2021 in northern california have affected 97% of lava beds national monument (california, usa) landscape that hosts numerous volcanic (lava) caves. volcanic (lava) caves are nutrient-poor, aphotic environments, and yet they

host a rich **diversity** of bacteria and archaea which often utilize reduced energy sources (e.g., reduced iron, sulfur, manganese, or nitrogen compounds) available within the host rock and mineral deposits within the caves. availability of nutrients in caves greatly depends upon the interactions between host rock (basalt) and meteoric water that infiltrates through surface soils into caves through fractured cave walls. this rapid study will obtain water and microbial samples from volcanic caves in wildfire affected and unaffected areas at lava beds, during a post-fire hydrologic response time, and correlate it with chemical and molecular signatures in the samples. post-fire changes in cave water chemistry will be quantified by measuring concentrations of cations, anions, trace metals, and dissolved organic matter, and comparing with pre-fire data from earlier studies, and from control caves. analysis of 16s rna gene sequencing and atp will be used to track changes in microbial **diversity** and activity within the caves during the post-fire period. one graduate student and several undergraduate students from the university of texas at san antonio and university of new mexico will perform samples collection and subsequent laboratory analyses. these results will provide a key information regarding impacts of surface wildfires on subsurface ecosystems. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: TOWARDS A SUSTAINABLE MANAGEMENT OF INSECT COLLECTIONS IN THE U.S. THROUGH THE ENTOMOLOGICAL COLLECTIONS MANAGEMENT WORKSHOP

Awardee: Entomological Society of America

Amount: \$99,000.00

Abstract: natural history collections are an archive of earth's bio**diversity**, informing our understanding of the planet and ecological interactions that impact society. recent global initiatives to digitize biological collections have transformed the scope and scale of how these biorepositories contribute to integrative biological research. interest in collections and their data is increasing,



however much of the workforce capacity remains the same. entomological collections are especially important because insects represent the most diverse and abundant group of animals with over one million known species. insects are ubiquitous in our everyday lives and an essential part of most ecosystems. they are also important to human health, as the majority of plant pollinators, disease vectors, and agricultural pests are insects. collections are organized and maintained only through the specialized knowledge and experience of museum personnel, generally passed directly from one generation to the next, as no formal program has existed to do this across the community. this generational knowledge transfer has been especially important in smaller collections with limited staff, which represent ~70% of all u.s. insect collections. despite their size, these collections are often extremely valuable due to their strong regional holdings. this effort will produce a comprehensive program to provide formal best-practices training, both in-person and online, to collections personnel, as well as providing much-needed networking opportunities for collections workers across career stages and institutions to share their knowledge and experience with the broader collections' community. this award supports the progressive advancement of the entomological collections management workshop series, including virtual participation and material, co-sponsored by the entomological collections network (ecn) and the systematics, evolution, and bio\*\*diversity\*\* (syseb) section of the entomological society of america (esa). the workshops are scheduled to take place annually in summer 2022 to 2024, with hosting rotating between the yale peabody natural history museum, cleveland museum of natural history, and arizona state university. the workshop will be developed as a hybrid virtual and in-person event. during the 3-4 day workshop, participants will receive training in entomological collections management covering a wide range of topics, various topics including policies, specimen handling, curation, conservation, and digitization. this project will encourage the participation of collections staff managers and students associated with smaller collections, as they often have with more limited resources for training and collection development. this workshop will also help fund participation by students and early career researchers, the largest and most diverse (in terms of gender, ethnicity, and

socio-economic background) segment of the collections management community. the professional development opportunities provided by this workshop will thus lead to a more highly skilled and integrative community of collections management personnel. the virtual components of this workshop will be shared to the broader community through the ecn website, with the results of in-person workshops also presented at the ecn annual meetings. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Kansas State University

Amount: \$99,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: BEE: IMEMEBA Workshop: Insights from Macro-Ecology and Macro-Evolution for Biodiversity Assessment

Awardee: University of California-Berkeley

Amount: \$98,860.00

Abstract: the earth's ecosystems are under serious threat due to ongoing stressors of the anthropocene. presently, we have no reliable way to assess the overall health of an ecosystem, and the bio\*\*diversity\*\* therein, let alone to identify thresholds of change beyond which a complex ecosystem cannot recover. much needed are insights into how patterns of species \*\*diversity\*\* that we understand to emerge at small scales are propagated up to shape entire ecosystems: what are the drivers, and what aspects impart resilience to perturbations such as those from invasive species or climate change? three rather disparate research areas have started to examine how large scale ecological and evolutionary patterns emerge through time, notably in the context of fossils, where changes in communities can be studied through the geological record; remote archipelagoes in which different ages of component islands can be used as snapshots of community composition through geological time; and microbial systems, where large scale patterns emerge relatively quickly. this project brings researchers from these different disciplines together, along with others who are developing theory focused on emergent patterns that can apply to any or all of these systems. the primary goal is to identify commonalities across systems and build a unified theory that describes large scale patterns of ecosystems and attributes that promote resiliency to change. the outcomes will have broad societal impact for understanding ecosystem response to changing climate. in addition, the workshop will contribute to the training and scholarly advancement of diverse early career investigators. the project has three organizers and an additional six core participants. there will be a preliminary planning workshop held for the core participants. this small workshop will be short and focused, based at blue oak field station, california in fall 2021, and geared towards expanding on concepts at the intersection of the different disciplines and planning for the main workshop. the primary workshop will be held at schoodic, maine and will be longer, larger, and more integrative, tentatively scheduled for june 7-13, 2022. for the main workshop the organizers have identified 30 key participants who are active in developing insights into large scale

ecological and evolutionary properties within each of the fields of paleoecology, island community ecology, and microbial systems, as well as researchers who are developing theory at the intersection of these disciplines. participants have been targeted with an eye to gender equality and **\*\*diversity\*\*** of career stages. for the primary workshop, eight slots have been reserved for applications from graduate students and early career scientists. this workshop was funded through the bridging ecology and evolution category in the biological sciences directorate, division of environmental biology. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Planning Grant: Engineering Research Center for Environmentally Applied Refrigerant Technology Hub (EARTH)

Awardee: University of Kansas Center for Research Inc

Amount: \$98,615.00

Abstract: abstract for planning grant: engineering research center for environmentally applied refrigerant technology hub (earth) part 1: pg: earth will bring together leaders from the research community, industry, and educational institutions to address critical scientific, engineering, workforce development, and policy issues related to the future of refrigeration and air conditioning (rac). rac systems are widespread throughout modern society, enabling transportation of fresh foods, storage of medicines, and cooling of buildings. the u.s. is a global leader in designing and manufacturing rac systems, and the u.s. chemical industry has been a major innovator in creating the hydrofluorocarbon (hfc) refrigerants that replaced ozone-depleting chlorofluorocarbons (cfcs). given that rac now accounts for nearly 20% of worldwide energy consumption, there is an urgent need to develop new and more energy efficient cooling technologies. at the same time, current hfc refrigerants are being phased out due to global warming concerns. there is thus a need to develop

innovative new refrigerants and cooling technologies that are safe for the environment and efficient processes that enable the economical and safe recovery and reuse of millions of kilograms of deployed hfc refrigerants. earth will be a critical national resource to address these challenges. this planning grant will enable stakeholders to assess a variety of important topics impacting the development of alternative refrigerants and novel cooling cycles. innovation in the global refrigerants market is often led by major u.s. companies, but the markets for their products are global and growing rapidly. understanding this global market landscape and developing cutting edge technologies in this space are critical components of earth and will help the u.s. maintain its leadership in innovation and manufacturing in the strategically important refrigerants industry. earth will facilitate the formation of partnerships between educational institutions, industry, national labs, trade groups, and policy makers. the phase down of hfcs over the next two decades is estimated to create 150,000 new jobs and increase manufacturing by \$39 billion in the u.s. while preventing global temperature from rising by 0.5 °c. the erc's foundational components will go beyond research to include technical training and workforce development at all participant stages. it will foster a culture of **\*\*diversity\*\*** and inclusion and create value within an innovation ecosystem that will extend beyond the lifetime of the erc. part 2: the erc we envision will address the basic science, engineering, education, and policy issues that are essential for meeting the many challenges facing the rac infrastructure. three major issues will shape the thrusts of earth. first, the high global warming potential of the current generation of refrigerants (hfcs) is requiring the rac industry to again consider new fluids that balance performance, efficiency, safety, environmental concerns, and a host of other factors. the number of small molecules and their mixtures that could potentially be used in rac cycles is almost limitless, but only a small subset have been synthesized and tested. second, the vast majority of rac systems are based on hundred-year-old vapor-compression technology, but new approaches including solid-state technologies that utilize magnetocaloric, electrocaloric, and mechanocaloric effects could revolutionize the field. third, millions of kilograms of high global warming potential hfcs valued in the billions of dollars are currently in use around the world, and

most consist of azeotropic mixtures. there is currently no means of separating and recovering these valuable compounds. earth will bring together experts in high fidelity experiments, advanced atomistic simulations, data science methods, and process design to develop novel refrigerants, energy-efficient cooling designs, and optimized hfc recovery processes. the core planning group from the university of kansas, university of notre dame, university of maryland, lehigh university, and university of south dakota has the needed expertise and experience to bring together a multi-disciplinary team composed of participants from academia, industry, national laboratories, professional organizations, and policy makers to prepare this proposal. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: MRA: Elucidating Plant and Mycorrhizal Fungal Relationships and Consequences Across Space and Time

Awardee: Smithsonian Institution

Amount: \$98,247.00

Abstract: many plants are dependent on belowground fungi to help them obtain nutrients and respond to environmental stress. revealing the patterns and drivers of these interactions is important for understanding forest ecology and improving management practices. plant-fungal associations in the soil can dramatically influence plant growth and terrestrial ecosystem function. this research will take the advantage of several existing datasets, including those collected by national ecological observatory network (neon) and the u.s. forest service (usfs), to understand: 1) nation-wide patterns of plant-fungal associations; 2) key factors that influence these associations; and 3) how plant-fungal interactions influence key ecosystem functions such as carbon cycling. this research project will contribute to the fields of microbial ecology, ecosystem science, and global change biology by formulating and testing new theories about plant-fungal associations. results of the

project will inform forest managers, policymakers, and other stakeholders on how to improve ecosystem management of plant and fungal bio\*\*diversity\*\* to promote sustainable ecosystems. the project will contribute to the professional development of diverse students at several stages. the goal of this project is to understand the patterns, drivers, and consequences of the linkages between plant and mycorrhizal fungal \*\*diversity\*\* across spatial and temporal scales. this information will enable better predictive understanding of essential ecosystem functions which they control. the project will use a holistic, scale-dependent framework that forecasts the strength and direction of arbuscular mycorrhizal (am) and ectomycorrhizal (em) fungal-plant associations, and provides greater insight about the consequences for ecosystem functioning across space and over time. specific objectives of the project include: 1) elucidation of patterns of plant and mycorrhizal fungal \*\*diversity\*\* across scales by extensive dna sequencing and analysis; 2) determination of key abiotic and biotic drivers of observed co-occurrence patterns; and (3) forecasting the effects of plant-mycorrhizal fungal couplings on tree productivity and soil c storage, two key forest ecosystem functions. by linking multiple facets of both above- and belowground \*\*diversity\*\* in a scale-dependent context, the project will produce robust continental-wide distribution maps of am and em fungi for the first time. leveraging data-rich sampling of putative biotic and abiotic drivers of plant and fungal \*\*diversity\*\* by neon and the usfs, the project will also provide broad-scale understanding of when and where these drivers serve to couple or decouple plant and mycorrhizal fungal \*\*diversity\*\*. finally, by linking plant and mycorrhizal fungal \*\*diversity\*\* to the consequences they have for plant productivity and soil c storage and stability, the project will improve understanding of ecosystem resilience to environmental stress. the project will train diverse undergraduate and graduate students, postdoctoral scholars, and will enhance the development of three early-career scientists. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: LEAPS: Enabling Scientific Societies to Support Inclusive, Diverse, Equitable & Accepting (IDEA) Scientific Environments

Awardee: American Institute of Biological Sciences

Amount: \$96,488.00

Abstract: Scientific institutions increasingly recognize the need to remove barriers for individuals historically underrepresented in science and to improve **diversity**, equity, and inclusion (DEI). A wider breadth of scientific competencies, achieved by improving DEI, is needed to address many critical scientific concerns with global impacts. However, improving DEI requires a significant cultural shift, and scientific societies provide a unique platform to lead these cultural changes in the biological sciences. Scientific societies represent a wide variety of individuals and institutions; they

have access to multiple fields of biology to impart resources and education; and they can enable networking and idea sharing across many disciplines and organizations to empower new approaches. the american institute of biological sciences (aibs) was founded with the goal of unifying the individuals and organizations that collectively represent the biological sciences, so that the community could address matters that impact life on earth. aibs brings together 115 member societies and organizations that represent the full spectrum of the life sciences to address matters of collective concern. it is critical that scientific societies create inclusive, diverse, equitable and accepting (idea) scientific environments to ensure that science is equipped to address 21st century grand challenges. creating idea scientific environments requires an iterative process of top-down and bottom-up approaches that rely on sharing information and experiences, analyzing personal assumptions and expectations, communicating with honesty and openness, and committing to change.

this project will engage and create a collaborative network of majority- and minority-serving biological scientific societies to foster cultural change through two virtual workshops. these workshops will engage scientific society leadership to collaboratively understand the components of idea cultures, assess the current culture in biology, identify barriers to enabling idea environments, create action plans to overcome these barriers, and commit to long-term cultural change. the first workshop will provide a forum for leaders of scientific societies to engage in shared learning, discussion, and reflection on three topics: (1) culture, (2) bias and stereotypes, and (3) equity. the workshop will offer tools for participants to develop action plans to enable idea scientific environments and to take the knowledge, resources, and tools they have gained back to their organizations. a second workshop will occur 6 months later and will be informed by a webinar and a participant survey to assess early implementation of the action plans. the workshop will result in longer-term steps to continue progress in creating idea scientific environments. among the intended project outcomes is a "tool kit," a repository of tools, templates, resources, and other information that will be available to scientific societies, other institutions, and the public. this tool kit will be curated over time as a place to share information and help cultivate the large-scale changes needed

to create idea scientific environments. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Mass transport in Jupiter's magnetosphere -- driven by internal or external processes?

Awardee: Trustees of Boston University

Amount: \$94,720.00

Abstract: the sun emits a stream of particles called the solar wind. the solar system presents a wide variety of obstacles to the solar wind in the form of planetary magnetospheres. magnetospheres arise from the internal magnetic field of a planet and serve to deflect the solar wind from the surface of the planet. mass from the solar wind hits the magnetosphere and is diffused toward the poles and then carried out behind the planet in a structure called the magnetotail. io is a moon of jupiter that also provides particles to its magnetosphere from within, and so it can be used to trace the flow of particles from within the magnetosphere. this project will use observations of sulfur and sodium ions to trace out the diffusion of particles from within jupiter's magnetosphere to better understand the process of diffusion in magnetospheres. the project will use a dedicated telescope for their observations. the project will also create a children's book, 'the misfit telescope' with a companion website and social media stream that use the benefits of \*\*diversity\*\* in scientific instrumentation as a parable to illustrate the benefits of racial and cultural inclusivity. the proposed project will study the io plasma torus (ipt) around jupiter in order to gain insight into the jovian magnetic field. the project will use the io input/output observatory to make time domain observations of s ii and na lines in the ipt to determine the nature of diffusion of material. ioio is a small-aperture robotic coronagraph that operates nightly, contemporaneously recording narrow-band images of the ipt ins s ii. combined with a model of the ipt, the observations will show whether diffusion is driven by mass loading from

io or by activity in the middle jovian magnetic field. the project's children's book will show the value of both being in the minority and havingg a different point of view and of being in the majority and accepting and respecting the minority point of view. the book will be produced by the planetary science institute's award winning public outreach team. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Convergent Evolution of Development and Feeding Biomechanics in Weakly Electric Fishes from South America and Africa

Awardee: Ford, Kassandra

Amount: \$93,000.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2020, broadening participation of groups under-represented in biology. the fellowship supports a research and training plan for the fellow that will increase the participation of groups underrepresented in biology. the project incorporates multiple scientific fields and examines the concept of "convergent evolution," or similar characteristics in unrelated organisms. this research addresses the lack of clear terminology associated with the term "convergent evolution" by investigating the question: at what point are organisms considered convergent? the fellow will use integrative methods to study two groups of diverse fishes and obtain training across scientific disciplines. this work is important preparation for the fellow's future research program that will be focused on convergent evolution research. the sponsor will provide extensive training on teaching and mentoring so the fellow will be a well-rounded academic with experience with advising, lecturing, and leading students in research projects. the fellow will interact with underrepresented students at all educational levels during the broader impacts activities: k-12 students, stem undergraduates, and graduate students. these efforts address the lack of representation in stem at all levels, to increase the overall \*\*diversity\*\* at

the postdoctoral level and beyond. the fellow will take an integrative and interdisciplinary approach to examining convergence (and its terminology) in two charismatic groups of freshwater fishes. electric fishes, gymnotiformes (south america) and mormyridae (africa), are generally deemed convergent in many ways, including genes, sensory systems, and ecology. previous work showed that while these two groups are indeed similar in these aspects, they are not identical. the project will use methods to quantify head and skull shape, characterize feeding modes, and measure feeding success for comparisons across electric fish species. the results of this work will allow the fellow to understand the degree to which species in these two groups are convergent in developmental processes and/or functional behaviors. the fellow aims to diversify the field of ichthyology through her research, collaborations, and mentorship of underrepresented students. the fellow will mentor undergraduates at a historically black college & university, advise a student during a research experiences for undergraduates project, lead scientific lessons at k-12 schools, and host workshops for graduate students aimed at increasing \*\*diversity\*\* at the postdoctoral level. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Expanding The Capacity Of The Center for Infrastructure Transformation and Education Through Integrating Diversity, Equity, and Inclusion into Infrastructure Education

Awardee: University of Wisconsin-Platteville

Amount: \$92,074.00

Abstract: this project aims to serve the national interest by expanding the capacity of the center for infrastructure transformation and education (cit-e) to support civil, construction, and environmental engineering faculty members in their efforts to integrate \*\*diversity\*\*, equity, and inclusion (dei) into infrastructure education. the causes of inequitable infrastructure are many; however, given its leading role in infrastructure-related education and research, the civil and environmental engineering

(cee) faculty has an obligation to recognize and address the need for systemic change. historically, cee faculty members have not received formal training on dei issues. while such training is becoming more common, a gap remains. this level 1 capacity building project will support cit-e, an existing and thriving community of practice (cop), through providing the foundation for future work in developing a multi-institutional effort to transform the cee education community into a community that can sustain growth in dei integration. the collaborative research project is a joint effort by the university of wisconsin, platteville, lafayette college, colorado state university, and virginia polytechnic institute and state university. with the increased capacity generated by this expanded network and a shared vision, the cit-e cop work will be transformative. leveraging the cit-e and the cop, the project frames the work through the lens of two continua: race neutral/race conscious and inclusion infrastructure/exclusion infrastructure. this project will develop i) cit-e communal understanding of how dei and infrastructure are related; ii) what the interaction among members reveals about dei; iii) how members of the cop can educate one another by addressing dei issues in education, research, and professional practice; and iv) how the cop can inspire real and lasting change. specifically, this project will increase the capacity of cit-e through the following project objectives: i) gather evidence by compiling a list of non-normative examples of successful institutional efforts that positively impact dei; ii) assess cit-e resources and needs via asset mapping; iii) evaluate community of practice as an appropriate change theory; iv) recruit additional stakeholders and organizations to cit-e based on the gaps identified in previous project objectives; v) identify, cluster, and prioritize ways of integrating dei into cee education using group concept mapping (gcm); and vi) provide the foundation for developing a multi-institutional effort to transform the cee education community into a community that can sustain growth in dei integration. the research team will ensure that key stakeholders, including experts in change theory, dei strategies, and curriculum development are invited to provide external peer review of the project. the research team will facilitate working sessions to address larger tasks such as gcm and asset mapping. through a collaboration with the institute for research in the social sciences (iriss), the project will i)

build the capacity of the geographically-dispersed research team by accelerating the team's integration to operate as a highly-functioning team and ii) explore how team science might add value to efforts to expand the work. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the institutional and community transformation track, the program supports efforts to transform and improve stem education across institutions of higher education and disciplinary communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of North Florida

Amount: \$92,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Linguistics: Reconstructing the Discipline through Universals Research

Awardee: Philadelphia Area Center for History of Science

Amount: \$91,674.00

Abstract: this project is a historical investigation of modern linguistics, embracing anthropological and cognitive traditions in the discipline. linguistics is strikingly heterogeneous, consisting of sub-fields that touch on almost every aspect of human life?from the study of human genealogy to the development of twentieth-century computer science. accordingly, there are few comprehensive accounts of the discipline, a gap that this project will help to fill. as contemporary society is grappling

with questions about who should have the authority to research and manage human **diversity**, there is an urgent need to understand the tension between particular and general approaches at the heart of linguistics, rather than focusing exclusively on one or the other. funding will support archival visits, conference participation, and translation services, and it will lead to the production of a book, scholarly papers, teaching materials, and community development initiatives that will shed light on the stakes and scope of linguistics as a discipline. correspondingly, the project will give practicing linguists historical insights that may inform policies around the preservation of linguistic **diversity**.

two prominent, yet mutually isolated, research programs dedicated to language universals emerged during the 1960s. one was empirical, and associated with joseph greenberg; the other was logical, with noam chomsky at the fore. drawing on archival materials at stanford university and the massachusetts institute of technology, this project will characterize these two programs in full. it will use them to reconstruct a maximally inclusive history of modern linguistics via patterns of citation, collaboration, and subsequent engagement. through the prism of language universals, it will survey major schools and developments in the history of modern linguistics including structuralism, machine translation, typology, and transformational-generative grammar. informed by recent work in science and technology studies concerned with the nature and historicity of data, research praxis, scientific communication, and the organization of knowledge, the project will promote understanding of the processes by which modern disciplines have taken shape and defended their societal relevance over time. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: PPOSS: Planning: A Disciplined Approach to Scaling in the Post-Moore's Law Era

Awardee: Northwestern University

Amount: \$91,300.00

Abstract: general-purpose processor speeds have not increased at their historical rates for over 15 years. designers have instead offered scalable computing systems with additional barriers to realizing the performance gains that once came "for free" with each processor generation. this situation has slowed the progress of all endeavors that involve scalable computing. a disciplined approach to reversing this trend must start and end with a direct engagement with the scalable-system users and programmers faced with these barriers. with this goal, the investigators are performing in-depth face-to-face interviews with a broad set of users. in addition, with these users, the project team is also examining codes, exchanging ideas, and offering assistance. this is producing a deep understanding of how users are coping with their growing demands for computing while computing is placing more demands upon them. the project's novelties are this in-depth study and the resulting formulation of an approach to address the limitations of scalable computing based on real users' needs. the project's impacts are the dissemination of the survey results and a recommended approach forward that restores meaningful layers of abstraction to scalable systems, freeing programmers from being drawn deeper into the complexity of scalable computing while delivering higher performance to them. the investigators performed a similar study in 2011. with this planning grant: (1) they are conducting a more ambitious study with a greater **\*\*diversity\*\*** of subjects. by re-engaging as many 2011 subjects as possible, this becomes a longitudinal study capable of revealing trends not visible in any single point-in-time study. (2) the investigators are using these interactions to explore transitioning their foundational work to practice, to build a larger team, and to expand the scope of future work. the results of the 2011 study inspired the

investigators to produce breakthroughs in speculation, dependence handling, latency tolerance, and automatic parallelization. the 2021 study serves as a vehicle to explore ways to transition these results to practice. (3) the investigators believe that hardware can be more domain-adept without being domain-specific. using prior insights, they are exploring hardware/software concepts that deliver top performance levels without undue programmer burden. by testing these ideas in the context of the study, the investigators can best frame the problem, refine approaches, and test hypotheses in the context of actual needs, opportunities, and constraints. all of these activities ensure that future work in scalable systems will have greater impact. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Proposal for a SUMMIT to Plan a Conference Workshop for Minoritized Geoscientists

Awardee: University of California-San Diego Scripps Inst of Oceanography

Amount: \$90,866.00

Abstract: this project aims to host a four-day summit with fifteen leaders from geoscience organizations with a demonstrated interest in improving belonging, accessibility, justice, equity, **\*\*diversity\*\***, and inclusivity (beajedi). the summit will provide these leaders with opportunities to share successful strategies for improving beajedi in geoscience. leaders at the summit will design a conference where ~100-300 geoscientists network, present their research, and share successful strategies for improving beajedi in geoscience. the summit will thus begin the process of increasing interagency and interpersonal sharing, design, and refinement of the strategies used to strengthen beajedi in geoscience. the main goal of this project is to host a four-day summit with 15 leaders from the largest and or influential geoscience organizations with a demonstrated interest in improving belonging, accessibility, justice, equity, **\*\*diversity\*\***, and inclusivity (beajedi) in

geoscience. summit participants will collaboratively design a conference workshop while sharing successful strategies for improving beajedi for geoscientists of color. this designed workshop will be primarily attended by geoscientists and will allow attendees to present research and network. the workshop will also include surveying and interviewing attendees to collect information that are germane for successfully recruiting and retaining people of color within geoscience. the questions that the surveys and interviews seek to answer are: 1. what attracts people of color to geoscience? 2. what are the experiences of geoscientists of color? 3. what do full belonging, accessibility, justice, equity, **\*\*diversity\*\***, and inclusivity look like to geoscientists of color? alongside developing a novel method of answering the questions listed above, this project's broader impacts are strengthened by including a mentorship component. the summit will pair early-career researchers interested in beajedi issues with established and experienced individuals. the early-career researchers will gain conference proposal writing experience while expanding their network. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Collaborative Research: 3 Myr of Laurentide Ice Sheet History Inferred from Cosmogenic Nuclides in Ice-Rafted Debris

Awardee: University of Vermont & State Agricultural College

Amount: \$88,394.00

Abstract: the laurentide ice sheet over north america caused large changes in climate and sea level as it grew and shrank over ice age cycles during the past three million years, but little is known

about the ice sheet's detailed history throughout this interval. this project will determine how big the ice sheet was through time using chemical markers in layers of sand on the seafloor that melted out of icebergs drifting from north america. this method provides a new way to learn about past changes in the laurentide ice sheet and test ideas for how climate change and ice sheets affect each other. the results should help with predictions of sea-level rise far into the future due to global warming and melting polar ice sheets. this project will also educate and involve a wide range of people in climate science in several ways. videos about the research will be sent to boston public schools through the bostem organization to help students in the area learn about careers in science. the researchers will participate in activities through the mcauliffe center for integrated science learning at framingham state university to teach middle and high school students and teachers about climate change. college students will help with the research during summers through the integrated science for society nsf research experience for undergraduates at boston college, which tries to find students from underrepresented minority groups or who are the first in their family to go to college and that do not have research possibilities at their school. lastly, the project will support a female ph.d. student already at boston college and an m.s. student at the university of vermont.

the laurentide ice sheet over north america was one of the largest drivers of climate and sea level over the ice age cycles of the past three million years, but its history over this interval is shrouded in uncertainty largely due to limitations of conventional geologic records. this project will take a new approach, measuring the concentrations of rare chemicals in quartz sand layers from ocean sediment cores that melted out of drifting north american icebergs. the chemistry of the sand reflects the history of north american ice sheet cover because the chemicals accumulate in land surfaces exposed to the atmosphere but radioactively decay away when the surfaces are buried by ice. four sediment cores will be analyzed to reconstruct long-term laurentide ice sheet evolution, and analyses of sand samples collected across eastern canada will show how their chemistry records ice sheet variations over the most recent ice age cycle. together with similar reconstructions produced over the past five years from greenland and antarctica, these records will provide a comprehensive picture of how



these three ice sheets varied in the past and contributed to global sea level. the results will offer much-needed constraints to test theories and models of paleo-ice sheet change, useful for improving long-term future projections of ice sheets on earth today. this project will increase literacy and **diversity** in climate science in multiple ways. ?science bites? videos about the research will be distributed to boston public schools through bostem to demystify careers in science. participation in ongoing efforts through the mcauliffe center for integrated science learning at framingham state university will help educate middle and high school teachers and students on climate change. this project will support an existing female ph.d. student at boston college and an m.s. student at the university of vermont. summer undergraduate research assistants will be recruited through the integrated science for society nsf reu at boston college, which seeks to attract underrepresented minority and first-generation college students from schools with limited research opportunities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Expanding The Capacity Of The Center for Infrastructure Transformation and Education Through Integrating Diversity, Equity, and Inclusion into Infrastructure Education

Awardee: Virginia Polytechnic Institute and State University

Amount: \$87,045.00

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Title: Collaborative Research: Population Dynamics in Random Environments: Theory and Approximation

Awardee: Texas A&M University

Amount: \$85,829.00

Abstract: this project will formulate and analyze a general mathematical framework to facilitate understanding the persistence and extinction of species affected by random environmental fluctuations. global climate change models predict increasing temporal variability in temperature, precipitation and storms in the next century. random environmental fluctuations have been shown to drive populations extinct, promote persistence, change genetic **diversity**, and modify the spread of infectious diseases. it is therefore urgent to develop tools for understanding the effects of random temporal fluctuations in environmental conditions on species. the pis will develop mathematical theory, in conjunction with analytical and numerical approximation methods, to help theoretical ecologists pinpoint how environmental fluctuations affect the long-term dynamics of ecological communities. in collaboration with the gore lab at massachusetts institute of technology the pis will test theoretical results by comparison with microbial ecology experiments. the investigators plan to involve high school and undergraduate students in projects allowing them to develop programming skills and diversify their mathematical and ecological knowledge. for outreach, the investigators will organize seminars and conferences and promote the participation of women and members of traditionally underrepresented minorities within the sciences. the pis will investigate continuous and discrete time models of interacting populations that experience random temporal environmental variations. in the continuous time setting the research will focus on piecewise deterministic markov processes - processes that switch between different systems of ordinary differential equations at random times. in the discrete time setting stochastic difference equations will be analyzed. new methods for checking when species persist and converge to their invariant probability measures (which describe the 'random equilibria' of subcommunities of species) will be developed, and

conditions under which species go extinct exponentially fast determined. since all theoretical models are merely approximations of natural systems, the pis will study how the persistence/extinction results change under small, density-dependent, perturbations of the model parameters. the extinction/persistence criteria will involve lyapunov exponents, which usually cannot be computed explicitly. in order to resolve this issue analytical and numerical approximation methods for estimating the lyapunov exponents will be developed. finally, together with the gore lab at massachusetts institute of technology, the pis will run experiments in order to see how analytical results qualitatively compare with multi-species microbial systems under environmental fluctuations. this project is jointly funded by the division of mathematical sciences mathematical biology program the established program to stimulate competitive research (epscor). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: LightningBug, An Integrated Pipeline to Overcome The Biodiversity Digitization Gap

Awardee: University of Florida

Amount: \$84,226.00

Abstract: insects are the largest and most diverse class of animals on our planet where they play essential roles in ecosystems and the services those provide to society. entomologists have long been engaged in collecting, preserving and depositing nearly one billion insect specimens at natural history museums around the globe. these collections form the basis for much of our knowledge about insects and provide critical information about the past from which scientists can assess current and future global change impacts. to fully realize the value of these collections, data from insect specimens must first be digitized. however, their small size, delicate structures, and traditional storage and labeling methods creates enormous challenges for large-scale digitization.

consequently, at present, only 5% of specimens have transcribed labels and less than 1% of specimens are imaged. the lightningbug project will break through this digitization bottleneck by establishing a semi-automated workflow involving advancements in robotic multi-view imaging, information extraction and 3d reconstruction. results from this work will provide researchers with the unprecedented capability to capture specimen metadata representing time, place and taxonomic identity along with accurate three-dimensional surface morphology representing color and shape. we expect lightningbug and related technologies will promote ecomorphological studies at a scale that has not been possible to date. the lightningbug project seeks to create an end-to-end pipeline for high-throughput data acquisition from pinned insects in entomological collections. to accomplish this goal, we will: (1) further develop an existing hardware and software platform to capture multi-view imagery of both labels and specimens; (2) build robust algorithms to automatically process fragmentary views of multiple labels into separate integrated "virtual labels;" (3) connect virtual labels to structured text extraction services; and (4) apply photogrammetric analysis to assemble the 3d shape and structure of specimens. guided by real-world science use cases that highlight the use of specimen-based multi-view imaging in studies of global change and functional morphology, the entomological collections of the yale peabody museum and the harvard museum of comparative zoology will be used in rigorous test-case implementations. results will include robust sets of annotated multi-view images, 3d models of specimens (point clouds, textured meshes), 2d reconstructed "virtual labels" and digitized specimen metadata generated from those labels. these digital specimens will present new challenges for data preservation and access, but they will also catalyze new solutions for large-scale storage and delivery of research imagery. this challenge will be addressed via a partnership with morphosource to develop a linked institutional repository model for data access to large digital assets such as those produced by multi-view imaging. ultimately, the ability to capture multi-view image suites and generate virtual specimens at scale will permit new avenues for remote access to research resources, and enable the application of computer vision and machine learning to trait identification and evolution, species recognition and new species

discovery. label data from pinned insects will give researchers access to critical temporal and geospatial information necessary for relating changes in bio\*\*diversity\*\* to other biotic and environmental variables. it will also provide collections staff with a complete digital portrait of their holdings, which can enable historical research, streamline collections use and tracking, and improve data quality control. results from this project will also have applications beyond the natural history collections and research communities, such as computer graphics, product imaging, motion pictures, 3d animation, virtual and augmented realities, and education. more information and results from this project can be found at <http://lightningbug.tech> this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Building consensus around the quantification and interpretation of Symbiodiniaceae diversity

Awardee: Trustees of Boston University

Amount: \$82,230.00

Abstract: single-celled microorganisms are highly diverse and play various roles in the function of natural ecosystems, but it is challenging to recognize how genetic, morphological, and physiological \*\*diversity\*\* relate to each other in microbial groups. in an exemplary case, micro-algae in the family symbiodiniaceae comprise many species that can only be distinguished using molecular data. symbiodiniaceae function as symbionts of various marine invertebrates, but are perhaps best known as the key to coral reef ecosystem health and persistence. the team is hosting a virtual workshop in august 2021 to identify and build further consensus among experts regarding the assessment of symbiodiniaceae \*\*diversity\*\*. by formalizing consensus approaches and disseminating them broadly, this workshop is creating a more collaborative and welcoming research community and ensuring that all current researchers, as well as those entering the field, feel confident applying for



grants, conducting research, and publishing papers that incorporate work on symbiodiniaceae **\*\*diversity\*\***. this workshop is defining additional forward-thinking research priorities that anticipate methodological advances over the next 5-10 years. resolving the molecular **\*\*diversity\*\*** of microorganisms is a major technical challenge, particularly for dinoflagellates in the family symbiodiniaceae. these micro-algal endosymbionts that associate with corals and other marine invertebrates feature massive genomes, high repeat content, and other unique aspects that have hindered their molecular characterization. as sequencing technologies have advanced, so too has our understanding of symbiodiniaceae **\*\*diversity\*\***, which has grown from the presumption of one widespread species in the 1960s to now encompass fifteen divergent genera and likely hundreds of species. this process of discovery has been fraught with controversy, as the most useful phylogenetic marker?the hyperdiverse internal transcribed spacer 2 (its2) region?is frustratingly difficult to interpret in a consistent manner. the ribosomal array is multicopy, it evolves at different rates in different lineages, and it is subject to concerted evolution, all of which complicate phylogenetic reconstructions. moreover, sampled coral tissues contain populations of symbiont cells that can potentially be from multiple symbiodiniaceae taxa, complicating efforts to characterize partner specificity. early debates focused on the extent to which unique its2 sequences indicated the presence of multiple symbiont species or simply multiple intraspecific variants. this central conflict has led to different schools of thought about how flexible coral-algal associations can be, and how they might respond to ongoing climate change. next-generation sequencing has provided more data, but the same foundational interpretive issues remain. this team is gathering pioneering symbiodiniaceae experts from around the world (ranging from seasoned veterans to newly-minted phds) who all collectively agree that a consensus interpretive framework can and must be identified and advanced in order to move the field forward. the participants are generating a ?consensus road map? leading to two workshop products: 1. an nsf white paper; and 2. an open-access, peer-reviewed manuscript. through pre-workshop surveys, four workshop sessions, post-workshop collaboration, and publication, the team is summarizing current practices and recommending key

methods for identifying and analyzing symbiodiniaceae genetic **\*\*diversity\*\*** across three ?umbrellas?: 1. communities, 2. populations, and 3. strains. the written products from this workshop are being distributed to the wider reef and conservation community by leveraging a separate mini-workshop previously developed for the 2022 international coral reef symposium. workshop participants are also highlighting new technologies and research priorities for the next decade that should help fill some of the remaining knowledge gaps. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: RCN-UBE Incubator: Course-based Undergraduate Research Experiences for Students Underrepresented in Biology

Awardee: Edward Waters College

Amount: \$75,000.00

Abstract: the goal of this project is to establish multi-faceted course-based undergraduate research experiences in cellular genetics and socio-biology for students underrepresented in biology. community colleges serve almost half of the undergraduates in the u.s., including many minority low-income, first-generation, and underrepresented students, and many of these students are pursuing careers in biology. in this rapidly changing field, it is important that community college faculty have up-to-date teaching materials that reflect the most recent discoveries in biology and innovative data-analysis approaches. this network will bring appropriate teaching materials and offer professional development with the goal of incorporating cutting-edge biology research and high-impact teaching practices to improve student outcomes. empowering community college faculty to increase student success will have a significant impact on the qualifications and **\*\*diversity\*\*** of the science and technology workforce. this project will take place at edward waters college, distinctively the state of florida's first independent institution of higher learning as well as florida's first institution established for the education of african americans. the wide-spread use of dna sequence data to enhance biological understanding, brings unique challenges for biology educators.

skills from computer and data sciences have become core competencies for students even though many biology faculty completed formal training without the computational expertise needed to effectively engage in this field. this network will bring together members of omics ((proteomics, transcriptomics, metabolomics)) education networks, leveraging their combined expertise to identify and curate common analysis tools, associated curricular and assessment materials, and faculty training strategies to facilitate the adoption of omics instruction. by making existing resources accessible, the network will enable current faculty to guide undergraduate biology students participating in authentic research projects. such work will enhance the ability of students to become productive members of the technological work-force, to succeed in post-graduation studies in biology and related disciplines, and to be better informed citizens and decision makers. the network will develop a consensus set of vetted resources and training materials to be disseminated to the education community through a single web portal for use in undergraduate classrooms. the network will also advance preparation of adjunct biology faculty and recruitment of future junior faculty, who might not otherwise have the opportunity to build relationships with tenured faculty around the country. this project is being jointly funded by the directorate for biological sciences, division of biological infrastructure, and the directorate for education and human resources, division of undergraduate education as part of their efforts to address the challenges posed in vision and change in undergraduate biology education: a call to action (<http://visionandchange/finalreport/>). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Collaborative Research: Development of an Energy-Harvesting Real-time Under-ice Monitoring System in the Arctic Ocean

Awardee: University of Alaska Fairbanks Campus

Amount: \$75,000.00

Abstract: the arctic is home to some four million people comprising a diverse range of cultures and an economy worth about \$230 billion annually. with global concerns spanning climate change, energy resources, freshwater supplies, and sustainable economic growth, the arctic has sparked intense research and public interest. international efforts to establish sustained arctic observing systems, especially for long-term arctic ocean monitoring with near-real-time data transfer, are urgently needed. the harsh and remote conditions constraining year-round observation sites present significant logistical challenges and energy needs for sustained arctic observations. in addition, monitoring of the arctic ocean using bottom-anchored stationary platforms is limited by a lack of real-time communication between the sensors deployed and arctic operators. the ultimate goal of this project is to develop new energy harvesting and communication solutions so that it is feasible to have a real-time under-ice monitoring system in the arctic ocean. this eager project tests the capacity to address three key challenges, including sustainable power supply through energy harvesting, near-real-time data communication under the sea ice, and survivability under harsh environmental conditions. specifically, the project aims to develop novel techniques to harvest ultra-low-speed oceanic current energy using a two-level diffuser augmented turbine and a novel transverse flux generator. the harvested energy will be used to support sensors and power a novel real-time communication system through the sea ice. the proposed communication system adopts a novel antenna design that overcomes seawater attenuation effects on radio waves and creatively leverages satellite protocols to ensure the under-ice communication unit can transmit observational data to satellites. the project also explores techniques to enhance the survivability of the under-ice monitoring system, such as robust material choice and ice ridge/keel detection and avoidance systems and extends science and engineering education among k-12 and phd-level students in arctic research with an emphasis on **\*\*diversity\*\*** including female and underrepresented students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: RCN-UBE Incubator: Building an interdisciplinary regional network to expose under-represented students to biological research in its community context

Awardee: Texas A&M University-San Antonio

Amount: \$74,208.00

Abstract: research has shown that under-served students typically have few opportunities to engage in high-impact research activities and that first-generation college students want their learning to be connected to their home communities. when educators attempt to improve upon undergraduate research opportunities they frequently focus on placing only select students in one-on-one faculty mentored research and fail to link the research to the students' daily lives. all students should have an opportunity to participate in research in ways that make explicit connections between the content, process, and application of research, or they risk not being able to see the relevance of biological science to their own lives. this rnc-ube incubator network will remove these barriers by developing course-based opportunities for students to engage with real-life data sets provided by regional organizations whose work is informed by biological research. therefore, all students taking introductory biology courses will build research skills within a socially meaningful and applied community context. furthermore, by participating in the course-based research modules developed by this regional network, students will gain a greater understanding of job market \*\*diversity\*\* as it pertains to skills gained during biological research. this network brings together educators from different universities, community colleges, as well as research scientists from an urban health department, a nationally recognized primate research center, and a major regional river authority



tasked with ecological stewardship. the network members will participate in workshops designed to develop course-based undergraduate research experiences (cures) which will be implemented as pilot modules in introductory biology courses. workshops will also identify alignment of modules with core curriculum learning objectives, community partner needs, and potential barriers to implementation. during the pilot cure modules students will collect and analyze data sets on the prevalence and disparities of heritable genetic disorders, diabetes, cancer or environmental threats to the community, many of which disproportionately burden the network?s predominately hispanic population. this rcn-ube incubator will increase collaborative research among students, academia, industry, and community civic services and thus enhance the **\*\*diversity\*\*** of the future stem workforce. students participating in the modules will develop skills in science communication by sharing their results with public groups, family members and network representatives. the impact of the network will extend beyond students and faculty to include members of the community who might otherwise have limited exposure to scientific research, thereby nurturing positive attitudes towards biological research and increased engagement and support of family members with their children?s stem education. this project is being jointly funded by the directorate for biological sciences, division of biological infrastructure, and the directorate for education and human resources (ehr), division of undergraduate education as part of their efforts to address the challenges posed in vision and change in undergraduate biology education: a call to action (<http://visionandchange/finalreport/>). this project is also supported by the nsf hsi and iuse:ehr programs. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Biocultural Heritage and Social-Ecological Resilience

Awardee: Esbach, Michael

Amount: \$74,000.00

Abstract: this award was provided as part of nsf's social, behavioral and economic sciences postdoctoral research fellowships (sprf) program. the goal of the sprf program is to prepare promising, early career doctoral-level scientists for scientific careers in academia, industry or private sector, and government. sprf awards involve two years of training under the sponsorship of established scientists and encourage postdoctoral fellows to perform independent research. nsf seeks to promote the participation of scientists from all segments of the scientific community, including those from underrepresented groups, in its research programs and activities; the postdoctoral period is considered to be an important level of professional development in attaining this goal. each postdoctoral fellow must address important scientific questions that advance their respective disciplinary fields. under the sponsorship of dr. joão biehl at princeton university and dr. flora lu at the university of california, santa cruz, this postdoctoral fellowship award supports an early career scientist examining the mechanisms through which indigenous governance and stewardship fosters social-ecological resilience. in numerous locations and contexts, indigenous institutions and cultural practices have resulted in positive environmental outcomes, such as promoting biological **\*\*diversity\*\***, maintaining ecosystem services, and curbing deforestation. these outcomes are important globally because indigenous peoples manage over 25 percent of the world's land surface. this study explores these dynamics through a partnership with indigenous communities, where accelerating deforestation and degradation, linked to resource extraction and urbanization, threaten their health, well-being, and sovereignty. through a combination of ethnographic, human ecological, and spatial methodologies, this research will examine the connections between indigenous biocultural heritage, institutions, and cultural values and their ecological impacts. a robust communication strategy ensures that results will inform both academics and the general public about how indigenous practices build resilience and support conservation. interdependent relationships over millennia between humans and their surroundings gave rise to a **\*\*diversity\*\*** of indigenous territories across the planet. drawing on rich biocultural heritage, indigenous peoples have developed sophisticated institutions that simultaneously maintain ecosystem services and

relationships with territory. this study investigates features of biocultural heritage, including the knowledge, innovations, and practices used by indigenous peoples to gauge, interpret, and respond to internal and external feedbacks, transmit knowledge, and adapt to changing social, environmental, and political contexts. how do indigenous peoples utilize their biocultural heritage in this manner, what limitations do they face in doing so, and why? this research will address such questions by leveraging a long-term partnership, where threats such as climate change and extractivism represent a microcosm of those impacting the broader region. a multi-methods approach (quantitative, qualitative, ethnographic, participatory) will support an examination of the coupling, decoupling, and potential for recoupling of biocultural heritage with specific territories. results from this research will describe how diverse threats impact the resilience of indigenous territories, and support how we theorize and understand territory. this work will contribute to the fields of human ecology, landscape ecology, land education, and social-ecological systems theory. more broadly, this research will support biological and cultural conservation by highlighting the importance of diverse indigenous values and approaches, and inform the on-going production of a participatory planning instrument for territorial governance. the project also builds local capacity, training, and mentoring by including indigenous researchers. finally, the project has built in mechanisms for research dissemination, for academic and policy audiences, including engaging media sources to broadly communicate research findings. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Belmont Forum Collaborative Research: Pacific Ocean Pathways in Support of Sustainable

Development: An Integrated Approach

Awardee: University of Maryland Center for Environmental Sciences

Amount: \$71,421.00

Abstract: this award provides support to u.s. researchers participating in a project competitively

selected by a 55-country initiative on global change research through the belmont forum. the belmont forum is a consortium of research funding organizations focused on support for transdisciplinary approaches to global environmental change challenges and opportunities. it aims to accelerate delivery of the international research most urgently needed to remove critical barriers to sustainability by aligning and mobilizing international resources. each partner country provides funding for their researchers within a consortium to alleviate the need for funds to cross international borders. this approach facilitates effective leveraging of national resources to support excellent research on topics of global relevance best tackled through a multinational approach, recognizing that global challenges need global solutions. this award provides support for the u.s. researchers to cooperate in consortia that consist of partners from at least three of the participating countries. the teams will establish transdisciplinary networks to develop innovative solutions for sustainable development pathways and seek to assess the positive and negative inter-linkages between the economy, technology, institutions with the environment, climate, bio\*\*diversity\*\*, and human well-being to understand potential pathways to a sustainable world. this project seeks to establish cost-effective, efficient, and sustainable transdisciplinary processes, methods and networks to assist stakeholders, scientists, public officers and citizens of the pacific islands to share common objectives and actions to achieve environmental sustainability. the project will build a network focusing on two pilot sites, fiji and new caledonia. the project will examine the impacts of climate change and other stressors on the ocean environment and ecosystem services. the team will investigate the consequences of these impacts on the environment, society, and economy, to develop sustainable and complementary pathways for future development and sustainable ocean stewardship. these pilot sites will create the framework and methodology and serve as a guide for application and adaptation to other interested pacific island countries. pacpath will integrate a broad range of existing data sets, generate new data sets, and develop new, locally relevant products that will rely on freely available sources such as from the copernicus marine service. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the

foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: LEAPS: A Diversity, Equity, and Inclusion Workshop at the Joint Aquatic Sciences Meeting

Awardee: Western Washington University

Amount: \$70,532.00

Abstract: scientific societies play an important role in engaging young scientists and creating opportunities that lead to stem careers. because of this role, these societies can help the nation increase the participation of students of color and other underrepresented groups in science and science careers. at the same time, scientific societies also present barriers to inclusion because their leadership, policies and practices have solidified over decades without consideration of the need to be inclusive and welcoming of underrepresented groups. this project develops a process to begin to examine the practices, procedures, and policies within scientific societies that may create an atmosphere of non-inclusivity, non-engagement, and an unfriendly environment for underrepresented groups. an inclusivity, **\*\*diversity\*\***, equity, and access (idea) audit tool will be developed for the consortium of aquatic science societies (cass), an affiliation of nine scientific societies (american fisheries society; association for the sciences of limnology and oceanography; coastal and estuarine research federation; freshwater mollusk conservation society; international association for great lakes research; north american lake management society; phycological society of america; society for freshwater science; and the society of wetland scientists), the majority of whom work in the biological sciences. the idea audit tool will be constructed to be able to identify (1) policies and procedures that perpetuate status quo culture, policies, and procedures (2) specific barriers to broadening participation to diverse populations, specifically black and indigenous people of color, communities from tribal colleges, and historically black colleges and universities, and (3) practices and programs that have been successful within the cass societies. leaders from the cass member societies will engage with leaders from societies and organizations that advance the

participation of underrepresented students in stem to develop the audit tool over the course of a year and a series of facilitated meetings and workshops. this process will include an in-person workshop meeting at the joint aquatic sciences meeting (jasm), as well as a series of remote meetings both before and after the in-person meeting. jasm2022 is expected to be the largest gathering of aquatic scientists to date and thus an opportunity to engage diverse societies and their leadership in collective planning. the development of the audit tool will be the first step in creating cultural change, by helping cass societies determine where barriers to participation exist. the audit tool and a compilation of current best practices for engaging members of underrepresented groups in aquatic sciences will be disseminated widely on our websites, through the nsf includes network, and conference presentations and publications. the idea audit tool, as well as lessons learned from the development process, will be shared with other societies wanting to broaden participation among their professional members. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Varieties of Crises, Elite Responses, and Executive Approval

Awardee: University of Mississippi

Amount: \$70,176.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2. this project examines four major types of crises -- economic, security, natural disaster, and public health crises ? and how they influence public support for political leaders in contemporary democracies. this is important to understand because leader approval is a key barometer of policymaker accountability and democratic stability, both of which can be undermined by crises. this project analyzes the interplay of four factors which vary systematically across these different types of crises and how, in turn, these shape public evaluations of political executives: (1) the ability of



citizens to assign responsibility for policy decisions and outcomes; (2) the degree of expert consensus on effective policy response; (3) how much a given crisis in one area generates acute challenges or crises in other areas; and (4) the extent to which an effective response depends on citizens acting collectively. several data sets including (quarterly) measures of executive approval and crises; the tone and salience of leader messaging about the crises; the media's treatment of leader messaging; and (monthly) leader approval for a smaller number of countries for which such data is available; and survey-based experiments in three countries are collected and made publicly available. the award supports education and **\*\*diversity\*\*** by building the research capacity of a student project lab at georgia state university, a minority serving institution, in coordination with pisa at four other universities who will also engage graduate and undergraduate students in this work.

puzzling divergences across countries in public reactions to leader responses to the covid-19 public health crisis have revealed major gaps in our understanding of how crisis events translate into public assessments of leaders. to resolve these puzzles, this project advances a unifying theoretical framework that identifies four major types of crises: economic, security, natural disaster, and public health. it then locates these crises on four key dimensions which should condition public support of top officials: the institutional and political context and other factors that impact attribution of responsibility, degree of expert consensus and incentives for politicians to follow expert recommendations, the likelihood and nature of spill-over to other crisis types, and the degree to which citizen action is required for an effective response. the project collects data to test theoretically-motivated hypotheses using: 1) a macro time-series cross-national data set to study the effects of crisis type on public approval for political executives for 48 countries, 2) a high-frequency time-series data set appropriate to test how approval dynamics reflect leader responses, as well as messaging choices and media effects for 18 countries for which this data is available, and 3) conjoint experiments in france, italy, and mexico, countries with different political and institutional settings, to assess the validity of the links between crisis types and dimensions as well as to validate proposed individual-level mechanisms. this project is supported by the accountable institutions

and behavior program and the sbe build and broaden program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Varieties of Crises, Elite Responses, and Executive Approval

Awardee: University of Mississippi

Amount: \$70,176.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2. this project examines four major types of crises -- economic, security, natural disaster, and public health crises ? and how they influence public support for political leaders in contemporary democracies. this is important to understand because leader approval is a key barometer of policymaker accountability and democratic stability, both of which can be undermined by crises. this project analyzes the interplay of four factors which vary systematically across these different types of crises and how, in turn, these shape public evaluations of political executives: (1) the ability of citizens to assign responsibility for policy decisions and outcomes; (2) the degree of expert consensus on effective policy response; (3) how much a given crisis in one area generates acute challenges or crises in other areas; and (4) the extent to which an effective response depends on citizens acting collectively. several data sets including (quarterly) measures of executive approval and crises; the tone and salience of leader messaging about the crises; the media's treatment of leader messaging; and (monthly) leader approval for a smaller number of countries for which such data is available; and survey-based experiments in three countries are collected and made publicly available. the award supports education and **\*\*diversity\*\*** by building the research capacity of a student project lab at georgia state university, a minority serving institution, in coordination with pis at four other universities who will also engage graduate and undergraduate students in this work. puzzling divergences across countries in public reactions to leader responses to the covid-19 public

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Matched Words: diversity

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Title: Belmont Forum Collaborative Research: Guiding the pursuit for sustainability by co-developing a Sustainable Agriculture Matrix (SAM)

Awardee: University of Maryland Center for Environmental Sciences

Amount: \$70,000.00

Abstract: this award provides support to u.s. researchers participating in a project competitively selected by a 55-country initiative on global change research through the belmont forum. the

belmont forum is a consortium of research funding organizations focused on support for transdisciplinary approaches to global environmental change challenges and opportunities. it aims to accelerate delivery of the international research most urgently needed to remove critical barriers to sustainability by aligning and mobilizing international resources. each partner country provides funding for their researchers within a consortium to alleviate the need for funds to cross international borders. this approach facilitates effective leveraging of national resources to support excellent research on topics of global relevance best tackled through a multinational approach, recognizing that global challenges need global solutions. this award provides support for the u.s. researchers to cooperate in consortia that consist of partners from at least three of the participating countries. the teams will establish transdisciplinary networks to develop innovative solutions for sustainable development pathways and seek to assess the positive and negative inter-linkages between the economy, technology, institutions with the environment, climate, bio\*\*diversity\*\*, and human well-being to understand potential pathways to a sustainable world. the project focuses on formulating pathways for sustainable agriculture by engaging with stakeholders to co-develop an indicator system and associated products that will measure agriculture sustainability. the consortium will identify the inter-linkages among various sustainable development goals (sdgs) related to agriculture and identify strategies for advancing sustainable agriculture to help inform policy. to maximize the interactions and collaborations across the boundaries of disciplines, sectors, and nations, the consortium will organize a range of networking and co-learning activities, such as consortium-wide meetings, regular experience sharing and peer-learning sessions, and field visits. the research team will also cultivate cross-country partnerships to investigate the historical trajectories of agriculture sustainability and to analyze tradeoffs between their developed indicators and sdgs in each region and the globe. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Belmont Forum Collaborative Research: Residual Risk of Extreme Floods: a challenge for achieving sustainable development goals

Awardee: University of California-Berkeley

Amount: \$70,000.00

Abstract: this award provides support to u.s. researchers participating in a project competitively selected by a 55-country initiative on global change research through the belmont forum. the belmont forum is a consortium of research funding organizations focused on support for transdisciplinary approaches to global environmental change challenges and opportunities. it aims to accelerate delivery of the international research most urgently needed to remove critical barriers to sustainability by aligning and mobilizing international resources. each partner country provides funding for their researchers within a consortium to alleviate the need for funds to cross international borders. this approach facilitates effective leveraging of national resources to support excellent research on topics of global relevance best tackled through a multinational approach, recognizing that global challenges need global solutions. this award provides support for the u.s. researchers to cooperate in consortia that consist of partners from at least three of the participating countries. the teams will establish transdisciplinary networks to develop innovative solutions for sustainable development pathways and seek to assess the positive and negative inter-linkages between the economy, technology, institutions with the environment, climate, bio\*\*diversity\*\*, and human well-being to understand potential pathways to a sustainable world. the project will create an international network of experts and a community of practice to address the residual risk of flooding damage to help inform sustainable development. the exposure of human populations to flooding has increased in the last several decades, but many people are unaware that they reside in flooding risk zones. residual risk of extreme floods (rreflood) project aims to help manage this risk and increase communication with the public by creating a network focused on the interplay among residual risk and its management. the project members will collaboratively design a framework to integrate

residual risk in local planning efforts, create a platform to facilitate advances in basic knowledge and tools to reduce residual flood risk, and identify research needs that will be beneficial to countries worldwide. this project will promote mechanisms to raise capacity for effective climate change-related planning and management and will identify effective ways to communicate the residual flood risk to residents and stakeholders, with the goal to reduce the adverse effects of natural disasters. the international scientific community will be enhanced by the addition of a novel network of experts on residual flood risk; this network will facilitate exchanges and mutual learning to improve methods in global practice. the rreflood project will thus create a new community around global flood risk and engage in pathways to sustainability through global research and community support. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Belmont Forum Collaborative Research: Building Urban Community Networks for Sustainable Cities in Africa

Awardee: Georgetown University

Amount: \$69,999.00

Abstract: this award provides support to u.s. researchers participating in a project competitively selected by a 55-country initiative on global change research through the belmont forum. the belmont forum is a consortium of research funding organizations focused on support for transdisciplinary approaches to global environmental change challenges and opportunities. it aims to accelerate delivery of the international research most urgently needed to remove critical barriers to sustainability by aligning and mobilizing international resources. each partner country provides funding for their researchers within a consortium to alleviate the need for funds to cross international borders. this approach facilitates effective leveraging of national resources to support excellent research on topics of global relevance best tackled through a multinational approach, recognizing

that global challenges need global solutions. this award provides support for the u.s. researchers to cooperate in consortia that consist of partners from at least three of the participating countries. the teams will establish transdisciplinary networks to develop innovative solutions for sustainable development pathways and seek to assess the positive and negative inter-linkages between the economy, technology, institutions with the environment, climate, bio\*\*diversity\*\*, and human well-being to understand potential pathways to a sustainable world. the project seeks to determine the social, economic, and ecological challenges and their interdependencies affect the sustainability of african cities. the project will develop and work with urban community networks in six representative african cities networks to develop potential pathways to foster sustainability of these and other african cities. the project will assess the social, economic and ecological assets of these cities and determine how these assets are distributed in space and time. this data will help the project reframe the question from ?what city communities do not have? to ?what city communities have? for building synergies and interdependencies. the project will utilize ground-truthed, satellite images, social and ecological facilities and participatory geographic information systems, maps of community spaces of interest, along with data from and extensive review of existing urban policies, directives, and by-laws, to build potential sustainability pathways. the stakeholders will then localize and downscale the plans from global to national level, and from national to community level. based on these findings and experiences, plausible scenarios for sustainable african cities will be developed. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Understanding How Students' Sense of Belonging Develops During Undergraduate Field Experiences: Supports, Barriers, and Implications for Faculty

Awardee: Regents of the University of Michigan - Ann Arbor

Amount: \$68,875.00

Abstract: this project aims to serve the national interest by addressing a critical need in the scholarship of stem teaching and learning. specifically, it is designed to advance understanding about how students' sense of belonging develops in undergraduate learning experiences outside of the traditional classroom. the project will focus on residential undergraduate field courses, a pivotal learning experience in stem disciplines such as ecology, geology, and geography. a sense of belonging plays an important role in students' mental health and well-being, academic achievement and motivation, and institution-level retention. it is also pivotal for the persistence of students from communities that are underrepresented in stem disciplines. the overarching goal of the project is to build the capacity of geosciences and biology faculty to support the development of students' sense of belonging. in this way, it can help to improve the inclusivity of courses that are a critical pathway for thousands of undergraduate students in field-based stem disciplines. this project has the potential for broad reach and impact on student engagement and learning in multiple stem disciplines and is likely to have a positive impact on the inclusivity of undergraduate field education. it may be especially important for students from communities that have been historically excluded from field-based stem disciplines, whose persistence is strongly linked to sense of belonging in the scientific community. the project focuses on advancing understanding about how students' sense of belonging develops in residential field experiences and builds capacity for faculty from geosciences and biology to support the growth of students' sense of belonging. the following objectives will guide the project study: 1) identify factors that contribute to and hinder the development of students' sense of belonging during residential geosciences and biology undergraduate field courses; 2) characterize the design and implementation of geosciences and biology undergraduate field courses, specifically what practices faculty are using and what challenges and needs exist for the development of students' sense of belonging during undergraduate field courses; 3) create an empirically-based framework of how students' sense of belonging develops during residential undergraduate field courses; 4) facilitate a community of practice that uses and contributes to promising practices for the design and assessment of inclusive field courses that support the



development of students' sense of belonging; and 5) articulate a suite of promising practices that have the potential to promote the development of students' sense of belonging during a range of formats of undergraduate field courses and for students from different backgrounds. using innovative and robust mixed methods research approaches, this work will contribute to the wider body of evidence-based, student-centered practices in undergraduate stem education. the work has the potential to provide a deep and impactful contribution to the fields of discipline-based education research (particularly in geosciences and biology), higher education, education and social psychology, and **\*\*diversity\*\***, equity, and inclusion. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the engaged student learning track, the program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: Collaborative Research: Research Initiation: Social Engagement & Belonging in Academic Makerspaces

Awardee: University of Texas at Austin

Amount: \$68,205.00

Abstract: academic makerspaces provide students with open access to resources that help them develop their problem solving skills, provide opportunities for collaboration, and encourage experimentation and discovery. however, recent research has shown that many makerspace environments do not readily support diverse populations, create tensions between different student groups, and can sometimes lead to a work environment that feels exclusive and unwelcoming. it is essential that our academic makerspaces are welcoming and that all students feel a sense of belonging and acceptance in these spaces. this project will use the flexible nature of an academic makerspace as the framework to provide students with the opportunity to connect socially in ways that have been shown to increase sense of belonging. this will be accomplished by integrating social engagement activities into a university affiliated makerspace. the engagement activities will be designed to support students' social and emotional development, which is an essential component to creating culturally competent, well-rounded engineers. due to the flexible and informal nature of the makerspace environment, it is an ideal place to build and create social connections between students. makerspaces provide a venue for informal learning and student connection that inspires

attributes associated with the professional formation of engineers: creativity, discovery, lifelong learning, teamwork, and critical thinking. this study will lay the foundation for future research that will inform strategies to create an equitable and inclusive makerspace culture with a focus on better supporting non-dominate students. this project aims to increase student sense of belonging in undergraduate engineering students through the integration of social engagement activities into an academic makerspace. the objectives of this project are to (1) strategically integrate social engagement activities that have been shown to contribute to increased sense of belonging and student persistence into an academic makerspace; (2) research the effects of the social engagement activities on student sense of belonging; and (3) increase engineering education research capacity at western washington university. the outcomes of this work will lead to identification of best practices for improving student sense of belonging in a makerspace environment. this research will investigate the impact of carefully designed social engagement activities on development of student sense of belonging. within the recent context of the covid-19 pandemic, social support and positive sense of belonging have been shown to counter the adverse social emotional effects of the experience. engagement activities will focus on supporting student social and emotional development, providing peer support, and building awareness of the importance of equity, inclusion, and **\*\*diversity\*\*** in engineering. the activities will be designed so that any student can participate regardless of ability level, time availability, or physical location. the research questions that will guide this work are (1) to what extent do students participate in the engagement activities within the makerspace and in which formats, and does this level of engagement vary based on student demographics? and (2) to what extent does participation in the engagement activities lead to an increased sense of belonging? these research questions will be investigated through a communities of practice theoretical framework using a two-year mixed methods research that includes survey development, analysis, student reflections, and focus groups. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Characterizing Inclusive Strategies that Retain Black Students in Computer Science to Graduation and Beyond

Awardee: Morehouse College

Amount: \$66,464.00

Abstract: this iuse project aims to serve the national interest by identifying factors that lead to the lack of **\*\*diversity\*\*** in computing professions. research has shown that the first two years of science, technology, engineering, and mathematics (stem) majors are often where students are lost in the pipeline. this project will identify factors that affect the retention and graduation of under-represented minority students in the computing major. the goals are to identify inclusive strategies for success in computing programs and investigate ways to increase the retention and post-graduation success of black students in computing. of particular interest are strategies that are transferable to different types of institutions and stem fields in general. this project features a collaboration between two historically black colleges/universities and a primarily white institution that will work together to understand the challenges facing each institution and the strengths each institution brings to addressing this problem. through detailed transcript analysis, this research will take an asset-based approach, focusing on the strengths of students succeeding in the major. two cohorts of lower division (freshman and sophomore) black cs students from two historically black colleges/universities (hbcus) and one primarily white institution (pwi) will be studied to measure perceived societal impacts and their understanding of content through conceptual assessment instruments. a cohort of upper division students will be studied to measure the factors that led to their success using surveys, a content assessment, and interviews. using a mixed methods analysis approach, white students will be compared to black students at the research intensive pwi and then the principal investigators will compare black students at the pwi to black students at the two hbcus. the goal is to expand knowledge of inclusive teaching strategies and provide institutional awareness

of factors that can go beyond recruiting urms to focus on retention in the major and student success post-graduation. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through its engaged student learning track, the program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: ABI Innovation: FuTRES, an Ontology-Based Functional Trait Resource for Paleo- and Neo-biologists

Awardee: Battelle Memorial Institute

Amount: \$65,744.00

Abstract: physical characteristics of animals can help determine which ones survive and flourish, especially in a changing environment. these characteristics, also known as functional traits, include features such as length, height, shape, weight, growth rate, sex, and reproductive state. studying these traits provides insights into how communities of different types of animals come together and how species and communities respond to changes in their environment over time, which is critical for conservation efforts. however, very little information about functional traits is available, and what is available is difficult to combine with other data. how these traits are influenced by environmental changes - such as climate change, pollution, urbanization and human predation - and how they shift over longer timescales are poorly understood, and the need for this information is outstripping the speed with which scientists can collect these data. digitized collections of animals representing life from the past two million years contain a treasure trove of information about these individuals' functional traits, but these data are stored in multiple places and in different formats. researchers may have recorded dates differently, for example, or used a variety of terms to describe a single physical feature. making these data widely available in standardized formats could help scientists

study changes in functional traits through time, linking their observations of traits of modern animals to those from fossil and archaeological records. the functional trait resource for environmental studies (futures) project will gather trait data from digitized records; to engage communities of researchers to make these data available, standardized, and useable; and to develop a more complete workflow for using these data in research. functional trait data have revolutionized ecology and are transforming paleontology, but acquiring them requires extensive labor, not only in measuring traits but in managing and communicating the resulting data. when trait data are lacking, researchers substitute average values, or other characteristics like behavioral or dietary categories. these substitutes - assigned at the species level - obscure intraspecific changes in traits. futures fills the clear need for informatics tools that give researchers access to existing trait data and a place to store new data as they are generated. futures is assembling a varied collection of existing trait data, building a pipeline that converts data to an integrated, semantically enriched form, and developing an application programming interface (api) and web platform to serve the data. one of the key innovations of futures is the use of ontologies, an information science approach that creates computer-readable definitions of traits and describes the interrelationships of traits, organisms, collecting events, and other entities. in this way, futures will make functional trait data searchable through reference to time, space, and vertebrate anatomy. futures will also provide access to trait data via popular data portals (e.g., vertnet) and software such as r, opening the data to scientists in bio\*\*diversity\*\* and other domains. the toolkit will be tested with mammalian use cases that leverage the massive scale of the unlocked data. in sum, newly created access mechanisms and tools will provide novel approaches for analyses of trait variation across space and time, providing researchers in disparate fields discovery capabilities for relevant data that would otherwise have been invisible to them. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Belmont Forum Collaborative Research: AWERRS Arctic Wetlands Ecosystems ? Resilience through Restoration & Stewardship

Awardee: University of Alaska Southeast Juneau Campus

Amount: \$65,378.00

Abstract: this award provides support to u.s. researchers participating in a project competitively selected by a 9-country initiative on global change research through the belmont forum. the belmont forum is a consortium of research funding organizations representing over 55 countries focused on support for transdisciplinary approaches to global environmental change challenges and opportunities. it aims to accelerate delivery of the international research most urgently needed to remove critical barriers to sustainability by aligning and mobilizing international resources. each partner country provides funding for their researchers within a consortium to alleviate the need for funds to cross international borders. this approach facilitates effective leveraging of national resources to support excellent research on topics of global relevance best tackled through a multinational approach, recognizing that global challenges need global solutions. this award provides support for the u.s. researchers to cooperate in consortia that consist of partners from at least three of the participating countries. the research teams will address key areas of arctic resilience understanding and action. this collaboration of academic and non-academic knowledge systems constitutes a transdisciplinary approach that will advance not only understanding of the fundamentals of arctic resilience but also spur action, inform decision-making, and translate into solutions for resilience. the project seeks to address the challenge of building resilience in a rapidly changing arctic by focusing on human activities that impact arctic wetlands ecosystems. the project will support and help communities to strengthen their capacity to engage in wetlands restoration and stewardship. at a local scale, wetlands buffer heavy precipitation and snowmelt and filter and store water. they provide crucial habitat for bio\*\*diversity\*\*, providing nesting and breeding areas for migratory bird species and spawning areas for fish species. as such, they support



traditional livelihoods activities including reindeer husbandry, hunting and fishing, other cultural and recreational activities, and tourism. less widely known is that intact wetlands store a large amount of global carbon. while they make up only about 3% of the earth's land area, wetlands store an estimated 20% of the worlds terrestrial carbon ? the largest regional store of carbon on the planet. identifying and testing approaches for strengthening the engagement of local communities and other actors in the restoration and stewardship of arctic wetlands ecosystems helps increase community resilience though shared engagement - and through the ecosystem service benefits derived from improving wetlands ecosystems' resilience. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: ISS: Collaborative Research: Individual and Collective Behavior of Active Colloids in Microgravity

Awardee: Colorado Mesa University

Amount: \$60,971.00

Abstract: this nsf-casis project involves microgravity experiments on the international space station (iss), complementary terrestrial experiments and theoretical/numerical modeling to improve understanding of active colloid transport. active colloids move by extracting energy from their surroundings and transforming it into mechanical work. these materials have similarities with biological matter, especially for concentrated suspensions where particle-particle interactions yield collective behaviors similar to those found in nature such as swarming flocks of birds, schools of fish and bacterial colonies. although most theoretical models pertain to an isolated particle traveling in the bulk, the weight of active colloids on earth causes them to settle at the bottom of the experimental chamber where they translate parallel to the surface. long term microgravity conditions on the iss offer a unique opportunity to mitigate buoyancy and sedimentation and obtain bulk

measurements that can be compared with theoretical models and elucidate the role of particle-wall interactions, which complicate terrestrial experiments. the results of this project may transform a variety of applications in biomedicine and applications at the food-water-energy nexus including colloidal assembly and bubble/droplet transport. the project is a collaboration between colorado mesa university (cmu) - a primary undergraduate institution with a diverse student body and florida international university (fiu) - a research intensive minority serving institution (msi). it offers a unique opportunity to promote **diversity** through exposure of undergraduate students to timely research and industry collaboration with the implementation partner space tango. the research team will develop a module for fiu's "engineers on wheels" program, which visits local schools, and will collaborate with the eureka science museum and maverick innovation center in colorado. this nsf-casis project will provide a comprehensive understanding of complex physical mechanisms controlling the mobility of individual active colloids and their collective behavior with two distinct goals: (1) optimizing active colloid transport, and (2) understanding effects of microgravity on collective dynamics and non-equilibrium interactions of active matter. the absence of buoyancy in microgravity is expected to resolve a conundrum in terrestrial experiments wherein theoretical models of these systems are derived for isolated particles in the bulk while experimental measurements are almost always made near a wall owing to gravity-induced sedimentation. proximity to a wall and the accompanying particle-wall interactions (hydrodynamic, phoretic, electrostatic etc.) are often invoked as corrections to explain discrepancies between theory and experiment. however, the precise roles of particle-wall interactions cannot be isolated without comparable measurements far from the wall. sustained microgravity conditions will enable measurement of particle mobility in the bulk, providing an experimental reference for theoretical models and insight into competing buoyancy effects and wall-particle interactions. comparison of particle-particle interactions on earth and on the iss will also elucidate effects of microgravity on collective behavior in active matter and dense colloidal systems including 3d phase separation. microgravity experiments will be complemented with terrestrial bulk measurements using optical

tweezers as an external forcing mechanism, which will provide insight into other active colloid transport mechanisms (e.g., catalytic) and the applicability of such external forcing for future fundamental studies. the collaboration between fiu and cmu and the partnership with space tango offers a unique opportunity to engage students. undergraduate students will participate through capstone projects at fiu, while cmu students will travel to fiu and gain exposure to a research intensive institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Expanding The Capacity Of The Center for Infrastructure Transformation and Education Through Integrating Diversity, Equity, and Inclusion into Infrastructure Education

Awardee: Lafayette College

Amount: \$60,899.00

Abstract: this project aims to serve the national interest by expanding the capacity of the center for infrastructure transformation and education (cit-e) to support civil, construction, and environmental engineering faculty members in their efforts to integrate **\*\*diversity\*\***, equity, and inclusion (dei) into infrastructure education. the causes of inequitable infrastructure are many; however, given its leading role in infrastructure-related education and research, the civil and environmental engineering (cee) faculty has an obligation to recognize and address the need for systemic change. historically, cee faculty members have not received formal training on dei issues. while such training is becoming more common, a gap remains. this level 1 capacity building project will support cit-e, an existing and thriving community of practice (cop), through providing the foundation for future work in developing a multi-institutional effort to transform the cee education community into a community that can sustain growth in dei integration. the collaborative research project is a joint effort by the university of wisconsin, platteville, lafayette college, colorado state university, and virginia

polytechnic institute and state university. with the increased capacity generated by this expanded network and a shared vision, the cit-e cop work will be transformative. leveraging the cit-e and the cop, the project frames the work through the lens of two continua: race neutral/race conscious and inclusion infrastructure/exclusion infrastructure. this project will develop i) cit-e communal understanding of how dei and infrastructure are related; ii) what the interaction among members reveals about dei; iii) how members of the cop can educate one another by addressing dei issues in education, research, and professional practice; and iv) how the cop can inspire real and lasting change. specifically, this project will increase the capacity of cit-e through the following project objectives: i) gather evidence by compiling a list of non-normative examples of successful institutional efforts that positively impact dei; ii) assess cit-e resources and needs via asset mapping; iii) evaluate community of practice as an appropriate change theory; iv) recruit additional stakeholders and organizations to cit-e based on the gaps identified in previous project objectives; v) identify, cluster, and prioritize ways of integrating dei into cee education using group concept mapping (gcm); and vi) provide the foundation for developing a multi-institutional effort to transform the cee education community into a community that can sustain growth in dei integration. the research team will ensure that key stakeholders, including experts in change theory, dei strategies, and curriculum development are invited to provide external peer review of the project. the research team will facilitate working sessions to address larger tasks such as gcm and asset mapping. through a collaboration with the institute for research in the social sciences (iriss), the project will i) build the capacity of the geographically-dispersed research team by accelerating the team's integration to operate as a highly-functioning team and ii) explore how team science might add value to efforts to expand the work.

the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. through the institutional and community transformation track, the program supports efforts to transform and improve stem education across institutions of higher education and disciplinary communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the

foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Expanding The Capacity Of The Center for Infrastructure Transformation and Education Through Integrating Diversity, Equity, and Inclusion into Infrastructure Education

Awardee: Colorado State University

Amount: \$59,982.00

Abstract: this project aims to serve the national interest by expanding the capacity of the center for infrastructure transformation and education (cit-e) to support civil, construction, and environmental engineering faculty members in their efforts to integrate \*\*diversity\*\*, equity, and inclusion (dei) into infrastructure education. the causes of inequitable infrastructure are many; however, given its leading role in infrastructure-related education and research, the civil and environmental engineering (cee) faculty has an obligation to recognize and address the need for systemic change. historically, cee faculty members have not received formal training on dei issues. while such training is becoming more common, a gap remains. this level 1 capacity building project will support cit-e, an existing and thriving community of practice (cop), through providing the foundation for future work in developing a multi-institutional effort to transform the cee education community into a community that can sustain growth in dei integration. the collaborative research project is a joint effort by the university of wisconsin, platteville, lafayette college, colorado state university, and virginia polytechnic institute and state university. with the increased capacity generated by this expanded network and a shared vision, the cit-e cop work will be transformative. leveraging the cit-e and the cop, the project frames the work through the lens of two continua: race neutral/race conscious and inclusion infrastructure/exclusion infrastructure. this project will develop i) cit-e communal understanding of how dei and infrastructure are related; ii) what the interaction among members reveals about dei; iii) how members of the cop can educate one another by addressing dei issues in education, research, and professional practice; and iv) how the cop can inspire real and lasting

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Matched Words: diversity

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Title: Annual REU Site Intersection of Linguistics, Language and Culture Conference

Awardee: MOLLOY UNIVERSITY

Amount: \$58,364.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). the nsf reu ilc annual 2021 and 2022 conferences will coincide with and complement the 2nd cycle of the nsf research experience for undergraduates site 'intersection of linguistics, language and culture' (ilc) housed by molloy college, long island and cuny brooklyn college, both in new york. the conferences aim at increasing **\*\*diversity\*\*** among emerging researchers and among the projects undertaken by future researchers and professionals in linguistics and speech-language-communication sciences. they will involve five components: (i) undergraduate projects by members of cultural, ethnic and linguistic groups underrepresented in higher education,



with a focus on novel findings in their language/language varieties, and on stem-based innovative methodologies and explanations of broader impacts; (ii) participation of high school students so that they discover linguistics and the research areas and professions associated with linguistics, before they enter college; (iii) empowerment of undergraduate and high school students, especially members of groups underrepresented in higher education, to become emergent scholars and valued members of higher education institutions in the process of the organization of the conference; (iv) dissemination of the conference oral and poster presentations during and beyond the conference through two complementary platforms: open-access publications of proceedings and video presentations; (v) recognition and valuing of college and high school participation and work through the competitive awarding of travel expenses and prizes. the proposed conferences will disseminate novel findings that reflect the u.s. and world cultural, ethnic and linguistic **\*\*diversity\*\*** and that are needed to advance the field. the proposed conferences will have three sets of broader impacts including (i) the clinical, educational and technological implications of the findings that emerge from the projects conducted by the nsf reu illc site fellows and the poster presenters, (ii) the increase of **\*\*diversity\*\*** of the workforce among researchers and professionals in speech-language-hearing-communication sciences, (iii) the increase of knowledge in the general population of the significance of linguistics, the fact that it is a stem-based discipline and that various professional sectors exhibiting rapid growth value both linguistic training and the ethnic, cultural and linguistic heritage of minority students from groups underrepresented in higher education this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RAPID: REU Site: A Virtual Research Experience in Macromolecular Structure and Function

Awardee: University of Illinois at Chicago

Amount: \$57,970.00

Abstract: the covid pandemic has caused closures of reu sites in summer 2020. the situation continues this summer 2021 with some reu programs already posting cancellations. this rapid proposal will mitigate the inadequate number of available opportunities for students. the university of illinois at chicago (uic), located in chicago, illinois, will support the training of seven students for eight weeks during the summer of 2021. research will be conducted online with faculty located in chicago, evanston (il), and dallas (tx). the students, who are from groups under-represented in science or from schools with limited research opportunities, will learn how research is conducted, and many will present the results of their work at scientific conferences. this program provides vital training, mentoring, and professional skills development to enable and encourage talented students to continue in degrees and careers in science, which is vital for the future of us science and the economy. students will participate in full-time mentored research projects using state-of-the-art computer-based methods to advance our understanding of the structure and function of dna, proteins and other macromolecules. assessment of the program will be done through the online salg urssa tool. students will be tracked after the program in order to determine their career paths. the scientific theme of the program is macromolecular structure and function. faculty mentors come from uic departments of biology, physics, and bioengineering, the university of chicago biological sciences collegiate division, the university of texas southwestern medical center green center for systems biology, and the northwestern university molecular biosciences department. the computer-based projects include elucidating protein functional sites, conformational changes involved in aggregation, cellular targeting signals, and mechanisms of nutrient uptake. program components include professional skills training in ethical issues, responsible conduct of research, **\*\*diversity\*\*** and inclusion, science careers, and oral and written scientific communication. participants will present their accomplishments at a research symposium. more information is available by visiting [/bios.uic.edu/profiles/jeffery-constance-j/](https://bios.uic.edu/profiles/jeffery-constance-j/), or by contacting the pi (prof. jeffery, [cjeffery@uic.edu](mailto:cjeffery@uic.edu)). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review

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Matched Words: diversity

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Title: Collaborative Research: BPC-AE: STARS: Catalyzing Action-Oriented Academic Communities for Broadening Participation in Computing

Awardee: Florida State University

Amount: \$57,000.00

Abstract: it is critical to address the longstanding issue of underrepresentation of women, black, and hispanic students in computing degree programs to provide an equitable foundation for all to participate in our society and the global economy as controllers and creators of technology, and to advance the preparation of a diverse, innovative, and competitive tech workforce. building on the prior success of the stars computing corps alliance for broadening participation in computing, the goal of the stars catalyst project is to: 1) increase the number of women, black, and hispanic students that persist in computing degree programs, and 2) advance the careers of students and faculty from groups that have been historically underrepresented in computing. through research and evaluation around stars catalyst activities, this project will advance knowledge about practices designed to increase persistence and support career advancement in computing for college computing students and faculty, particularly for those from underrepresented and intersectional groups in computing. the stars catalyst alliance is a collaborative effort across temple university, north carolina state, kent state, florida state university, morgan state, and university of north carolina charlotte. the stars computing corps alliance for broadening participation in computing (bpc) engages computing faculty and students at colleges, universities, and community colleges in a community of practice with a shared commitment to take action to advance **diversity**, equity, and inclusion in computing. stars computing corps conferences, communities, and networks create significant institutional and human resources that can expand bpc research to a larger audience of researchers, educators, administrators, cs departments, and k-20 students, and can dramatically

increase the number of people taking action in bpc efforts. prior results show that the stars computing corps alliance increases intentions to persist in computing among stars students and faculty, with enhanced outcomes for black students and faculty. this project will significantly extend the stars alliance to expand upon those impacts, by 1) including new partners that expand the reach of stars and that emphasize participation of black and hispanic students and faculty, particularly from emerging hispanic serving institutions and community colleges, 2) creating new program elements that test new and propagate evidence-based bpc practices within computing departments, and 3) leveraging partnerships to support identity-focused affinity groups, and 4) developing stars alumni groups employed in industry positions to promote transition to and retention within the tech workforce. extensions to the stars leadership corps program, stars launch program, and the stars celebration conference will serve to develop and propagate evidence-based approaches aimed at improving the teaching and learning of computing for black and hispanic students and build evidence of their effectiveness, and the respect research conference will continue to advance peer-reviewed bpc scholarship. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Title: Collaborative Research: Linking predator functional diversity to prey dynamics through the functional response

Awardee: Florida Atlantic University

Amount: \$56,741.00

Abstract: human activities such as habitat modification, harvesting and species introductions are rapidly changing the type and number of predators in aquatic and terrestrial ecosystems. these changes in predator communities can have significant ecological and socio-economic impacts. however, our ability to predict and manage the effect of predator loss or introduction on prey populations on ecosystems remains limited. this study will integrate experimental and mathematical approaches to improve existing tools for predicting the consequences of predator loss or introduction in aquatic ecosystems. the investigators will conduct a series of observations and experiments in rock pools in streams to document the responses of prey to changes to multiple predator populations. the responses include patterns of prey mortality, and alterations in prey behavior or morphology. the data generated from this phase of the study will be used to test the ability of existing and improved models to predict the long- term consequences of predators on prey populations and overall ecosystem function. collectively, the results of this research will significantly advance our ability to predict the consequences of predator loss or invasion. the project will also integrate education with outreach activities in two ways: 1) the investigators will partner with high school teachers to create teaching modules and field labs focusing on predator-prey interactions. 2)

the investigators will participate as mentors in a faculty-mentoring network (nsf-quantitative undergraduate biology education and synthesis project). this network provides support to k-12 teachers and college faculty around the country seeking to implement more rigorous quantitative components in their courses. additionally, the study will provide research training for post-doctoral, graduate and undergraduate students. this project will support an early career investigator, and two investigators at primarily undergraduate institutions. this research will advance our ability to predict how predator loss or introduction affect prey populations and influence other ecosystem functions by focusing on the overall effect of multiple predators. the study will combine theoretical, statistical and empirical approaches and will include the following activities: 1) field surveys to measure density, size and species composition of predator and prey communities in rocky pools. 2) experiments to measure prey survival, fecundity and growth as functions of prey density and size, predator identity and food resources. 3) use of the data and patterns observed in the field and experiments to develop new models for predicting prevalence and magnitude of emergent multiple predator effects. 4) experimentally test predictions of the existing and improved models to quantify the importance of predator species and functional **\*\*diversity\*\*** on prey population dynamics in rock pool food webs.

Matched Words: diversity

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Title: Collaborative Research: Hominoid origins in a unique paleocommunity

Awardee: Oregon State University

Amount: \$54,580.00

Abstract: this project advances knowledge about a crucial time in primate evolution when the ancestors of apes and humans are thought to have first diverged from other primate lines. a team of experts in paleoanthropology, paleontology and geology are conducting excavations and analyzing fossils and paleoenvironmental data from a fossil-bearing site in order to better understand the environmental context for primate adaptations and ecological **\*\*diversity\*\***. the project offers invaluable research and training opportunities to scientists and students, including individuals from

groups underrepresented in stem, and provides opportunities for science outreach about human origins and climate change with local communities and the general public. an extraordinary new fossil primate site provides an opportunity to obtain new data related to the origins of the hominoids during the oligocene. the primary objective of the project is to characterize the species **\*\*diversity\*\*** and paleoenvironmental context for the site. the central hypothesis is that the earliest stem hominoids arose within unique ecological communities that were very unlike those of the later miocene hominoid radiations. the team of paleoanthropologists, geologists, and paleontologists carry out this work through additional fieldwork and analysis of the hundreds of fossils and geological samples already obtained. the goals are three-fold: (1) characterize the paleobiological disparity between hominoids and cercopithecoids in the mid-oligocene by analyzing functional disparity; (2) build out a robust geologic framework that integrates current and future fossil localities into a well constrained chronology; and (3) characterize the mammalian community **\*\*diversity\*\*** by contextualizing its taxonomic, functional, and phylogenetic composition. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: US GEOTRACES GP17-OCE: Mapping nitrous oxide sources and sinks through isotopic measurements in the Pacific Ocean

Awardee: University of South Carolina at Columbia

Amount: \$54,049.00

Abstract: nitrous oxide is a powerful greenhouse gas that is produced by microbial activity in soils and the ocean. the pacific ocean is an important component of oceanic nitrous oxide production and emission to the atmosphere due to its large area and pockets of low oxygen in the eastern tropical pacific. the largest amounts of nitrous oxide observed in the global ocean occur in these pockets of low oxygen. these regions appear to impact nitrous oxide distributions throughout the pacific ocean,



but the sources of nitrous oxide in these regions may be quite different. this work will provide a better understanding of both the natural distribution of nitrous oxide in the global ocean, as well as the mechanisms and controls on its production for future emission projections. this will be accomplished by collecting nitrous oxide isotopic measurements at different water depths from the central pacific, where relatively little work has focused. measurements of nitrous oxide isotopic composition is a powerful analytical tool that will help to answer these important questions about this powerful greenhouse gas. the stanford component of this project will be carried out primarily by a phd student, who will be trained in a variety of laboratory techniques, data analysis, and computer modeling. we will also use support from this project to increase **\*\*diversity\*\*** in the geosciences by providing first-time research experiences to underrepresented minority students through stanford's surge (summer undergraduate research in geoscience and engineering) program. one of the project's lead investigators, bourbonnais, will also give a series of introductory chemical oceanography lectures at benedict college, a private historically black, liberal arts college in columbia, sc and support two undergraduate students from benedict college through summer internships at the university of south carolina. this project will address three main questions related to n<sub>2</sub>o cycling in the pacific ocean: (1) what features of n<sub>2</sub>o distribution in the central pacific ocean are driven primarily through mixing and circulation vs. biological processes; (2) which biogeochemical processes control the distribution of biologically produced n<sub>2</sub>o in the central pacific ocean; and (3) how does the production (amount, mechanism, yield) of n<sub>2</sub>o relate to the availability of oxygen in situ? this collaborative project will be carried under the geotraces program, an international effort to understand the distribution of elements in the global ocean. with the synthesis of the geotraces gp17 and gp15 sections, we will have an opportunity to examine the distributions of n<sub>2</sub>o and its isotopes (an indicator of production mechanisms) relative to oxygen, trace elements, and water mass tracers. data from this project will be made available to the public through the biological and chemical oceanography-data management office ([www.bco-dmo.org](http://www.bco-dmo.org)). the data will also be compiled in geotraces data products that will be freely available. this award reflects nsf's statutory

mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF-sponsored workshop: The cross-disciplinary study of post-transcriptional and post-translational modifications: Finding the commonalities of interests, approaches, and future di

Awardee: University of Pennsylvania

Amount: \$52,707.00

Abstract: every organism on earth relies on its dna content (i.e., genome) to direct its life, growth, and development. however, the genome is not the destiny of the organism. for example, caterpillars and butterflies have exactly the same genome, but distinct forms. the difference can be largely attributed to the other important biomolecules that are encoded by the genome. these biomolecules are rna and proteins, which can be modified in hundreds of different ways after their synthesis. recognition of the **\*\*diversity\*\*** and complexity of modifications of rna and proteins has changed how we think about their different functions of these molecules in fundamental ways in both large and small organisms, ranging from microbes to plants and humans. understanding how rna and proteins are modified, and their biological implications is very important in many areas of basic and applied biological and medical research. improving our understanding will require building community resources, technical breakthroughs, and cross-disciplinary research efforts to achieve cross-cutting advances in rna and protein biology. this project will support a virtual national workshop that will bring together 100-150 diverse participants that are actively involved in both the meeting and discussion sessions. in addition, all research talks, and discussion sessions will be open for anyone interested to watch through zoom. the participants are from many different disciplines and areas, including plant, animal, and human biology, and cover research areas such as chemistry, engineering, computer science, artificial intelligence, and systems and synthetic biology. keynote talks from leaders, small-group and interactive sessions will facilitate and stimulate researchers to

address the following key topics: 1) successes and failures in rna and protein modification research in a variety of research organisms; 2) experimental systems as well as research approaches that leverage all rna and protein-related scientific disciplines; 3) possible "rules of life" to guide baseline and comparative questions across the different realms of organisms; 4) advantages and disadvantages of currently available tools, consortia, and databases; 5) training needs for researchers capable of contributing to future advancement in rna and protein biology; and 6) short- and medium-term research and knowledge goals, noting potential strategies to reach these goals.

in the framework of our current understanding of genetic information flow, post-transcriptional modifications (prms) of rna molecules and post-translational modifications (ptms) of proteins are extremely important cellular regulatory moieties. yet significant gaps remain in the integrated understanding of these two regulatory moieties and their effects on overall cellular metabolism in different biological organisms. fragmented research efforts in different systems (e.g., microbe, plant, animal, and human) and using different approaches and standards, has prevented integrative analyses of different datasets and identification of common principles of prms and ptms. this workshop aims to fill these gaps and advance research from descriptive and specific mechanistic focus towards integration, general theory, modeling and prediction, and global understanding. moreover, this workshop will promote studying the functions and mechanisms of the key regulatory modifications, of their roles in cellular signaling and metabolism, as well as their impact on organisms. the workshop will provide significant opportunities for cross-disciplinary interactions to advance the field of rna and protein biology by identifying: 1) core questions driving/prm and ptm studies; 2) conceptual and theoretical foundations that provide a useful lens for hypothesis testing; 3) big ideas to drive advances in these areas and increased understanding of the rules of life; and 4) a path forward for collaborative research and synthetic analyses that will further integrate the two closely-related areas of research through multidisciplinary approaches. early-career post-doctoral scientists and graduate students will participate in the workshop organization and serve as virtual discussion leaders, providing them the opportunity to network with many of the

leaders in these cutting-edge fields. the workshop aims to increase broad participation of underrepresented groups in rna and protein modification research, and serves as a model for integration of inclusive and interactive online conference opportunities allowing participation from broader audiences. collectively, this workshop will identify critical gaps in resources and understanding of prms and ptms across disciplines, and importantly draft a path forward for community-wide collaborative research to advance these important areas of research that affect our understanding of human, plant, animal, and ecosystem biology. funding for this workshop was provided by the physiological and structural systems cluster, plant genome research program, and genetic mechanisms cluster in the bio directorate and the cellular and biochemical engineering program in the eng directorate. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Expanding Participation for Women and Minorities in the 2022 Neurobiology of Cognition  
Gordon Research Seminar & Conference

Awardee: Gordon Research Conferences

Amount: \$50,250.00

Abstract: the field of cognitive neuroscience has expanded by leaps and bounds over the past 20 years - the number of yearly publications has increased 20-fold over these two decades. bringing the cognitive neuroscience community together for focused and in-depth discussion of cutting edge research every two years is incredibly valuable (the 2020 gordon conference was not held because of the pandemic). meanwhile there has also been an explosion of information in molecular, cellular, circuit and systems neuroscience but little of that information has made significant inroads into our understanding of cognitive function. this gordon research conference on the neurobiology of cognition should help bridge the gap, at the very least by identifying the avenues for connection that

have the most potential for near-term traction and by linking scientist from disparate fields. the gordon conference (grs and grc) will take place in july, 2022. the emphasis of the workshop is to facilitate in-depth discussion between scientists working in divergent fields whose integration is essential to understanding the neurobiology of cognition. nsf support will enable graduate students and postdoctoral trainees and early investigators to participate in this high-profile workshop and will allow early stage investigators (non-tenured) to attend as speakers and full participants. trainee fellowships to cover travel and registration expenses will be preferentially given to women and under-represented minorities in order to enhance \*\*diversity\*\* in the field of cognitive neuroscience.

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: 2022 Gordon Research Conference on Multifunctional Materials & Structures: Imparting Intelligence in and through Self-Learning Materials & Structures; Ventura, CA; 23-28 Jan 2022

Awardee: Gordon Research Conferences

Amount: \$50,000.00

Abstract: this award will provide financial support to the 2022 gordon research conference on multifunctional materials and structures: imparting intelligence in and through self-learning materials and structures to be held in ventura, california, 23-28 january 2022. this conference seeks to address fundamental scientific issues associated with hierarchical multifunctional material systems from the molecular scale to the structural scale, with principal considerations to intelligence and self-learning. the potential societal benefits and impact of multifunctionality are materials sustainability and energy resource management through material sustainability, recycling, and upcycling; safer systems through adaptive and self-aware capabilities, and improved energy efficiency through mass and/or volume reductions, energy recapture, and ambient harvesting. the conference will seek a broad balance in the speakers, discussion leaders, and attendees including

young and established scientists and engineers, national and international representation from academic, industry, and government institutions/groups, and gender and racial \*\*diversity\*\*. funding through this award would increase the number of graduate students and postdoc participants to prepare the next generation of scientific leaders in this field. in the ongoing series of biennial conferences on multifunctional materials and structures, the focus of this conference is on intelligence and self-learning. researchers will address key scientific issues associated with envisioning, designing, and creating synthetic multifunctional materials and structures with intelligence and self-learning. they will identify gaps and present potential solutions on the integration of these novel functionalities into engineering structures, e.g., how to optimize the disparate roles of interfaces and the design and fabrication approaches. the conference is being organized by leading researchers in this emerging field with deep ties to the worldwide community of scientists and engineers engaged in multifunctional research. the conference outcomes are expected to include novel concepts and mechanisms for achieving intelligence and self-learning, as well as new collaborations and ways of collaborating across disciplines. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Mathematics Leaders Exploring Racial Equity

Awardee: University of Texas at Austin

Amount: \$49,999.00

Abstract: this project aims to serve the national interest by increasing the number of and \*\*diversity\*\* of successful mathematics and stem students. students' experiences in higher education mathematics courses take place in departments. policies and practices relating to student and faculty experiences, admissions criteria and other aspects of departmental have too often contributed to longstanding inequities in representation and outcomes for minoritized students. in

the summer of 2020, amidst the larger national discussion on racial equity, a grassroots workshop brought together over 100 leaders in the mathematics community to understand these disparate racial impacts, brainstorm, and explore opportunities for positive change. participants built a shared understanding and commitment to promote greater racial equity for students and faculty in mathematics departments across the nation. this project looks to expand upon that initial work with a goal of encouraging further discussions and fostering wider transformation in the mathematical sciences community. department chairs, undergraduate and graduate directors, and national math organization leaders will gather regularly in facilitated groups to work through shared readings and analyze departmental policies and practices. each group will engage in conversations relevant to their experiences and institutions with a goal of identifying strategies to more equitably serve their students. some areas of focus for working groups will include mentoring and advising, graduate admissions, and both student-facing and faculty-facing policies. participants will be asked to select an "avenue of change", which is an explicit goal to bring about change in their department or at their institution, and will be held accountable by their peers to carry out this task. in addition to broader dissemination of workshop outcomes, each cohort of participants will share their activities through social media, publications, sessions at national meetings or other means chosen to maximize reach and potential replication. the nsf iuse: ehr program supports research and development projects to improve the effectiveness of stem education for all students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Transforming Secondary Mathematics Teacher Preparation: A Conference to Focus on Recruitment and Equity

Awardee: University of Nebraska-Lincoln

Amount: \$49,967.00

Abstract: this project aims to serve the national interest by convening a conference focused on increasing the number of higher education institutions that are committed to improving secondary mathematics teacher recruitment and preparation programs, ultimately improving access to high-quality mathematics instructions for 6-12th grade students. the association of mathematics teacher educator?s (amte), get the facts out (gfo) taskforce, and the mathematics teacher education partnership (mte-p), will use this conference as a vehicle to address issues related to recruiting diverse mathematics teacher candidates, exploring transformational efforts relevant to teaching, and examining the role of equity in secondary mathematics teacher recruitment and preparation. new and existing partners will share tools and strategies for solving common challenges and develop ideas for local program transformation efforts. broadening participation in who becomes mathematics teachers is vital; therefore, the project will approach recruitment and program transformation efforts from an equity perspective. at the 2022 mte-p & gfo conference, participants will engage in focused discussions about the significant work of transforming preparation programs to more closely align with the amte?s standards for preparing teachers of mathematics. the conference will be offered in a hybrid format, with participants invited to fully engage either in-person or online. the in-person portion will be held in the same location as the 2022 amte annual conference, one day prior to the amte conference. an evaluation effort will examine (1) the ways in which the conference has expanded the network of partners who focus on secondary mathematics teacher preparation beyond the gfo and mte-p communities, and (2) the degree to which the sessions address equity, **\*\*diversity\*\***, and inclusivity; recruitment strategies; as well as supports for and dimensions of program transformation. information and materials from the mte-p & gfo conference themes and sessions will be disseminated through the amte newsletter and the teaching mathematics teachers podcast. by utilizing ideas of improvement science to support institutional transformation, participants will impact stem educational experiences across k?12 and post-secondary contexts. the nsf iuse: ehr program support research and development projects to improve the effectiveness of stem education for all students. through the engaged student learning



track, the program supports the creation, exploration, and implementation of promising practices and tools. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Cultivating Networks and Innovative Scholarship in Law and Courts, June 2022

Awardee: Wesleyan University

Amount: \$49,961.00

Abstract: in spite of efforts by both professional associations and other groups concerned about the **\*\*diversity\*\*** of the subfield, women and minorities are underrepresented among the scholars who study law and courts. we know that women scholars within the law and courts field, as compared to their male counterparts, face barriers to tenure and promotion due to disparities in resources for research, heavier teaching loads and service expectations, and a lack of parity in placement of law and courts-focused articles in top disciplinary and subfield journals. the effects of these barriers are amplified for those women scholars who are black, indigenous, or from another minority group. this project?a workshop and mentoring community?will serve as one targeted effort to improve representation in the law and courts field. in addition to serving as a space for junior women and nonbinary scholars to gather and receive feedback on their research, the workshop aims to facilitate connections between junior scholars and senior mentors in the field. further, this workshop will invite undergraduate and graduate researchers (those pre-ph.d.) to take part in the professional development sessions. the workshop thus serves a three-fold purpose: it aids in rectifying the ?leaky pipeline? problem for women and non-binary people, assists law and courts scholars in gaining acceptance in the top journals, and facilitates collaborative projects by bringing detached communities together. this workshop will provide a novel forum for cutting edge research on law and courts by junior women scholars to be shared with and reviewed by leading scholars in the field, thus advancing knowledge across a variety of topics within the subfield. this project grows out of a

successful pilot effort conducted over the past year where the researchers: (1) identified members of the community of junior women in law and courts through a widely distributed online survey, (2) developed a series of online peer-to-peer writing groups, and (3) engaged in outreach efforts to decrease the invisibility of research by members of the writing groups and other junior women scholars. the in-person workshop will continue these efforts by bringing together a community of junior women scholars and will augment the pilot efforts by engaging a group of leading women scholars in the subfield for professional development and networking. the workshop will be held in june 2022. participants will be selected through a multi-stage, competitive process which will evaluate the suitability of their projects for the workshop and will also take into account the global **\*\*diversity\*\*** goals of the workshop cohort. at the one-and-a-half-day workshop, scholars will receive feedback on their work from peers and senior scholars and will also participate in professional development and networking panels. workshop participants' progress will be tracked and promoted through the project's outreach channels. it is thus the aim of the proposed workshop and ongoing peer and senior mentoring to assist junior scholars in producing and publishing high-quality research in order to achieve professional success, both at their institutions and in the discipline. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Conference: Math for All

Awardee: Tulane University

Amount: \$49,951.00

Abstract: this three-year award provides support for the annual conference "math for all" in new orleans. the first of the three events will be held on february 4-6, 2022. the overall goal of this conference is to increase **\*\*diversity\*\*** in mathematics and expose mathematicians in the greater new orleans area to research and novel teaching practices as well as provide the opportunity for

networking and developing mentor-mentee relationships. the conference strives to make mathematics more accessible to underrepresented groups, ultimately increasing **\*\*diversity\*\*** in the field. the conference will have participants representing historically black colleges and universities (hbcus) and smaller universities in the new orleans area. one of the goals is to expose the participants to a broad mathematical research community. this aspect of the conference aims to help students transition to research-focused environments, which will increase retention of underrepresented groups in the mathematical fields. the conference will also stimulate discussions among faculty on inclusive pedagogy aimed at advancing students from underrepresented groups. the organizing committee is dedicated to amplifying the voices of underrepresented minorities in mathematics by highlighting the importance of representation, connections, and individual actions towards changing systemic forms of oppression in mathematics. the conference will include four broadly accessible plenary talks, six contributed research sessions, a diverse career panel, two workshops and a poster session. through these avenues, the conference is designed to engage undergraduate and graduate students into a community of mathematics and prepare them for future careers in the field. the plenary speakers and panelists come from around the united states, representing multiple ethnic and mathematical backgrounds, giving students visible role models in industry and academia with whom they can identify. participants will have the opportunity to present research and attend professional development workshops in a welcoming and inclusive environment. the conference will also support a few satellite events. at each of the satellite institutions, the organizers will set up a space for attendees to gather, watch and discuss the plenary talks. the pis will provide the foundation of the math for all conference to the satellite institutions but also allow them to plan their own activities. these satellite conferences will help engage a broader community and amplify the impact of the conference by sharing the resources of the math for all conference, in the hopes of reaching mathematicians who would otherwise not be able to attend the in-person conference. the conference website is: <http://www.math.tulane.edu/mathforallnola> this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation

using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: International Scientific Community Workshop Series on the Access and Benefit Sharing of Digital Sequence Information

Awardee: American Institute of Biological Sciences

Amount: \$49,932.00

Abstract: sequences of biological macromolecules, such as dna, rna, and proteins (collectively ?digital sequence information? or dsi) have become increasingly important to advancing scientific research and discovery worldwide. information of this kind helps scientists understand how genes affect organisms? shape, physiology, behavior, and function. in turn, this knowledge provides the raw material for innovations that will advance human health, food security, and the preservation of bio\*\*diversity\*\* as the climate changes rapidly. the free and unfettered exchange of non-commercial dsi enables the global community of researchers, educators, bio\*\*diversity\*\* collections managers, students, and innovators, including those in the united states, to work fluidly with each other to enable scientific progress. such free flow of information is not guaranteed. discussions have been taking place under the auspices of the united nations convention on biological \*\*diversity\*\* (cbd) and other multilateral bodies to apply a principle known as access and benefit sharing (abs), which was initially developed for physical biological specimens, such as a plant or an insect, to dsi as well. for the most part, the scientists whose research projects depend on openly sharing dsi do not have a seat at the table at which decisions about dsi are being made. this could result in limiting access to information that is currently freely available; indeed, many scientists are unaware that the conversations are even taking place. it is important, then, to ensure that scientists and scientific societies in the united states and elsewhere become more fully engaged in these deliberations, in part by highlighting the importance of transnational collaborations that depend on the exchange of dsi, and making recommendations for how related benefits can be shared. this project will engage

scientific societies, most of which have international memberships, to co-host a workshop series that will educate the community on the issues, perspectives, and requirements that are associated with discussions about dsi/abs in the context of the cbd. the workshops are slated to begin in late summer or early fall of 2021, before the major cbd bio\*\*diversity\*\* negotiations to be held in kunming, china (tentatively in october 2021), and will extend into 2022. activities will include talks from high profile us and international scientists and facilitated discussions tailored to the scientific societies? concerns, which will help to build capacity within societies to accelerate compliant and outstanding bio\*\*diversity\*\* science across geopolitical borders and to develop recommendations that may be helpful to parties to the cbd. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: RAPID: Quantifying Wetland Root Structure, Strength, and Uprooting due to Hurricane Ida

Awardee: Louisiana State University

Amount: \$49,770.00

Abstract: coastal wetlands are valuable ecosystems. they improve water quality, provide wildlife habitat and bio\*\*diversity\*\*, store organic carbon, and protect coastal communities from storms by dampening waves and reducing storm surge heights. yet, severe storms are one of the most common natural drivers of coastal wetland loss. for coastal louisiana, the combined impacts of hurricanes katrina and rita (2005) and then hurricanes gustav and ike (2008) converted nearly the area of new york city into open water. as a result, predicting wetland loss due to hurricanes is an important goal because of the significant consequences with respect to coastal populations. this rapid award will allow timely field testing and core sampling to quantify wetland root strength and structure in the barataria basin of coastal louisiana, which experienced extreme land loss from hurricane ida. this information will help inform the scientific community and public on how the

wetlands are eroded, what controls erosional resistance, why some hurricanes are more damaging than others, and what potential is for long-term recovery. hurricane ida made landfall on the southeastern louisiana coast, bringing storm surge and waves of approximately 4.5 m above the normal water level that caused immense damage to the natural and built environment, specifically undermining the wetland root systems and removing much of the marsh platform. current knowledge of the ability of the wetland platform to withstand hurricane-induced uprooting is limited, and the roles of wetland root structure, biomass volume, and strength need further research. the objective of this rapid research is to collect perishable data of wetland uprooting, including (i) quantifying the micro-scale live biomass, necromass, root structure, pore structure, and sediment density using x-ray computed tomography (xct) scans; (ii) measuring the macro-scale field strength of root systems using cone penetrometer tests (cpts); and (iii) assessing the resilience of wetland vegetation and root systems to recover from a disturbance. this award will develop new knowledge concerning how the wetland platform withstands storm surge and waves, how these systems could evolve over space and time (particularly in the face of sea level rise, restoration activities, and recovery after an extreme event), and how these changes could alter their ability to protect the coastline from further damage. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: The Geoscience Behind Critical Infrastructure Careers; Unlocking the Intrinsic Value of Diverse Communities - a GEO-STEM Learning Ecosystem in Practice

Awardee: LIMITLESS VISTAS, INC

Amount: \$49,710.00

Abstract: there is a well-documented lack of **diversity** in the geoscience classroom, faculty and geoscience professional ranks and environmental workforce. this workshop introduces a diverse population of high school and undergraduate participants to solution based geoscience and potential career pathways. the workshop will help increase the **diversity** in the educational and career pipeline of future geoscience professionals and show participants ways to become active in addressing the impact of public facilities on their communities. working with practicing geoscientists and educators, participants will develop and present on cutting edge environmental infrastructure (water, power, sewer, solid waste, etc.) issues, technologies and careers which affect their daily lives. they will learn the skill sets necessary to become more active participants and problem solvers who are focused on using geoscience to address the impact of public facilities on their communities. this workshop has the potential to increase participants' awareness of environmental infrastructure and the connection to community impacts and stem-related careers. the proposed workshop squarely addresses agu's **diversity** and inclusion strategic plan including to 1) promote and expand collaborative activities... with local community-relevant scientific endeavors, particularly in support of under-served and disadvantaged communities and 2) increase the visibility of education and career paths (in earth science) among diverse audiences and encourage participation in the geosciences. program participants will develop creative content for presentation at the 2020 agu virtual fall meeting - including virtual tours, videos, and interactive communication pieces to demonstrate how new orleans', san francisco's and los angeles' unique geology and seaport locations impact the critical infrastructure of those cities and respective communities. this award reflects nsf's statutory mission and has been deemed worthy of support



through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: Developing Institutional Responsible Conduct of Research Training Plans that Reflect Best Practices

Awardee: University of California-Riverside

Amount: \$46,807.00

Abstract: the workshop is designed to identify and share best practices in the implementation of robust educational programming for responsible and ethical conduct of research [recr]. the workshop will focus on the achievements of peer model institutions and identify best practices for successful implementation at other institutions. by directly addressing common hurdles that institutions face and building on what has been successful, this workshop will produce a roadmap of resources and guidelines which can be widely distributed and adopted, as appropriate, across a **\*\*diversity\*\*** of other institutions. the outcomes will directly contribute to enriching recr programming and program implementation to support the progress of science by fostering responsible and ethical research. educators, university administrators, industry and scientific communities will be interested the outcomes of this workshop. this workshop will focus on 1) examining the elements that need to be addressed in an institutional recr plan, 2) identifying the key challenges and barriers to the creation and implementation of such programming, and 3) exploring strategies for how those challenges might be met. this goal of this workshop is to create a framework of best practices for implementing robust recr programs based on peer models of excellence. representatives from institutions will share opportunities and challenges in the implementation of recr programming on their campuses to find common ground for further exploration of best practices. the workshop will collect and disseminate practical advice for recr implementation that is not otherwise currently

addressed/available. the outcomes will directly contribute to knowledge of recr implementation by providing institutions with key factors and considerations for improving their recr programs based on peer examples of success, something that has not been previously collected or disseminated. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: GeoGaze: Gaze-Driven Adaptive Multimedia to Augment Geoscience Learning for Neurodiverse Learners

Awardee: University of Massachusetts Boston

Amount: \$46,758.00

Abstract: much of learning occurs today in multimedia environments. this project will design and test geogaze, a novel technology that uses eye tracking to augment learning with multimedia in real time. geogaze analyzes and predicts effective strategies for students based on differences in working memory capacity and changes the presentation of learning materials to help everyone view and learn information. investigators will first study what visual attention strategies work best for learners with different levels of working memory capacity. this information will be used to build a gaze-driven technology to help each learner use the most effective strategies by adapting the learning materials in real time and for each learner. examples of this include predicting where learners will look on the screen, what order they will explore the content, and then highlighting the most important elements in the sequence to be viewed or blurring the less relevant content before revealing when appropriate. the results of this project will help us understand how individual differences in visual attention and working memory capacity influence multimedia learning and how to adapt learning materials to improve learning in real time. this project seeks to engage more students in learning geoscience, a field not well represented by a **\*\*diversity\*\*** of students and researchers. studies of multimedia learning traditionally focus on final learning outcomes but what

happens during the learning process (e.g., visual attention strategies to integrate multimedia) is often unexplored. this project addresses these shortcomings to gain a robust perspective of how students with different working memory capacities learn authentic stem content (geoscience) in multimedia environments, and how their cognition can be enhanced using gaze-driven adaptive learning technology, geogaze. this approach is based on a novel integration of behavioral and psychophysiological data as well as multi-layer backpropagation neural network analysis to predict media integration strategies. geogaze represents a novel gaze-driven technology for adapting multimedia learning in real time based on effective media integration strategies for each learner. this research will generate new empirical evidence for using real-time gaze-driven adaptation of learning materials to augment cognition and improve learning. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: A Professional Learning Community for Advancing Community College Education and Student Success (ACCESS)

Awardee: University of California-Berkeley

Amount: \$46,575.00

Abstract: the university of california berkeley museum of paleontology (ucmp) will lead a one-year virtual conference to establish a professional learning community (plc) of community college instructors and graduate students to support the development of teaching resources for diverse audiences. the plc builds upon existing partnerships with community colleges and resources developed as part of the access (advancing community college education and student success) program to make the geosciences and practices of scientific inquiry more accessible to all learners. while earth science literacy and perspectives from diverse stakeholders are essential for addressing 21st century societal and environmental challenges, the geosciences remain one of the least

diverse stem disciplines. by partnering with community colleges, the program will serve students who identify as low-income, first-generation, or underrepresented minorities. the access program is uniquely positioned to help enhance online and in-person geoscience learning experiences for students while simultaneously helping community college instructors and uc berkeley graduate students develop inclusive pedagogical practices to enhance their teaching skills. the access plc will support the revision and implementation of inquiry-based lessons for diverse audiences using active, equitable, and inclusive learning practices known as model-based inquiry. through a year-long series of workshops and meetings, the plc will develop lessons that deepen students' understanding of the earth history and processes, which is necessary to contextualize the complexity and urgency of global climate and local environmental challenges. efforts to enhance stem education that focus on issues related to **\*\*diversity\*\*** and inclusive practices are typically one-time efforts and not a continual means of providing professional development and support for instructors. year-long support for instructors and iterative development of resources in the ucmp access plc will help transform and sustain shifts in teaching practices as we face the ongoing challenges of providing online and blended learning experiences for students. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: Western Connecticut State University

Amount: \$46,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in

science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Graduate Research Fellowship Program (GRFP)

Awardee: University of Wisconsin-Milwaukee

Amount: \$46,000.00

Abstract: the national science foundation (nsf) graduate research fellowship program (grfp) is a highly competitive, federal fellowship program. grfp helps ensure the vitality and **\*\*diversity\*\*** of the scientific and engineering workforce of the united states. the program recognizes and supports outstanding graduate students who are pursuing research-based master's and doctoral degrees in science, technology, engineering, and mathematics (stem) and in stem education. the grfp provides three years of financial support for the graduate education of individuals who have demonstrated their potential for significant research achievements in stem and stem education. this award supports the nsf graduate fellows pursuing graduate education at this grfp institution. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Varieties of Crises, Elite Responses, and Executive Approval

Awardee: Indiana University

Amount: \$42,019.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2. this project examines four major types of crises -- economic, security, natural disaster, and public health crises ? and how they influence public support for political leaders in contemporary democracies. this is important to understand because leader approval is a key barometer of policymaker accountability and democratic stability, both of which can be undermined by crises. this project analyzes the interplay of four factors which vary systematically across these different types of crises and how, in turn, these shape public evaluations of political executives: (1) the ability of citizens to assign responsibility for policy decisions and outcomes; (2) the degree of expert consensus on effective policy response; (3) how much a given crisis in one area generates acute challenges or crises in other areas; and (4) the extent to which an effective response depends on citizens acting collectively. several data sets including (quarterly) measures of executive approval and crises; the tone and salience of leader messaging about the crises; the media's treatment of leader messaging; and (monthly) leader approval for a smaller number of countries for which such data is available; and survey-based experiments in three countries are collected and made publicly available. the award supports education and **\*\*diversity\*\*** by building the research capacity of a student project lab at georgia state university, a minority serving institution, in coordination with pis at four other universities who will also engage graduate and undergraduate students in this work.

puzzling divergences across countries in public reactions to leader responses to the covid-19 public health crisis have revealed major gaps in our understanding of how crisis events translate into public assessments of leaders. to resolve these puzzles, this project advances a unifying theoretical framework that identifies four major types of crises: economic, security, natural disaster, and public health. it then locates these crises on four key dimensions which should condition public support of top officials: the institutional and political context and other factors that impact attribution of responsibility, degree of expert consensus and incentives for politicians to follow expert recommendations, the likelihood and nature of spill-over to other crisis types, and the degree to which citizen action is required for an effective response. the project collects data to test

theoretically-motivated hypotheses using: 1) a macro time-series cross-national data set to study the effects of crisis type on public approval for political executives for 48 countries, 2) a high-frequency time-series data set appropriate to test how approval dynamics reflect leader responses, as well as messaging choices and media effects for 18 countries for which this data is available, and 3) conjoint experiments in france, italy, and mexico, countries with different political and institutional settings, to assess the validity of the links between crisis types and dimensions as well as to validate proposed individual-level mechanisms. this project is supported by the accountable institutions and behavior program and the sbe build and broaden program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: EAGER: Scaling Necessary Change, Coalitions and Community (SNC): brave leadership for better geoscience"

Awardee: Amherst College

Amount: \$41,819.00

Abstract: in 1972, geoscientist dr. randolph bromery chaired the "first national conference on minority participation in earth science and mineral engineering", a gathering of more than 300 representatives of academia, industry, government, and civil rights organizations. the goal of the conference was to broaden participation and support the success of black, native, and latinx geoscientists. despite this goal, the geoscience community remains a long way from achieving the level of \*\*diversity\*\* needed to tackle some of the nation's most pressing environmental challenges. this project will develop a scholarly, community-driven, forward-looking roadmap that institutions, funding agencies, industry, and the public can use to contribute to the universally beneficial goal of broadening participation in the geosciences over the next half century. training a diverse cohort of geoscientists is essential to meeting the growing demands for a robust geoscience workforce that



can address the societal challenges posed by natural hazards, global change, and energy in the 21st century. however, historical efforts to advance this goal have been ignored or forgotten among most geoscientists, the scientific community, and the broader public. to make substantive and lasting demographic change in the geosciences, the research community must understand past efforts to advance justice and use them to inform new ways forward and to establish mechanisms for accountability over the next fifty years. to develop the roadmap report, this project will first convene the geoscience community at a "second national conference" to examine the past fifty years of efforts to advance broadening participation in the geosciences. following the convening, the project will form a group of twenty early-career geoscientists that will co-author and deliver the roadmap report. this project has a novel approach as early-career scholars usually are not in the leading role of such large community-wide efforts. the project leads and the twenty-person writing team will be early career professionals. if successful, this project will provide the new and innovative ways forward towards achieving more justice, equity, **\*\*diversity\*\***, and inclusion in the geosciences.

this project advances a radically new strategy, centered on brave leadership, to achieve broadening participation goals in the geoscience community. by drawing on tenets of black studies and other frameworks from social science and humanities, this project will take a novel, interdisciplinary approach and establish evidence and experience-based strategies for broadening participation that expand the understanding of the history, current state, and future of geoscience. to ensure that progress is made on reaching the goals for broadening participation in the coming decades, the geoscience community needs a roadmap that will provide checkpoints, strategies, and accountability. to create this roadmap, principal investigators (pis) will (1) convene a conference with participation from stakeholders, representatives, and leaders across academia, industry, professional organizations, and government agencies. participants will reflect on past efforts to advance geoscience goals and cultivate partnerships to support new institutional and community goals. then, pis will (2) identify a team of twenty early-career leaders to develop "the 2072 report". developing the report will be a unique professional development experience that will equip the next

generation of geoscience leaders with tools, frameworks, and partnerships necessary for making lasting change in the field. this project has a novel approach as early-career scholars usually are not in the leading role of such large community-wide efforts. the project leads and the twenty-person writing team will be early career professionals. if successful, this project will provide the new and innovative ways forward towards achieving more justice, equity, **\*\*diversity\*\***, and inclusion in the geosciences. a primary outcome of this work will be the co-creation of a community-driven framework for achieving a just, diverse, and equitable geoscience community. it will include best practices, tools, and ideas for broadening participation; checkpoints and goals that will keep the community on track; and strategies for ensuring accountability over the next fifty years. this roadmap will provide the geoscience community with direct opportunities for reflection on what can be achieved in two years, what is feasible in a five- or ten-year strategic plan, and how those components can provide building blocks towards fundamental, sustainable, systemic change. another outcome will be the establishment of a cohort of early-career geoscientists who are committed to dedicating their careers to transforming the geoscience landscape while they pursue academic positions. this will encourage novel and interdisciplinary research directions across geosciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: 2022 CONFERENCE: A Workshop on Undergraduate Research for Faculty in Glass Science and Engineering (Cedar Rapids, Iowa)

Awardee: Coe College

Amount: \$40,876.00

Abstract: this workshop is supported by three programs: condensed matter physics (cmp), metals and metallic nanostructures (mmn), and ceramics (cer). non-technical description: this multiday workshop in may 2022 serves to encourage faculty who work with undergraduates to conduct

research in glass science and engineering. best practices are discussed and include what are suitable projects, funding opportunities and writing proposals, collaborating with r-1 institutions, and how research is best carried out with undergraduate students in the summer and in the academic year. building a diverse workforce in the field has high value. thus, various aspects of **\*\*diversity\*\*** and undergraduate research are discussed including its inherent importance, recruitment of diverse scholars, and encouragement and mentoring. follow-up with the faculty members participating in the workshop is taking place to ensure that the goals of undergraduate research are being reinforced. one important broader impact is that many coe college undergraduate students, with research experience, consistently over time enter graduate school and industry in the field at rates approaching 75%. technical details: there is a documented need for more glass scientists and engineers. a key element that encourages undergraduate students, in general, to engage at a high level is involvement in publishable research. this workshop, at coe college, involves twenty faculty who are working with undergraduates in glass science and engineering. the workshop is led by professors feller and affatigato and several nationally known experts in research with undergraduate students and **\*\*diversity\*\***. at coe college, nearly 400 students who perform publishable research enter the field in industry and graduate school at about the 75% level. this impact occurs while simultaneously increasing **\*\*diversity\*\***. workshop participants are benefitting from well over 100 years of hands-on experiences by the presenters. a transformational aspect of the activity is the multiplicative effect of having a large cadre of faculty geometrically increasing student involvement in the field at the undergraduate level. documentation of these efforts take place by presentations at meetings of the american ceramic society, the iowa glass conference, and the international congress on glass. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: 3 Myr of Laurentide Ice Sheet History Inferred from Cosmogenic Nuclides in Ice-Rafted Debris

Awardee: Purdue University

Amount: \$38,150.00

Abstract: the laurentide ice sheet over north america caused large changes in climate and sea level as it grew and shrank over ice age cycles during the past three million years, but little is known about the ice sheet's detailed history throughout this interval. this project will determine how big the ice sheet was through time using chemical markers in layers of sand on the seafloor that melted out of icebergs drifting from north america. this method provides a new way to learn about past changes in the laurentide ice sheet and test ideas for how climate change and ice sheets affect each other. the results should help with predictions of sea-level rise far into the future due to global warming and melting polar ice sheets. this project will also educate and involve a wide range of people in climate science in several ways. videos about the research will be sent to boston public schools through the bostem organization to help students in the area learn about careers in science. the researchers will participate in activities through the mcauliffe center for integrated science learning at framingham state university to teach middle and high school students and teachers about climate change. college students will help with the research during summers through the integrated science for society nsf research experience for undergraduates at boston college, which tries to find students from underrepresented minority groups or who are the first in their family to go to college and that do not have research possibilities at their school. lastly, the project will support a female ph.d. student already at boston college and an m.s. student at the university of vermont. the laurentide ice sheet over north america was one of the largest drivers of climate and sea level over the ice age cycles of the past three million years, but its history over this interval is shrouded in uncertainty largely due to limitations of conventional geologic records. this project will take a new approach, measuring the concentrations of rare chemicals in quartz sand layers from ocean sediment cores that melted out of drifting north american icebergs. the chemistry of the sand reflects the history of

north american ice sheet cover because the chemicals accumulate in land surfaces exposed to the atmosphere but radioactively decay away when the surfaces are buried by ice. four sediment cores will be analyzed to reconstruct long-term laurentide ice sheet evolution, and analyses of sand samples collected across eastern canada will show how their chemistry records ice sheet variations over the most recent ice age cycle. together with similar reconstructions produced over the past five years from greenland and antarctica, these records will provide a comprehensive picture of how these three ice sheets varied in the past and contributed to global sea level. the results will offer much-needed constraints to test theories and models of paleo-ice sheet change, useful for improving long-term future projections of ice sheets on earth today. this project will increase literacy and **\*\*diversity\*\*** in climate science in multiple ways. ?science bites? videos about the research will be distributed to boston public schools through bostem to demystify careers in science. participation in ongoing efforts through the mcauliffe center for integrated science learning at framingham state university will help educate middle and high school teachers and students on climate change. this project will support an existing female ph.d. student at boston college and an m.s. student at the university of vermont. summer undergraduate research assistants will be recruited through the integrated science for society nsf reu at boston college, which seeks to attract underrepresented minority and first-generation college students from schools with limited research opportunities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity  
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Title: Collaborative Research: Building consensus around the quantification and interpretation of Symbiodiniaceae diversity

Awardee: William Marsh Rice University

Amount: \$35,394.00

Abstract: single-celled microorganisms are highly diverse and play various roles in the function of

natural ecosystems, but it is challenging to recognize how genetic, morphological, and physiological **diversity** relate to each other in microbial groups. In an exemplary case, micro-algae in the family Symbiodiniaceae comprise many species that can only be distinguished using molecular data. Symbiodiniaceae function as symbionts of various marine invertebrates, but are perhaps best known as the key to coral reef ecosystem health and persistence. The team is hosting a virtual workshop in August 2021 to identify and build further consensus among experts regarding the assessment of Symbiodiniaceae **diversity**. By formalizing consensus approaches and disseminating them broadly, this workshop is creating a more collaborative and welcoming research community and ensuring that all current researchers, as well as those entering the field, feel confident applying for grants, conducting research, and publishing papers that incorporate work on Symbiodiniaceae **diversity**. This workshop is defining additional forward-thinking research priorities that anticipate methodological advances over the next 5-10 years.

Resolving the molecular **diversity** of microorganisms is a major technical challenge, particularly for dinoflagellates in the family Symbiodiniaceae. These micro-algal endosymbionts that associate with corals and other marine invertebrates feature massive genomes, high repeat content, and other unique aspects that have hindered their molecular characterization. As sequencing technologies have advanced, so too has our understanding of Symbiodiniaceae **diversity**, which has grown from the presumption of one widespread species in the 1960s to now encompass fifteen divergent genera and likely hundreds of species. This process of discovery has been fraught with controversy, as the most useful phylogenetic marker, the hyperdiverse internal transcribed spacer 2 (ITS2) region, is frustratingly difficult to interpret in a consistent manner. The ribosomal array is multicopy, it evolves at different rates in different lineages, and it is subject to concerted evolution, all of which complicate phylogenetic reconstructions. Moreover, sampled coral tissues contain populations of symbiont cells that can potentially be from multiple Symbiodiniaceae taxa, complicating efforts to characterize partner specificity. Early debates focused on the extent to which unique ITS2 sequences indicated the presence of multiple symbiont species or simply multiple intraspecific variants. This central conflict

has led to different schools of thought about how flexible coral-algal associations can be, and how they might respond to ongoing climate change. next-generation sequencing has provided more data, but the same foundational interpretive issues remain. this team is gathering pioneering symbiodiniaceae experts from around the world (ranging from seasoned veterans to newly-minted phds) who all collectively agree that a consensus interpretive framework can and must be identified and advanced in order to move the field forward. the participants are generating a ?consensus road map? leading to two workshop products: 1. an nsf white paper; and 2. an open-access, peer-reviewed manuscript. through pre-workshop surveys, four workshop sessions, post-workshop collaboration, and publication, the team is summarizing current practices and recommending key methods for identifying and analyzing symbiodiniaceae genetic **\*\*diversity\*\*** across three ?umbrellas?: 1. communities, 2. populations, and 3. strains. the written products from this workshop are being distributed to the wider reef and conservation community by leveraging a separate mini-workshop previously developed for the 2022 international coral reef symposium. workshop participants are also highlighting new technologies and research priorities for the next decade that should help fill some of the remaining knowledge gaps. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Island Population Responses to Environmental Stresses

Awardee: Florida International University

Amount: \$35,000.00

Abstract: large and unpredictable stressors like new diseases are impacting practically all species with increasing frequency and strength. understanding how species respond often relies on studies of genetics. islands are a good place to study such responses because a large fraction of resident species are usually impacted. the covid pandemic has disrupted the ability of many students ? especially those from underrepresented groups -- to get the training and mentoring they need to study genetic responses to stressors. this workshop will help fix that problem by providing students

from puerto rico and southern florida with cutting edge skills for analyzing and interpreting genetic data that they may find challenging. the workshop will help ensure the continued academic progress of participants from stem underrepresented communities by engaging them in research activities that can be undertaken when most laboratory and fieldwork is limited. workshop participants will acquire skills to analyze gene expression data from their independent research projects on response of organisms across the span of biological **\*\*diversity\*\*** to biotic and abiotic stressors. a high degree of ?hands-on? virtual interaction between participants and instructors will be used as a platform. this will be followed with email and chat group communications and coupled with posted recorded sessions and associated supporting instructional materials. results are likely to yield new insights about how organisms adapt to new environmental challenges. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: LTREB Renewal: Long-Term Dynamics of Amphibian Populations Following Disease-Driven Declines

Awardee: University of Tennessee Institute of Agriculture

Amount: \$34,837.00

Abstract: this project will examine the processes of invasion of a novel pathogen into a population for the case of a fungal pathogen that causes the disease chytridiomycosis in frogs and salamanders. outbreaks of emerging infectious diseases are increasingly recognized as major threats, not just to human populations but also to wildlife, and they increasingly threaten global bio**\*\*diversity\*\***. the initial invasion of a novel pathogen into a susceptible host population can cause a disease outbreak resulting in high levels of mortality and declines in population size. when this happens, natural selection can occur for both the host and pathogen populations resulting in evolutionary changes in the host's susceptibility and tolerance to infection by the pathogen and the

pathogen's ability to damage the host (virulence). these changes can in turn determine whether the host population can persist and recover from the disease. understanding these evolutionary processes is crucial in development of conservation strategies for threatened species. chytridiomycosis has had catastrophic effects on amphibians worldwide, and has been linked to numerous species extinctions in recent decades and many more species at risk. the researchers will investigate the patterns of evolutionary change in both the pathogen and the host (mountain yellow-legged frogs), following the invasion of the disease into hundreds of high elevation lakes in the california sierra nevada. this project will contribute to the understanding of the role of infectious diseases, such as chytridiomycosis, as agents of evolutionary change in natural populations. it will provide critical information to state and federal agencies, facilitating endangered species recovery and will train and educate undergraduates, graduate students, and the general public. this research builds on data from a long-term study of the population dynamics of mountain yellow-legged frogs (*rana sierrae* and *rana muscosa*) in the complex landscape of the california sierra nevada, and the affects of *batrachochytrium dendrobatidis* (bd) as it has invaded and spread through hundreds of frog populations. in most cases, invasion of bd results in outbreaks of the disease chytridiomycosis, rapid frog population declines, and local extinctions. in some cases, long-term persistence of frog populations occurs with bd in an enzootic state in which the impact of the pathogen is greatly reduced. the research will extend and leverage 25 years of host population and disease data and archived genetic samples from *r. sierrae*/*r. muscosa* and bd. these resources will provide insight into how populations of both host and pathogen change during the transition from pre-pathogen arrival, to disease outbreak, to enzootic disease, to potential recovery of the pre-disease host population abundances. this dataset will be used to investigate the genetic basis for differences in host resistance/tolerance and pathogen virulence. cutting-edge genomic analysis of existing frog and fungal samples will complement laboratory experiments on bd virulence and frog susceptibility using bd cultures and frog mucosal samples from wild host populations. continued surveys of wild host populations will identify new disease outbreaks and describe the transition from

initial outbreak to persistent enzootic state. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Tackling Functional Protein States at Atomic Detail by Integrating Weighted Ensemble Simulations with Magnetic Resonance Restraints

Awardee: Carnegie-Mellon University

Amount: \$34,334.00

Abstract: this project is designed to characterize the alternate structures of proteins?the workhorses of life whose functions in biology are determined by their structures. a major challenge to characterizing these so-called ?functional structures? is that these structures are often too diverse or fleeting to be captured by experimental techniques at the level of individual atoms. an unmet need is therefore a strategy that can determine the structures of functional protein structures at the atomic level and even more crucially, a strategy that can provide insights into how the functional structures interconvert. this project will develop a new software tool that can determine the functional structures of proteins, how the proteins move to convert from one structure to another, and the rates at which the structures interconvert. this tool combines the use of computer simulations with distances within proteins that are measured by experiments and will be made available through a popular, freely available westpa simulation software package. this interdisciplinary, collaborative project is providing a valuable training ground for graduate and undergraduate students participating in the research, and is supporting diverse educational and outreach activities, including biennial westpa software workshops to provide training to the scientific community in using the new tool for determining the functional structures of proteins. a new frontier in biophysics has been the structural characterization of protein functional states. proteins are the workhorses of life and their functions are determined by their structures. a major challenge to characterizing protein structures is

that many proteins adopt not just a single structural state, but alternate states that are relevant to the biological functions of the proteins. due to the **\*\*diversity\*\*** and often transient nature of such functional states, the determination of their structures at the atomic level has been elusive to experimental techniques. an unmet need is therefore a strategy that can generate atomically detailed structures of functional states, and even more crucially, a strategy that can provide detailed insight into the pathways for interconversion between the states and corresponding kinetics. a key advance of the project is the development of a general strategy that integrates sparse distance restraints from magnetic resonance experiments with rigorous simulations to provide atomic level structures and dynamics of functional protein states. this project will provide a new simulation tool that will be made available to the scientific community through the freely available westpa software. to further enhance the accessibility of the software, the westpa software will be integrated with the orion cloud-computing platform on amazon web services, the world's largest on-demand, cloud-computing facility. this project is funded by the molecular biophysics cluster in the division of molecular and cellular biosciences, with partial co-funding from the chemical measurement and imaging program in the division of chemistry. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Collaborative Research: Towards an Extensible Internet

Awardee: Mount Holyoke College

Amount: \$34,295.00

Abstract: the internet's basic design has remained largely unchanged since it first became commercial in the 1990s. now that the internet is the centerpiece of our global communications infrastructure, it is essentially impossible to alter its design in any significant way. unfortunately, such changes are needed to improve the internet's performance and security. this project aims to resolve

this paradox with a design called the extensible internet. this is a collaborative project which brings together investigators from mount holyoke college, new york university, the university of washington, and international computer science institute at the university of california at berkeley. in today's internet, layer 3 has two basic functions: (i) connect all layer 2 networks and (ii) provide the packet delivery services on which host applications are built. the key aspect of the extensible internet is that it splits layer 3 into two layers. the first, which remains layer 3 and can use the current internet protocol (ip), handles the first function of connecting layer 2 networks. the second requires a new layer (called layer 3.5) that supports an extensible set of packet delivery services, and thus handles the second function of providing the services on which host applications are built. in this way, the extensible internet design leaves the current internet unchanged but is able to provide an extensible set of new packet delivery services that will improve the internet's performance and security. the extensible internet design is incrementally deployable (i.e., no unchanged applications or domains would lose connectivity), compatible with economic incentives, and can continue to evolve as new requirements arise. as such, it provides a practical way for the internet to evolve far beyond its current design. if the extensible internet design is adopted, it would have a significant impact on the nature of the internet. in particular, transitioning to the extensible internet is not just a one-time change in functionality, but transforms the internet from a single and unchanging service model (best-effort packet delivery) to an evolving and expanding set of network-provided services. in addition, in pursuing this agenda, the investigators will work to increase the **diversity** of the stem workforce through ongoing efforts in their own research groups and the outreach programs in their respective departments. the investigators will also incorporate their results into their courses and make the material freely available. all of the code from this project will be available on the project's website at [extensibleinternet.org](http://extensibleinternet.org). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: GP-UP: A near surface geophysics field experience to improve the recruitment and retention of under-represented minority students in the geosciences

Awardee: Dickinson College

Amount: \$32,834.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). undergraduate geoscience education in the united states lags behind other science, technology, engineering and mathematics (stem) fields when it comes to racial and ethnic **\*\*diversity\*\***. this deficit is particularly notable for students who come from communities that have been historically excluded in stem fields and translates to a larger gap in the workforce and at the graduate level. notably, there has been no improvement in the racial and ethnic **\*\*diversity\*\*** of students earning doctoral degrees in the geosciences over the past 40 years. research has shown that **\*\*diversity\*\*** has demonstrated benefits for scientific advancement, including that diverse perspectives provide unique approaches to problem solving; these perspectives are necessary to meet the challenges and to solve the complex problems of the geosciences. to address this gap, the pis have designed a field program: ?geophysics of the near-surface: an outdoor motivational experience for students? this project aims to inspire students to major in the geoscience and help these students develop some of the workplace skills necessary to succeed in geoscience careers. the project will provide an engaging outdoor field experience for the student participants that will influence their choice of major, provide mentorship opportunities for upper-level undergraduates, create positive and lasting student-student and student-faculty mentor relationships, provide meaningful research experiences for the students, and create a strong cohort of students across multiple institutions. the goals of the program are: (1) recruit a diverse cohort of undergraduate students; (2) support student learning in critical zone science and geophysics; (3) increase students? science communication, problem solving, teamwork, and leadership skills; (4) enhance psychosocial factors that are linked to retention in stem fields; (5) increase participation in

geoscience research; (6) increase positive attitudes towards geoscience careers and research; (7) increase mentors? leadership and professional skills. by attaining these goals, the pis propose to build a geoscience learning community of students across the participating institutions and within the broader scientific community and will increase recruitment and retention of these students in geoscience degrees and careers. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: REU Site: Collaborative Research: Research Opportunities in Rock Deformation

Awardee: University of Minnesota-Twin Cities

Amount: \$32,208.00

Abstract: rock deformation, a sub-discipline of earth science, uses geology and engineering methods to measure the strength of rocks. information about rock strength can be applied to a wide range of problems in engineering, natural hazards, and material science, as well as geology. however, very few scientists specialize in the field of rock deformation; thus, many important research questions remain unexplored or underexplored, slowing advances in science and engineering. geoscience departments at primarily undergraduate or primarily minority-serving institutions often do not have active rock deformation research programs and labs that deal with rock deformation are relatively rare. this reu site aims to increase access and exposure of a diverse population of students to career opportunities in this area. the project offers undergraduate students the unique opportunity to conduct summer research at one of eleven state-of-the-art, experimental rock deformation labs across the country. experts in rock deformation will serve as mentors to a cohort of 10 students each summer. this reu site provides access and training, professional and career development activities, and robust workforce development for students from all backgrounds.

the reu site will provide research and mentorship opportunities for undergraduate students in the



field of experimental rock deformation. the long-term objective is to increase the number and **\*\*diversity\*\*** of students pursuing research or industry careers in rock deformation. student participants will receive training in research methods and professional development topics that will provide a stable foundation for graduate school or related career paths. a large team of pis and senior participants ensures that students who participate in the program will have a deep professional network to support their future endeavors. students will be drawn from the full spectrum of higher education institutions. strong emphases will be placed on recruiting students from diverse and under-represented backgrounds, and smaller colleges and universities that do not have research programs in rock deformation. the reu site will include three integrated sessions: a field session to introduce students to the geological study of deformed rocks, a laboratory session where students conduct experiments on specimens collected during the field session, and a conference session where students can present the results of their research projects. the reu site will adopt a distributed model, leveraging the combined lab capacity of the pis and other senior participants to support 10 students per year. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: CAREER: Memory-Efficient, Heterogeneity-Aware and Robust Architecture for Federated Intelligence on Edge Devices

Awardee: George Mason University

Amount: \$31,592.00

Abstract: the recent trend of migrating computation from the centralized cloud to distributed edge devices is reshaping the landscape of today's internet, especially under the unprecedented challenges of the covid19 pandemic. with privacy being a critical concern in data aggregation, federated learning emerges as a promising solution to such privacy-utility challenge. it pushes the computation towards consumer's edge devices, where the data is generated. by exchanging statistical information, the participants perform collaborative learning in a distributed fashion. unfortunately, the original design still faces new system-architectural challenges from limited memory, software/hardware heterogeneity, security and statistical **\*\*diversity\*\*** from different edge devices. the overarching goal of this career project is to design, optimize and implement a memory-efficient, heterogeneity-aware and robust architecture for federated learning on consumer's edge devices. in particular, it aims to: 1) remove the memory barriers of running the computational-intensive learning tasks; 2) resolve the software and hardware heterogeneity among various kinds of devices; 3) secure the information exchange and the machine learning backend. the research will provide a stack of solutions to address the urging needs in realizing collaborative intelligence on edge devices with computation/memory/energy-efficiencies, security and robustness.

this research will address an urgent problem to bridge the gap between the vast data available from consumer's edge devices and the rising interest of utilizing such private data to improve our wellbeing. the algorithms and tools developed in this career project will lay the foundations to a plethora of new applications on massively distributed edge devices, as the essential elements for building a smart, connected and resilient community. the career program will advance stem education by developing new educational components related to machine learning, edge computing

and security. this includes diverse outreach plans of cybersecurity summer camps, junior research symposium, high school instructor mentorship, coding competitions and the inclusion of underrepresented minority and women engineers. the potential use cases will be also explored with the collaborating industrial partners to enrich their business models. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: CAREER: Memory-Efficient, Heterogeneity-Aware and Robust Architecture for Federated Intelligence on Edge Devices

Awardee: George Mason University

Amount: \$31,592.00

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Matched Words: diversity

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Title: Doctoral Dissertation Research: The effects of forest habitat modification on hunting and prey abundance

Awardee: Ohio State University

Amount: \$31,500.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). the world's rainforest ecosystems are hotspots of global bio\*\*diversity\*\* and have extensive histories of occupation by indigenous peoples as locations for customary agriculture and subsistence foraging and hunting. with these reservoirs of bio\*\*diversity\*\* now showing signs of decline, we require a better understanding of how human-influenced forests can both support indigenous livelihoods and sustain diverse floral and faunal communities. while human use and modification of rainforests has historically been thought of as a potential driver of species loss,

recent research suggests that forest mosaics created by human activities harbor a substantial degree of habitat **diversity** and novel foraging opportunities that may benefit animal and plant communities. the purpose of this doctoral dissertation project is to study the relationship between customary agricultural practices and subsistence hunting to understand how these practices impact local faunal and floral **diversity** in a neotropical rainforest. in addition to training a doctoral student in anthropological science, the research helps local stakeholders manage natural resources and generalize these insights so they can be used to develop management designs that incorporate local practices to prevent wildlife loss. the central research question of this dissertation project is whether the human-influenced forests that are created by customary agriculture can support populations of wild game and enable sustainable harvests of wild game by subsistence hunters. the researchers test whether and how human disturbance precludes or facilitates resource conservation. integrating theory and methods from human behavioral ecology, wildlife management, and community ecology, this research documents hunter movements and harvest returns and links them to patterns of wildlife abundance along a disturbance gradient created by customary agricultural practices. the researchers use semi-structured interviews and participant observation to ethnographically contextualize the social and ecological dimensions of customary agriculture and subsistence hunting. by studying how humans and wildlife select and use habitat in a mosaic of cultivated, secondary, and climax forest, this study contributes theoretical insights about the mechanisms for sustainable harvest of wild game species and the coexistence of ecological communities with human communities. rather than study hunting and farming as distinct forms of human-environment relations, this study conceptualizes these practices as key parts of an integrated socioecological system. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Collaborative Research: Towards an Extensible Internet

Awardee: New York University

Amount: \$30,067.00

Abstract: the internet's basic design has remained largely unchanged since it first became commercial in the 1990s. now that the internet is the centerpiece of our global communications infrastructure, it is essentially impossible to alter its design in any significant way. unfortunately, such changes are needed to improve the internet's performance and security. this project aims to resolve this paradox with a design called the extensible internet. this is a collaborative project which brings together investigators from mount holyoke college, new york university, the university of washington, and international computer science institute at the university of california at berkeley. in today's internet, layer 3 has two basic functions: (i) connect all layer 2 networks and (ii) provide the packet delivery services on which host applications are built. the key aspect of the extensible internet is that it splits layer 3 into two layers. the first, which remains layer 3 and can use the current internet protocol (ip), handles the first function of connecting layer 2 networks. the second requires a new layer (called layer 3.5) that supports an extensible set of packet delivery services, and thus handles the second function of providing the services on which host applications are built. in this way, the extensible internet design leaves the current internet unchanged but is able to provide an extensible set of new packet delivery services that will improve the internet's performance and security. the extensible internet design is incrementally deployable (i.e., no unchanged applications or domains would lose connectivity), compatible with economic incentives, and can continue to evolve as new requirements arise. as such, it provides a practical way for the internet to evolve far beyond its current design. if the extensible internet design is adopted, it would have a significant impact on the nature of the internet. in particular, transitioning to the extensible internet is not just a one-time change in functionality, but transforms the internet from a single and unchanging service model (best-effort packet delivery) to an evolving and expanding set of network-provided services. in addition, in pursuing this agenda, the investigators will work to increase the **diversity** of the stem

workforce through ongoing efforts in their own research groups and the outreach programs in their respective departments. the investigators will also incorporate their results into their courses and make the material freely available. all of the code from this project will be available on the project's website at [extensibleinternet.org](http://extensibleinternet.org). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Conference on Homological Commutative Algebra and Related Topics

Awardee: Georgia Southern University Research and Service Foundation, Inc

Amount: \$30,000.00

Abstract: this award funds the research conference "homological commutative algebra and related topics and their applications." this international conference will be held at georgia southern university's armstrong campus in savannah, georgia during may 13-15, 2022. the main goal of the meeting is to bring together a diverse group of researchers from a mixture of fields, and in different stages of their careers, in a forum where they will be able to exchange and build on their mathematical ideas and work. in particular, the conference will highlight the recent results and developments in homological commutative algebra and will further connect with several fields of mathematics, including combinatorics, geometry, number theory, and others. the event will include established and early-career mathematicians, as well as post-doctoral fellows and students, allowing collaborations, networking, and professional development between these different groups. special care will be taken to ensure participation from women and researchers in underrepresented groups to enhance and promote **\*\*diversity\*\*** and inclusion in the mathematical sciences. the expected outcome is to support and promote these mathematical topics for students and researchers in the southeastern region and beyond. homological algebra originated from algebraic topology as a tool used in the commutative algebra localization conjecture of regular local rings. subsequently,



homological algebra has become a major subdiscipline of commutative algebra. the conference activities will address many connections between homological commutative algebra and other mathematical disciplines. specifically, the event includes discussions on fundamental problems in commutative algebra, algebraic geometry, algebraic number theory, representation theory, combinatorics, deformation theory, category theory, rational homotopy theory, and other related areas. it will follow a typical format with research talks in conjunction with collaboration opportunities, and it will feature a mix of 50-minute research talks given by established mathematicians and 25-minute presentations from early-career researchers. for more information, see [the conference webpage](https://sites.google.com/georgiasouthern.edu/commutative-algebra-conference/home) <https://sites.google.com/georgiasouthern.edu/commutative-algebra-conference/home> this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Enhancing Diversity in Graduate Education: Research Results from More than Twenty Years of Empowering Women in Mathematics

Awardee: University of Wisconsin-Eau Claire

Amount: \$30,000.00

Abstract: this award supports participation of graduate students, postdoctoral researchers, and early-career faculty in the session titled "the edge (enhancing **diversity** in graduate education)

program: pure and applied talks by women math warriors? at the 2022 and 2023 joint mathematics meetings (jmm). the 2022 jmm session will be held in seattle, washington and the 2023 jmm session will be held in boston, massachusetts. the edge program was founded in 1998 to improve retention and completion rates for women and minorities in graduate programs and increase **\*\*diversity\*\*** in the mathematics community. the 2022 and 2023 sessions will showcase the research of women who are affiliated with the edge program. the session provides a platform for women in all areas of mathematics to present their research findings and generate ideas for new research techniques and directions. opportunities to strengthen participants' network of women mathematicians and establish new mentoring relationships with other women affiliated with the edge program are provided. the session benefits the larger mathematics community by increasing the visibility of women in mathematics by highlighting their research work, thereby creating opportunities for recruitment and retention of women in mathematics. further information about the edge program can be found at the link below. [www.edgeforwomen.org](http://www.edgeforwomen.org) this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Mass transport in Mass transport in the Jupiter magnetosphere: driven by internal # or external processes?

Awardee: University of Colorado at Boulder

Amount: \$30,000.00

Abstract: the sun emits a stream of particles called the solar wind. the solar system presents a wide variety of obstacles to the solar wind in the form of planetary magnetospheres. magnetospheres arise from the internal magnetic field of a planet and serve to deflect the solar wind from the surface of the planet. mass from the solar wind hits the magnetosphere and is diffused toward the poles and then carried out behind the planet in a structure called the magnetotail. io is a moon of jupiter that

also provides particles to its magnetosphere from within, and so it can be used to trace the flow of particles from within the magnetosphere. this project will use observations of sulfur and sodium ions to trace out the diffusion of particles from within jupiter's magnetosphere to better understand the process of diffusion in magnetospheres. the project will use a dedicated telescope for their observations. the project will also create a children's book, 'the misfit telescope' with a companion website and social media stream that use the benefits of \*\*diversity\*\* in scientific instrumentation as a parable to illustrate the benefits of racial and cultural inclusivity. the proposed project will study the io plasma torus (ipt) around jupiter in order to gain insight into the jovian magnetic field. the project will use the io input/output observatory to make time domain observations of s ii and na lines in the ipt to determine the nature of diffusion of material. ioio is a small-aperture robotic coronagraph that operates nightly, contemporaneously recording narrow-band images of the ipt ins s ii. combined with a model of the ipt, the observations will show whether diffusion is driven by mass loading from io or by activity in the middle jovian magnetic field. the project's children's book will show the value of both being in the minority and havingg a different point of view and of being in the majority and accepting and respecting the minority point of view. the book will be produced by the planetary science institute's award winning public outreach team. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Doctoral Dissertation Research: Paleontological and population genetics approaches for reconstructing hominin evolutionary history

Awardee: Washington University

Amount: \$28,998.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). this doctoral dissertation project reconstructs evolutionary relationships among

ancient populations of homo erectus, a pivotal human ancestor, using dental and skeletal data. the project integrates paleontological and population genetics approaches for reconstructing evolutionary history, thereby advancing knowledge about how hominins, including our species, homo sapiens, evolved. the project promotes interdisciplinarity by using approaches typically used in the field of bioarchaeology, increases **\*\*diversity\*\*** in the field of paleoanthropology by supporting the scholarship of a female paleoanthropologist, and fosters international research collaborations. the investigator conducts public and k-12 science outreach through a weblog about human evolution and through science activities with middle and high school students. homo erectus, represented in the hominin fossil record, is morphologically diverse through both time and space. the current understanding of how populations of h. erectus were related to each other is limited. bony and dental anatomy provide the primary basis for assessing evolutionary relationships between populations in the fossil record, but the genetic basis of anatomical traits is not always well understood. this research examines h. erectus temporal and geographic patterns in the relationships among past h. erectus populations using biodistance methods and comparative data. matrices of dental and neurocranial shape distances will be compared separately using mantel tests to a matrix describing the temporal, geographic, or genetic distances between populations. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Collaborative Research: Building consensus around the quantification and interpretation of Symbiodiniaceae diversity

Awardee: University of South Florida

Amount: \$28,222.00

Abstract: single-celled microorganisms are highly diverse and play various roles in the function of natural ecosystems, but it is challenging to recognize how genetic, morphological, and physiological

**\*\*diversity\*\*** relate to each other in microbial groups. in an exemplary case, micro-algae in the family symbiodiniaceae comprise many species that can only be distinguished using molecular data. symbiodiniaceae function as symbionts of various marine invertebrates, but are perhaps best known as the key to coral reef ecosystem health and persistence. the team is hosting a virtual workshop in august 2021 to identify and build further consensus among experts regarding the assessment of symbiodiniaceae **\*\*diversity\*\***. by formalizing consensus approaches and disseminating them broadly, this workshop is creating a more collaborative and welcoming research community and ensuring that all current researchers, as well as those entering the field, feel confident applying for grants, conducting research, and publishing papers that incorporate work on symbiodiniaceae **\*\*diversity\*\***. this workshop is defining additional forward-thinking research priorities that anticipate methodological advances over the next 5-10 years. resolving the molecular **\*\*diversity\*\*** of microorganisms is a major technical challenge, particularly for dinoflagellates in the family symbiodiniaceae. these micro-algal endosymbionts that associate with corals and other marine invertebrates feature massive genomes, high repeat content, and other unique aspects that have hindered their molecular characterization. as sequencing technologies have advanced, so too has our understanding of symbiodiniaceae **\*\*diversity\*\***, which has grown from the presumption of one widespread species in the 1960s to now encompass fifteen divergent genera and likely hundreds of species. this process of discovery has been fraught with controversy, as the most useful phylogenetic marker?the hyperdiverse internal transcribed spacer 2 (its2) region?is frustratingly difficult to interpret in a consistent manner. the ribosomal array is multicopy, it evolves at different rates in different lineages, and it is subject to concerted evolution, all of which complicate phylogenetic reconstructions. moreover, sampled coral tissues contain populations of symbiont cells that can potentially be from multiple symbiodiniaceae taxa, complicating efforts to characterize partner specificity. early debates focused on the extent to which unique its2 sequences indicated the presence of multiple symbiont species or simply multiple intraspecific variants. this central conflict has led to different schools of thought about how flexible coral-algal associations can be, and how

they might respond to ongoing climate change. next-generation sequencing has provided more data, but the same foundational interpretive issues remain. this team is gathering pioneering symbiodiniaceae experts from around the world (ranging from seasoned veterans to newly-minted phds) who all collectively agree that a consensus interpretive framework can and must be identified and advanced in order to move the field forward. the participants are generating a ?consensus road map? leading to two workshop products: 1. an nsf white paper; and 2. an open-access, peer-reviewed manuscript. through pre-workshop surveys, four workshop sessions, post-workshop collaboration, and publication, the team is summarizing current practices and recommending key methods for identifying and analyzing symbiodiniaceae genetic **\*\*diversity\*\*** across three ?umbrellas?: 1. communities, 2. populations, and 3. strains. the written products from this workshop are being distributed to the wider reef and conservation community by leveraging a separate mini-workshop previously developed for the 2022 international coral reef symposium. workshop participants are also highlighting new technologies and research priorities for the next decade that should help fill some of the remaining knowledge gaps. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Doctoral Dissertation Research: Variation in Island Adaptations

Awardee: Texas A&M University

Amount: \$25,205.00

Abstract: this project will investigate the origins and development of island subsistence-based economies. in this dissertation proposal a case study is presented in which two atlantic islands were likely colonized multiple times by more than one cultural group. the islands also have varying environmental characteristics and human subsistence adaptations. the archaeological study of ancient islanders reveals novel information regarding the many ways in which humans adapt and prosper, as islands present often limited, marginal, and vulnerable landscapes. research on one island shows the arrival of iron age peoples who brought with them grains, herding animals, and

other cultural elements. in addition, recent excavations on the other revealed a roman factory where marine gastropods, stramonita haemastoma, were exploited for commercial purposes to obtain the highly prized royal purple dye. these findings may suggest that the human settlement occurred due to the expansion of ancient seafaring trading networks with the intent to exploit coastal natural resources. archaeology confirms the islands to have been a nexus of cultural exchange and **\*\*diversity\*\***. evidence from ancient material culture, linguistics, and genetics suggest the presence of a heterogenous sociopolitical and economic landscape in the archipelago; however, there is little scholarly consensus as to who exactly peopled the islands and why. a major obstacle to answering these questions is the deficit of reliable chronologies for the entire region ? a problem that will be tackled in this current research by developing a series of radiocarbon chronologies. the project will use stable isotope ratios of carbon, nitrogen, oxygen, and strontium coupled with ancient dna markers from archaeological human remains to better understand local adaptive strategies, social organization, and landscape management methods. the research will address unresolved questions such as the role of coastal resources in the aboriginal economies. through exploring diet and mobility, researchers will deepen into the issue of understanding aboriginal modes of production within such culturally diverse island communities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Professional Experiences for Students in Plasma Science: Student Travel Support for 2021 and 2022 Gaseous Electronics Conferences

Awardee: University of Alabama in Huntsville

Amount: \$25,000.00

Abstract: this award will support student participation in the 74th annual gaseous electronics conference (gec) to be held october 4 - 8, 2021 in huntsville, alabama and the 75th gec to be held in

late 2022 in sendai, japan. the gec has a three quarter century history in pursuit of the foundational physical and chemical processes occurring in partially ionized, collisional plasmas, encompassing the interactions between atoms, molecules, charged particles, photons, waves, and fields. the gec has a strong tradition of encouraging and promoting student participation. the attendance at research conferences is an important educational experience for students that cannot be replicated at their home institutions. the gec provides opportunities for students to expand their networks both domestically and internationally, to learn about the most cutting edge research and discoveries, and to develop their professional communication skills. the gec is a conference that welcomes student participation and introduces them to the global professional community where they can envision themselves developing their careers. the gec program is organized with breaks mid-morning and mid-afternoon, as a way of facilitating conversation among participants. at the 2021 and 2022 gec, intentional steps are being taken to create a more inclusive conference atmosphere for those from groups not well represented at the conference. these steps include a reconsideration of the gec experience to add a commitment to **\*\*diversity\*\*** and inclusivity to its reputation as a premier venue for gaseous electronics and plasma research. although demographic changes in research communities have slower time constants than might be desirable, the student participation enabled by this award has the potential for long term impact on the **\*\*diversity\*\*** of the future gec community. this approach includes introduction of several tested professional development and social events intended to appeal to early career attendees such as student research competition, including students from underrepresented groups. questions added to the post-conference survey will help to assess need for, interest in and effectiveness of the added events, and responses will be used to guide planning for subsequent future conferences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Doctoral Dissertation Research in Economics: The Effects of Gender and Racial Stereotypes on Math Confidence, Effort, and Achievement

Awardee: National Bureau of Economic Research Inc

Amount: \$24,984.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). there are large, persistent gender and race gaps in stem participation and achievement, as well as persistent academic stereotypes about race and gender. this project seeks to understand the effects of providing information to elementary and middle school students to counteract the negative stereotypes and social norms surrounding the participation and achievement of under-represented groups in stem ? particularly the effects of this information on students? confidence, stem engagement, and achievement. while research show that stereotypes about ability matter for adults? confidence and participation in stem, these stereotypes emerge at much younger ages. this study will evaluate the impacts of intervening against these negative stereotypes early in students? educational trajectory, which may be more effective and more long-lasting than intervening with adults. in addition to increasing **\*\*diversity\*\*** in stem and encouraging more equal opportunities for all students, closing the gender and race gaps in stem engagement is expected to improve productivity and innovation in the sector and reduce wage gaps, since more than 90 percent of stem occupations offer wages above the national average. closing gaps in stem participation is thus a top priority for the us government as well as business leaders and professional organizations in stem fields. the results of this research could guide policies to close the racial and gender stem gaps and thus increase the supply of stem workforce. this will increase economic growth, decrease poverty as well as decrease income inequality in the us. this study will provide the first experimental evidence on the role of stereotypes in creating gaps in stem achievement. it will also provide novel evidence on the mechanisms through which stereotypes cause these effects; specifically, the effects of stereotypes on confidence, engagement with and responsiveness to feedback, and effort. this research uses a randomized intervention ? a series of

videos and exercises that provide information to counteract prevailing negative academic stereotypes ? delivered to students on a leading online learning platform to study these issues. student behavior on the platform will provide high-frequency measures of student effort, learning strategies, and engagement with feedback. additional outcomes will be measured in a survey, also integrated into the platform, which will provide psychometric and revealed-preference measures of math interest, confidence, and endorsement of stereotypes. finally, student achievement will be measured using standardized test scores. differences in outcomes between treated and control students will deliver the effect of the intervention, and the large set of considered outcomes will be used to test various mechanisms that explain the effect of race and gender stereotypes on math achievement. the results of this research could guide policies to close the racial and gender stem gaps and thus increase the supply of stem workforce. this will increase economic growth, decrease poverty as well as decrease income inequality in the us. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Does genomic recombination stabilize populations and enhance ecosystems?

Awardee: Nadeau, Christopher Paul

Amount: \$24,800.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. ecosystems provide invaluable services to humans such as maintaining water quality and reducing coastal flooding effects. a key rule of life is that ecosystems with more species often provide better and more consistent services. the same rule might also apply

within species, where populations with a higher **diversity** of individuals ? that is higher genetic **diversity** ? are more stable and provide better ecosystem services. if this is true, managing communities of species to maintain high genetic **diversity** could provide significant benefits to humans. however, within a single species, sexual reproduction alters genetic **diversity** over time by producing offspring with new combinations of genes (a result of recombination). this project asks whether this circumstance breaks down the aforementioned rule of life by disrupting optimal states of genetic **diversity**. by answering this question, new insights will be made about how to appropriately manage genetic **diversity** across geographic regions that encompass multiple levels of biological organization. the fellow will provide outreach activities associated with this work by involving members of underrepresented groups in research and training activities. this project will address how recombination at the intraspecific level alters predictions from interspecific theory, and therefore contributes to a cross-scale synthesis in biology. specifically, interspecific theory predicts that communities with a mix of highly diverged species will have higher stability and function. recombination at the intraspecific level could change this prediction because it can produce offspring with low fitness and thereby reduce stability and function (outbreeding-depression hypothesis). conversely, recombination between highly diverged genotypes could increase genotypic **diversity** among offspring and thus increase stability and function (increased-**diversity** hypothesis). the fellow will use genomics, lab-based breeding experiments, and field-based mesocosm experiments in a model system - daphnia magna - to test how divergence and recombination interact to alter population stability and function. the fellow will learn, apply, and advance genomic techniques for measuring the various forms of genetic divergence within species. the fellow will also produce a guide to genetic management for conservation practitioners, provide training and research exposure to two technicians from underrepresented communities in biology, and continue outreach to k-12 educators. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: NSF Postdoctoral Fellowship in Biology FY 2021: Does genomic recombination stabilize populations and enhance ecosystems?

Awardee: Nadeau, Christopher Paul

Amount: \$24,800.00

Abstract: this action funds an nsf postdoctoral research fellowship in biology for fy 2021, integrative research investigating the rules of life governing interactions between genomes, environment and phenotypes. the fellowship supports research and training of the fellow that will contribute to the area of rules of life in innovative ways. ecosystems provide invaluable services to humans such as maintaining water quality and reducing coastal flooding effects. a key rule of life is that ecosystems with more species often provide better and more consistent services. the same rule might also apply within species, where populations with a higher **\*\*diversity\*\*** of individuals ? that is higher genetic **\*\*diversity\*\*** ? are more stable and provide better ecosystem services. if this is true, managing communities of species to maintain high genetic **\*\*diversity\*\*** could provide significant benefits to humans. however, within a single species, sexual reproduction alters genetic **\*\*diversity\*\*** over time by producing offspring with new combinations of genes (a result of recombination). this project asks whether this circumstance breaks down the aforementioned rule of life by disrupting optimal states of genetic **\*\*diversity\*\***. by answering this question, new insights will be made about how to appropriately manage genetic **\*\*diversity\*\*** across geographic regions that encompass multiple levels of biological organization. the fellow will provide outreach activities associated with this work by involving members of underrepresented groups in research and training activities. this project will address how recombination at the intraspecific level alters predictions from interspecific theory, and therefore contributes to a cross-scale synthesis in biology. specifically, interspecific theory predicts that communities with a mix of highly diverged species will have higher stability and function. recombination at the intraspecific level could change this prediction because it can produce



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Matched Words: diversity

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Title: Workshop: Halo-DaSH: The Deep and Shallow History of Aquatic Life's Passages between Marine and Freshwater Habitats

Awardee: University of Connecticut

Amount: \$24,365.00

Abstract: this award supports a symposium and workshop, the goal of which is to highlight how biological exchanges between salty and freshwater habitats have transformed the biosphere. life in the ocean and in freshwater habitats have long been intertwined. major branches of the tree of life originated in the oceans and colonized fresh waters, often adapting to the new regime and diversifying. similar exchanges continue to this day, including some species that continually migrate between salty and fresh waters. scientists who study these processes typically focus on a single group of living organisms, or on the fossil record that documents ancient colonizations. the purpose of the activities supported by this grant is to stimulate new research on the history of life and

present-day stresses to aquatic systems. planned activities will consist of a day-long symposium during the 2022 annual meeting of the society for integrative and comparative biology, and a one-day workshop designed to facilitate innovative thinking and the involvement of scientists who are diverse in disciplinary orientation, country of origin, and stage of professional development. these interactions will yield products including manuscripts that synthesize research findings across disciplines and grant proposals for new research on gaps in knowledge that have been highlighted by the workshop collaborations. because global conditions such as sea level that shaped ancient exchanges are currently changing at a rapid rate due to intensifying human impacts, the results of the symposium and workshop should help scientists understand emerging threats to bio\*\*diversity\*\* related to changes in aquatic habitat solute concentration and global climate change. the symposium and workshop will address several questions about how biotic exchange between salty and fresh habitats has transformed the biosphere: when did major colonizations of fresh waters happen? what circumstances facilitated the transition? how frequent have been returns to marine habitats? how porous is the boundary: is change in halohabitat routine, requiring few modifications, or does it rarely occur because it requires special conditions and substantial genomic alterations? what adaptive changes occurred to accommodate the physiochemical and ecological differences? how do marine and freshwater lineages differ in organism-level features, ecological relationships, evolutionary processes? to what extent has diversification been propelled by the transitions? what differences in ecosystem services arise from these transformations? in what ways are the freshwater and marine forms subject to different anthropogenic stressors? the symposium, workshop, and resulting products will integrate findings at multiple levels of biological organization and from disparate fields, and use this science to better understand responses to global change in each realm. the transdisciplinary approach will allow participants to establish new collaborations and address questions that cross disciplinary boundaries, thereby stimulating new research to fill identified gaps in knowledge. diverse scientists from a broad range of disciplines, including graduate students and individuals from groups under-represented in science, will participate, and results will

be disseminated in journal articles, white papers, and via a project website, twitter account and instagram feed. the resulting collaborations will enhance interactions across biological and geoscience disciplines and will impact interdisciplinary curricula for undergraduate and graduate students. this award is co-funded by the physiological mechanisms and biomechanics program in the division of integrative organismal systems, directorate for biological sciences, and the sedimentary geology and paleobiology program in the division of earth sciences, directorate for geosciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Workshop: Halo-DaSH: The Deep and Shallow History of Aquatic Life's Passages between Marine and Freshwater Habitats

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these interactions will yield products including manuscripts that synthesize research findings across disciplines and grant proposals for new research on gaps in knowledge that have been highlighted by the workshop collaborations. because global conditions such as sea level that shaped ancient exchanges are currently changing at a rapid rate due to intensifying human impacts, the results of the symposium and workshop should help scientists understand emerging threats to bio\*\*diversity\*\* related to changes in aquatic habitat solute concentration and global climate change. the symposium and workshop will address several questions about how biotic exchange between salty and fresh habitats has transformed the biosphere: when did major colonizations of fresh waters happen? what circumstances facilitated the transition? how frequent have been returns to marine habitats? how porous is the boundary: is change in halohabitat routine, requiring few modifications, or does it rarely occur because it requires special conditions and substantial genomic alterations? what adaptive changes occurred to accommodate the physiochemical and ecological differences? how do marine and freshwater lineages differ in organism-level features, ecological relationships, evolutionary processes? to what extent has diversification been propelled by the transitions? what differences in ecosystem services arise from these transformations? in what ways are the freshwater and marine forms subject to different anthropogenic stressors? the symposium, workshop, and resulting products will integrate findings at multiple levels of biological organization and from disparate fields, and use this science to better understand responses to global change in each realm. the transdisciplinary approach will allow participants to establish new collaborations and address questions that cross disciplinary boundaries, thereby stimulating new research to fill identified gaps in knowledge. diverse scientists from a broad range of disciplines, including graduate students and individuals from groups under-represented in science, will participate, and results will be disseminated in journal articles, white papers, and via a project website, twitter account and instagram feed. the resulting collaborations will enhance interactions across biological and geoscience disciplines and will impact interdisciplinary curricula for undergraduate and graduate students. this award is co-funded by the physiological mechanisms and biomechanics program in

the division of integrative organismal systems, directorate for biological sciences, and the sedimentary geology and paleobiology program in the division of earth sciences, directorate for geosciences. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Collaborative Research: Enhancing Asian American and Pacific Islander Participation and Belonging in the Geosciences

Awardee: Pennsylvania State Univ University Park

Amount: \$23,695.00

Abstract: asian americans and pacific islanders (aapi) represent one of the fastest growing demographics in the u.s. today and yet lag in participation and representation in geoscience graduate programs compared to other stem fields. thus, new programs are needed that specifically recruit aapi stem undergraduates to geoscience graduate programs and enhance belonging of aapi geoscientists as a whole. the proposed activities will focus on minority serving institutions (msis) that serve aapi. this project will expose as many as 1,000 undergraduates from msis in geoscience-adjacent stem fields to geoscience research and careers, provide a new research internship opportunity and create national cross-career stage connections between aapi geoscientists to produce a cohort of geoscience leaders from a group often left out of \*\*diversity\*\* discussions. aapi scientists desire to relate their work to local populations and problems relevant to their communities; therefore, diversifying geoscience graduate programs with those identifying as aapi will have a direct impact on communities facing important geoscience problems of the 21st century such as climate change, natural hazards, and resource scarcity. this project supports pilot programs to enhance participation and belonging for asian american and pacific islander (aapi) communities in geosciences. the proposed activities include: 1) establishing a researcher visit program to recruit undergraduate aapi into geosciences via visits to aapi-serving msis from

geoscience researchers; 2) a pilot research internship program for undergraduates at these institutions to carry out research with aapi mentors; 3) organizing virtual and in-person events and a career development workshop to enhance belonging, identity, and leadership within the aapi geoscience community across career stages and sectors. the outcomes of this combination of the proposed activities will help to develop geoscience programs, and create a cohort and community of belonging, access, justice, equity, **\*\*diversity\*\***, and inclusion (bajedi) leaders of aapi geoscientists. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: The Role of Marketplaces in the Development of Complex Society

Awardee: Humboldt State University Foundation

Amount: \$22,007.00

Abstract: this multidisciplinary pilot project identifies prehispanic marketplaces and establishes a set of marketplace indicators that can be applied elsewhere in the world. in the process, the project works with students to train a new generation of archaeologists currently underrepresented in the field. the objectives address a research gap that impedes archaeology's contributions to economic theory. pre-modern markets offer particular promise for adding **\*\*diversity\*\*** to economic ideas. isolated from global capitalist forces, these markets allow researchers to re-examine foundational concepts ? such as money, credit, debt, and investment ? in non-western contexts, expanding understanding of how culture influences economic behavior. for both theoretical and methodological reasons, however, archaeologists have only recently begun to establish the undisputed existence of pre-modern markets. previously prevailing western theories created a false dichotomy between past and present economies and suggested that market exchange ? the transfer of alienable goods and services between strangers ? could not exist outside of capitalism. while recent research has challenged these theories, archaeologists still lack sound methods for investigating the physical

manifestations of markets, market systems and marketplaces, which are often ephemeral, barely leaving a material imprint. few archaeological projects worldwide have even tried to identify marketplaces, and their locations remain an important missing component in pre-modern market research. to help fill this gap, eight independent research programs are cooperatively investigating a possible prehispanic regional market system by identifying marketplace locations. economic investigations in the region have lagged due to several factors, including a historical mischaracterization of the past society which had been conceived as less complex than those of other neighboring groups. researchers now however have begun to search for marketplaces as a sign of economic complexity. while marketplace investigations across archaeological sites have already had some success, varying metrics have hindered the research. additionally, the dense vegetation covering sites makes it difficult to employ conventional approaches such as examining item distributions, which rely on surface collections. to ensure comparable results, collaborators on this project are examining marketplace indicators by using a cross-cultural set of marketplace indicators that depend on a combination of approaches from archaeology, botany, soil science, and physics. researchers are analyzing both old and new data according to common protocols to produce joint results that address the central research hypothesis: an integrated system of large and small markets existed in the region, allowing access to similar goods for households within it. these results will further establish precedents for future research in terms of both methodology and cross-program cooperation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Collaborative Research: Towards an Extensible Internet

Awardee: University of Washington

Amount: \$21,566.00

Abstract: the internet's basic design has remained largely unchanged since it first became commercial in the 1990s. now that the internet is the centerpiece of our global communications infrastructure, it is essentially impossible to alter its design in any significant way. unfortunately, such changes are needed to improve the internet's performance and security. this project aims to resolve this paradox with a design called the extensible internet. this is a collaborative project which brings together investigators from mount holyoke college, new york university, the university of washington, and international computer science institute at the university of california at berkeley. in today's internet, layer 3 has two basic functions: (i) connect all layer 2 networks and (ii) provide the packet delivery services on which host applications are built. the key aspect of the extensible internet is that it splits layer 3 into two layers. the first, which remains layer 3 and can use the current internet protocol (ip), handles the first function of connecting layer 2 networks. the second requires a new layer (called layer 3.5) that supports an extensible set of packet delivery services, and thus handles the second function of providing the services on which host applications are built. in this way, the extensible internet design leaves the current internet unchanged but is able to provide an extensible set of new packet delivery services that will improve the internet's performance and security. the extensible internet design is incrementally deployable (i.e., no unchanged applications or domains would lose connectivity), compatible with economic incentives, and can continue to evolve as new requirements arise. as such, it provides a practical way for the internet to evolve far beyond its current design. if the extensible internet design is adopted, it would have a significant impact on the nature of the internet. in particular, transitioning to the extensible internet is not just a one-time change in functionality, but transforms the internet from a single and unchanging service model (best-effort packet delivery) to an evolving and expanding set of network-provided services. in addition, in pursuing this agenda, the investigators will work to increase the **diversity** of the stem workforce through ongoing efforts in their own research groups and the outreach programs in their respective departments. the investigators will also incorporate their results into their courses and make the material freely available. all of the code from this project will be available on the



project's website at [extensibleinternet.org](http://extensibleinternet.org). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: IRES Track II: Rivers of the Andes Field Training

Awardee: University of Colorado at Boulder

Amount: \$21,094.00

Abstract: this project will train students in interdisciplinary, international river sciences and prepare them for the stem workforce, for their research, and for applying river science toward developing sustainable solutions to the human-induced stresses on rivers in the andes and globally. the proposed 12-day advanced studies institute will immerse 14 us-based graduate students in innovative field training in hydrology, geomorphology, and ecology for, in each of two years. working in the magdalena river basin, colombia, students will learn cutting-edge field, remote sensing, and computational tools, develop critical and systems thinking, and complete team-based research projects. students will work with instructors from university of montana, university of colorado, and colombia, taking advantage of long-term research sites in the magdalena river basin and broad expertise. the rivers of the andes field training course will recruit a diverse group of students that broadens participation in sciences, and course materials and lessons learned will be shared openly and widely. river systems are under stress from climate change and growing demands for water, energy, and food. there is a strong disconnect, however, between where research and teaching about fluvial processes is concentrated, and where stresses on river systems such as new dam construction and associated impacts on humans and bio\*\*diversity\*\* are more recently evolving, such as in the andes. moreover, innovative and interdisciplinary approaches are needed to address challenges such as those surrounding river systems and to prepare students for the 21st century workforce. to address these challenges, we propose rivers of the andes field training (raft), a course

to be taught in colombia that will provide field-based training in river sciences. course content will focus on hydrology and fluvial geomorphology, especially river mechanics, floods, and sediment regimes, and complementary content in tropical fish ecology and basin-scale, cumulative-impact and decision-support analysis. raft will use the magdalena river and its tributaries as a field site to illustrate broader content about river processes and andean rivers. the course will augment field training with classroom teaching about fluvial processes and observational, measurement and modeling approaches for understanding river processes. raft will provide a transformative experience for graduate student participants by combining innovative approaches and technologies with evidence-based best practices to not only advance knowledge of river sciences and associated tools, but also to promote critical and systems thinking and observational, interdisciplinary, and teamwork skills. raft will include international and multicultural experience, interdisciplinary teaching on cutting-edge process knowledge and tools, training in cross-scale and systems thinking, team-based projects, and practice in science communication. participants will be equipped to tackle wicked problems at the nexus of water, energy, and food systems and to apply science toward sustainable solutions to the challenges surrounding rivers in the andes and in the anthropocene. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: 2021 NSF Student Poster Competition at the ASME International Mechanical Engineering Congress and Exposition (ASME-IMECE); Virtual; November 1-5, 2021

Awardee: University of Arkansas

Amount: \$19,900.00

Abstract: the objective of this researched effort is to provide support for 100 students who are currently working with principal investigators through nsf funding from the directorate for engineering (eng) or research experiences for undergraduates (reu) programs to attend the 2021 asme

international mechanical engineering congress and exposition (asme-imece) virtually and participate in a student poster competition. the awardees will be selected based on application including a brief resume, a one-page statement of why they want to attend the conference, and a statement of support from their faculty advisor. consideration in the selection process will be given to inclusion of members of underrepresented groups, **\*\*diversity\*\*** of institutions that the students represent, and **\*\*diversity\*\*** of programs within engineering. the competition is divided into the topics of (1) nsf-funded research grants/programs and (2) research experience for undergraduates (reus). this award will benefit the nation through the education of a skilled and diverse engineering workforce better prepared to provide transformative solutions the challenges of their chosen fields. this participation support is expected to benefit students' professional, scientific and technical development as they present their nsf funded research projects to the broad mechanical engineering community. attendance at the conference will provide the students a wonderful opportunity to learn about the engineering profession and state-of-the-art research in their fields via access to technical and professional development talks by domestic and international speakers. students will enhance their communication skills via lively discussions of their work with the top researchers in their fields during the society-wide poster symposium. they will also have an opportunity to attend many technical presentations, join the keynote and plenary sessions featuring technological pioneers, and network with potential mentors, colleagues, and employers. this interactive experience will significantly broaden their education, increase their enthusiasm for their research topic, acquaint them with expectations for scientific careers, and expose them to new avenues for innovative research. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Doctoral Dissertation Research: Articulatory Dynamics and Stability of Multi-gesture

## Complexes

Awardee: University of Southern California

Amount: \$18,962.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). spoken language production involves combined and coordinated articulatory actions of the tongue, lips, nasal port, and larynx; yet the natural variation in speech and the difficulty of "seeing" events occurring inside the human vocal tract mean that the elegant choreography of these articulatory events critical to the formation of spoken words remains mysterious. this project is a study of speech production using real-time magnetic resonance imaging (rtmri)?a technique that can image vocal tract movement during speech. the project's goal is to characterize the dynamics of articulatory actions as they are organized into coordinated complexes such as speech segments (roughly ?alphabetic-sized? units). the investigation of stabilities in coordination will help scientists understand the cognitive representation of the linguistic units that are used to structure and say the words we know. ultimately such an understanding has implications for language in breakdown (e.g., due to stroke or disease), for language acquisition, for language and dialect **\*\*diversity\*\***, and for technologies that synthesize and recognize human speech. this dissertation undertakes real-time mri experiments on speech production and concomitant computational modeling to examine how the smallest movement 'atoms' of speech segments are systematically coordinated. the project tests the hypothesis that vocal tract movements composing a segmental unit are tightly coordinated with one another. therefore, their coordination is predicted to be stable across natural contextual variations in speech such as phrase boundaries and emphasis, unlike other movement sequences spanning across segments, which have been shown to exhibit more plastic coordination. using data from two under-studied languages, both larynx-oral coordination in glottalic consonants and velum-oral coordination in nasal consonants are dynamically imaged, and vocal tract movements are tracked to analyze articulatory patterning and coordination in space and time. empirical findings are computationally assessed using a model of dynamical coupling with which degrees of stability can

emerge from certain coupling structures. the project seeks to incorporate coordination relations into linguistic cognitive representations and thereby illuminate the dynamic and emergent nature of speech segments in the encoding system of the phonological units that form words. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: Collaborative Research: The Role of Marketplaces in the Development of Complex Society

Awardee: Elon University

Amount: \$18,648.00

Abstract: this multidisciplinary pilot project identifies prehispanic marketplaces and establishes a set of marketplace indicators that can be applied elsewhere in the world. in the process, the project works with students to train a new generation of archaeologists currently underrepresented in the field. the objectives address a research gap that impedes archaeology's contributions to economic theory. pre-modern markets offer particular promise for adding **\*\*diversity\*\*** to economic ideas. isolated from global capitalist forces, these markets allow researchers to re-examine foundational concepts ? such as money, credit, debt, and investment ? in non-western contexts, expanding understanding of how culture influences economic behavior. for both theoretical and methodological

reasons, however, archaeologists have only recently begun to establish the undisputed existence of pre-modern markets. previously prevailing western theories created a false dichotomy between past and present economies and suggested that market exchange ? the transfer of alienable goods and services between strangers ? could not exist outside of capitalism. while recent research has challenged these theories, archaeologists still lack sound methods for investigating the physical manifestations of markets, market systems and marketplaces, which are often ephemeral, barely leaving a material imprint. few archaeological projects worldwide have even tried to identify marketplaces, and their locations remain an important missing component in pre-modern market research. to help fill this gap, eight independent research programs are cooperatively investigating a possible prehispanic regional market system by identifying marketplace locations. economic investigations in the region have lagged due to several factors, including a historical mischaracterization of the past society which had been conceived as less complex than those of other neighboring groups. researchers now however have begun to search for marketplaces as a sign of economic complexity. while marketplace investigations across archaeological sites have already had some success, varying metrics have hindered the research. additionally, the dense vegetation covering sites makes it difficult to employ conventional approaches such as examining item distributions, which rely on surface collections. to ensure comparable results, collaborators on this project are examining marketplace indicators by using a cross-cultural set of marketplace indicators that depend on a combination of approaches from archaeology, botany, soil science, and physics. researchers are analyzing both old and new data according to common protocols to produce joint results that address the central research hypothesis: an integrated system of large and small markets existed in the region, allowing access to similar goods for households within it. these results will further establish precedents for future research in terms of both methodology and cross-program cooperation. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Doctoral Dissertation Research: Subjacency, the Empty Category Principle (ECP), and the nature of constraints on phrase movement

Awardee: University of Maryland, College Park

Amount: \$18,539.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). in general, it is possible to form a question by 'moving' a wh-phrase like "who?" or "which boy" out of a seemingly arbitrary number of clauses, as in "who did allie say that amy saw?", "who did alicia hear that allie said that amy saw?", and so on. in these questions, "who" is the logical object of "saw" yet appears at the beginning of the sentence. however, there are certain syntactic environments, commonly called 'islands,' in which question formation is not possible. a question like "who did the book by delight everyone?"--whose intended meaning is 'who is the person such that the book by that person delighted everyone'--sounds unnatural to speakers of english, suggesting that it is not a possible question despite having a reasonable meaning. some linguists have claimed that these constraints disappear when the offending structure is elided, such as in a sentence like "amy said that the book by someone delighted everyone, but i don't remember who". such sentences sound a bit more natural to speakers of english, but their status isn't entirely clear. this dissertation project will advance linguistic theory by using recent experimental techniques to ascertain whether such sentences are grammatical. in advancing the field, this project will also support education and **\*\*diversity\*\*** by training an undergraduate research assistant in these experimental techniques, scientific thinking, and statistical analysis. using behavioral methods, this doctoral dissertation project probes the link between speakers' reported judgments and their sensitivity to structure in questions with and without ellipsis. the goal is to determine whether the same principles apply to dependencies involving ellipsis as those that do not, with the longer term goal of identifying the computational principles governing syntactic locality. more generally, the



project addresses the consequences of mismatches between reported acceptability and subliminal sensitivity to structure in acceptability judgments. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Varieties of Crises, Elite Responses, and Executive Approval

Awardee: University of Connecticut

Amount: \$16,739.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2. this project examines four major types of crises -- economic, security, natural disaster, and public health crises ? and how they influence public support for political leaders in contemporary democracies. this is important to understand because leader approval is a key barometer of policymaker accountability and democratic stability, both of which can be undermined by crises. this project analyzes the interplay of four factors which vary systematically across these different types of crises and how, in turn, these shape public evaluations of political executives: (1) the ability of citizens to assign responsibility for policy decisions and outcomes; (2) the degree of expert consensus on effective policy response; (3) how much a given crisis in one area generates acute challenges or crises in other areas; and (4) the extent to which an effective response depends on citizens acting collectively. several data sets including (quarterly) measures of executive approval and crises; the tone and salience of leader messaging about the crises; the media's treatment of leader messaging; and (monthly) leader approval for a smaller number of countries for which such data is available; and survey-based experiments in three countries are collected and made publicly available. the award supports education and **\*\*diversity\*\*** by building the research capacity of a student project lab at georgia state university, a minority serving institution, in coordination with pis at four other universities who will also engage graduate and undergraduate students in this work.

puzzling divergences across countries in public reactions to leader responses to the covid-19 public health crisis have revealed major gaps in our understanding of how crisis events translate into public assessments of leaders. to resolve these puzzles, this project advances a unifying theoretical framework that identifies four major types of crises: economic, security, natural disaster, and public health. it then locates these crises on four key dimensions which should condition public support of top officials: the institutional and political context and other factors that impact attribution of responsibility, degree of expert consensus and incentives for politicians to follow expert recommendations, the likelihood and nature of spill-over to other crisis types, and the degree to which citizen action is required for an effective response. the project collects data to test theoretically-motivated hypotheses using: 1) a macro time-series cross-national data set to study the effects of crisis type on public approval for political executives for 48 countries, 2) a high-frequency time-series data set appropriate to test how approval dynamics reflect leader responses, as well as messaging choices and media effects for 18 countries for which this data is available, and 3) conjoint experiments in france, italy, and mexico, countries with different political and institutional settings, to assess the validity of the links between crisis types and dimensions as well as to validate proposed individual-level mechanisms. this project is supported by the accountable institutions and behavior program and the sbe build and broaden program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Varieties of Crises, Elite Responses, and Executive Approval

Awardee: University of Connecticut

Amount: \$16,739.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2. this project examines four major types of crises -- economic, security, natural disaster,

and public health crises ? and how they influence public support for political leaders in contemporary democracies. this is important to understand because leader approval is a key barometer of policymaker accountability and democratic stability, both of which can be undermined by crises. this project analyzes the interplay of four factors which vary systematically across these different types of crises and how, in turn, these shape public evaluations of political executives: (1) the ability of citizens to assign responsibility for policy decisions and outcomes; (2) the degree of expert consensus on effective policy response; (3) how much a given crisis in one area generates acute challenges or crises in other areas; and (4) the extent to which an effective response depends on citizens acting collectively. several data sets including (quarterly) measures of executive approval and crises; the tone and salience of leader messaging about the crises; the media's treatment of leader messaging; and (monthly) leader approval for a smaller number of countries for which such data is available; and survey-based experiments in three countries are collected and made publicly available. the award supports education and **diversity** by building the research capacity of a student project lab at georgia state university, a minority serving institution, in coordination with pis at four other universities who will also engage graduate and undergraduate students in this work.

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time-series data set appropriate to test how approval dynamics reflect leader responses, as well as messaging choices and media effects for 18 countries for which this data is available, and 3) conjoint experiments in france, italy, and mexico, countries with different political and institutional settings, to assess the validity of the links between crisis types and dimensions as well as to validate proposed individual-level mechanisms. this project is supported by the accountable institutions and behavior program and the sbe build and broaden program. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Doctoral Dissertation Research: The effects of nutritional ecology and feeding competition on growth and development

Awardee: George Washington University

Amount: \$15,750.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). learning what to eat, how, and where to find food are significant challenges that arise over the course of development. such challenges can also be social, when individuals have to compete with others for access to food. yet how feeding competition affects food choice and developmental outcomes is poorly understood, particularly in scenarios where food is abundant and distributed evenly across an environment. this doctoral dissertation research tests how variation in feeding ecologies, including food competition, affects food choice and developmental outcomes among wild juvenile non-human primates inhabiting changing ecological and demographic environments. results contribute to existing conservation management plans and provide concrete training opportunities to graduate and undergraduate students. results will be disseminated widely to academic and non-academic audiences. the proposal merges theory from nutritional ecology and life history to investigate the significance of feeding competition among developing non-human

primates, who lack the foraging competence of adults. major objectives include investigating: 1) variation in food nutritional properties along ecological gradients; 2) development of adult-like foraging competence; and 3) impacts of feeding competition on dietary development of infant and juvenile individuals. the researchers integrate novel and long-term data on food nutritional properties and feeding behavior sampled across a **\*\*diversity\*\*** of habitat types. they collect novel nutritional data from plant food samples as well as feeding data generated through long-term monitoring and new behavioral observations. results inform understanding of the evolution of primate juvenile periods, by improving our understanding of how immatures are impacted by feeding competition, even in contexts where food is apparently abundant. further, this research generates insights regarding developmental responses to changes in ecology, which are important for predicting population dynamics and associated implications for conservation efforts. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Collaborative Research: Enhancing Asian American and Pacific Islander Participation and Belonging in the Geosciences

Awardee: Princeton University

Amount: \$15,599.00

Abstract: asian americans and pacific islanders (aapi) represent one of the fastest growing demographics in the u.s. today and yet lag in participation and representation in geoscience graduate programs compared to other stem fields. thus, new programs are needed that specifically recruit aapi stem undergraduates to geoscience graduate programs and enhance belonging of aapi geoscientists as a whole. the proposed activities will focus on minority serving institutions (msis) that serve aapi. this project will expose as many as 1,000 undergraduates from msis in geoscience-adjacent stem fields to geoscience research and careers, provide a new research

internship opportunity and create national cross-career stage connections between aapi geoscientists to produce a cohort of geoscience leaders from a group often left out of \*\*diversity\*\* discussions. aapi scientists desire to relate their work to local populations and problems relevant to their communities; therefore, diversifying geoscience graduate programs with those identifying as aapi will have a direct impact on communities facing important geoscience problems of the 21st century such as climate change, natural hazards, and resource scarcity. this project supports pilot programs to enhance participation and belonging for asian american and pacific islander (aapi) communities in geosciences. the proposed activities include: 1) establishing a researcher visit program to recruit undergraduate aapi into geosciences via visits to aapi-serving msis from geoscience researchers; 2) a pilot research internship program for undergraduates at these institutions to carry out research with aapi mentors; 3) organizing virtual and in-person events and a career development workshop to enhance belonging, identity, and leadership within the aapi geoscience community across career stages and sectors. the outcomes of this combination of the proposed activities will help to develop geoscience programs, and create a cohort and community of belonging, access, justice, equity, \*\*diversity\*\*, and inclusion (bajedi) leaders of aapi geoscientists. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: 2021 EDGE Summer Symposium

Awardee: Pomona College

Amount: \$14,993.00

Abstract: the 2021 edge (enhancing \*\*diversity\*\* in graduate education) summer symposium is a three-day event that addresses mathematical research and professional development. the symposium uses a vertical mentorship model to fill in a variety of gaps (academic and non-academic) that are not guaranteed to be filled by other means. the community built during edge

programs is the primary mechanism that increases retention, access to professional opportunities, and likelihood that our participants don't just succeed, they thrive and are propelled into careers in the mathematical sciences that influence the whole community. the edge summer symposium combines research talks, panel discussions, and formal and informal networking events. the edge symposium will bring together (virtually and in-person) 75 mathematicians, primarily an intersection of women and graduate students, and will be hosted by the university of minnesota in minneapolis. participants of the summer symposium discuss cutting-edge research, motivating further discoveries and empowering less senior participants to strive for similar work. these more junior participants also receive indispensable career advice, while more established mathematicians hone their mentoring skills, strengthen their own support network, and deepen their commitment to influencing the next generation of mathematicians. in increasing the number of women who succeed in graduate school and beyond, the summer symposium increases the visibility of a diverse collective of mathematicians, inspiring younger mathematicians to persevere and become leaders in the mathematical sciences. further information about the edge program may be found at: <https://www.edgeforwomen.org/> this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: 2021 EDGE Summer Symposium

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Matched Words: diversity

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Title: Collaborative Research: EAGER: Using allies to expand your network: Implementing a psychological methodology to attract and retain underrepresented (UR) students in geoscience

Awardee: Texas Tech University

Amount: \$14,715.00

Abstract: geoscience maintains a base-rate problem with respect to **diversity**: ethnic minorities and people with disabilities are highly underrepresented. this has been traced to a variety of barriers for underrepresented (ur) ethnic scholars including: a lack of geoscience majors at hbcus and



primarily hispanic-serving institutions, a lack of experience with, and time spent in, nature (e.g., < 3% of visitors to u.s. national parks are black and hispanic), and negative attitudes about career prospects. for people with disabilities, the main challenge is accessibility and the provision of appropriate accommodations. ur individuals may self-select out of geoscience programs due to these perceptions and barriers. this project will test the idea that allies, or members of dominant social identities, are best situated to positively influence these statistics. academic allies, whether faculty or graduate student teaching assistants, have tremendous impact on their students? academic engagement and can serve as linchpins for improving the future trajectories of ur students. pis will train individuals in effective allyship behaviors, and incentivize them to recruit ur students into their academic field trips. the pis plan to target allies who engage in field research and education, as geoscience is a unique stem field insofar as much of the data collection and skill development are practiced out in nature at locations around the world. the pis propose testing a strategy to overcome barriers in this context for ur students, as positive (or negative) experiences in field settings have profound impacts on recruitment and retention. this project will facilitate training and assessment of approximately 80 academic allies and measure the effect of that training on allies as well as hundreds of majority and ur students. the expectation is that the training will produce a secondary effect: academic allies role model effective behaviors to all of their students and faculty networks, creating a ?train-the-trainer? ripple effect. the pis will use academic field trips as a vehicle for measurement, including multisource ratings, applying 360-degree-type ratings typically collected in performance appraisals to this setting. deliverables include an experimental, longitudinal (over time), and multisource analysis of the allyship program and its improvement of allyship-related attitudes and behaviors, as well as its impact on the performance of ur students. these results will inform research efforts regarding the effectiveness of implemented strategies, and the materials and procedure will be made open-source for maximum replicability. a capstone conference will be used to disseminate findings to all participating allies and ur students, inform about methodologies that improve attraction and retention of ur groups in the geosciences, and

expand ur networks. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Using Herbivorous Insect Genomes for Crop Tracking

Awardee: Washington University

Amount: \$14,175.00

Abstract: the goal of this project is to conduct a research study of the histories of crop range expansions by indigenous north americans. the domestication and assisted dispersal of plant and animal species by humans has dramatically changed global ecosystems, but the direct study of historical domestication of some species is often limited by methodological challenges. for example, while the ancestral ranges and subsequent range extensions of some north american crops are well studied, others remain relatively inaccessible. this research explores whether historical signals of range expansion captured within the genomes of insects, parasitic on focal crop plants, can be used as proxies for the histories of the plants themselves. this research provides a general proof of principle for using parasitic insects to study demographic histories of their plant hosts, but also specifically tests hypotheses for the pre-domestication ranges and histories of expansion for three crops of the eastern agricultural complex (eac): common sunflower, jerusalem artichoke, and sumpweed. this research results in the training of graduate and undergraduate students, lead to design and implementation of new materials for public outreach demonstrations, and bring about a large public science event focused on the indigenous agriculture. this research uses information captured in the genomes of specialist insects to reconstruct signatures of past cultivation and subsequent range expansions for three north american crops; the work addresses the questions: where did these plants grow before they were first used as crops, and where (and when) were they subsequently moved by people? common sunflower, jerusalem artichoke, and sumpweed are

known to have been cultivated by indigenous north americans as part of the eastern agricultural complex, but beyond this there is great variance in how much is known about their respective ancestral ranges and subsequent patterns of range extensions. two fly species in the north american genus *Stratiotia* feed on, respectively, common sunflower and jerusalem artichoke, while caterpillars of the slender flower moth are specialist herbivores on sumpweed. the researchers are making large collections of these three insect parasites from across their host plants' ranges in the north america, and then interrogating their genomes for signals of historical population size changes and the direction and timing of range expansions. a general prediction is that the region of highest genetic **\*\*diversity\*\*** for each insect will correspond to the historical boundaries of the eac, implicating this area as having been part of the ancestral range for each plant. a second expectation is that tests of demographic scenarios using genetic data will best support relatively recent range expansions, radiating out from their respective native range(s). this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: ABI Development: Improved Tools for Population Genomics

Awardee: San Diego State University Foundation

Amount: \$13,444.00

Abstract: the goal of this project is to develop computer software that allows scientists to compare the genomes of natural populations of organisms. population genomics (the study of **\*\*diversity\*\*** in the genomic dna of populations instead of individuals) has important applications in agriculture, anthropology, conservation, medicine, and several other fields of biology. recent technology advances have greatly lowered the cost of dna sequencing so large amounts of data are available. at the same time statisticians have developed new methods for analyzing large collections of genome-sized data. combining the data with the new analysis approaches can let scientists answer

fundamental questions about the biology of species that have never before been accessible. however, most population genomics studies fail to take advantage of the latest population genomics statistical methods. this is because the genomic data requires a lot of processing to prepare it for the analysis steps, and these operations are not easy to learn. lack of bioinformatics knowledge has led to erroneous conclusions, irreproducible results, incomplete analyses, and slow turnaround time of population genomics projects. this project aims to provide software that can handle those tasks in a consistent and correct way and allow direct access to the statistical tools, to bring about new insights in population biology. this project will address the largest impediments to model-based population genomics by building a user-friendly and intuitive pipeline platform, the "pop-gen pipeline platform" (ppp). this platform will help researchers avoid the problems inherent in re-inventing data processing scripts to feed data into their population genomics analyses, and considerably reduce time and effort. ppp will include tested scripts and pipelines for data preparation, and in addition the tools needed to build evolutionary models, carry out analyses of data, and create visualization of results via the ruffus computation pipeline library in python. ppp will also be developed as a stand-alone application with a graphical user interface (gui) under the popular and robust galaxy project ([www.galaxyproject.org](http://www.galaxyproject.org)) for bioinformatics analyses. an online server deploying galaxy/ppp will be developed and maintained at temple university, philadelphia ([www.dev3.cst.temple.edu](http://www.dev3.cst.temple.edu)) for users to interactively submit jobs on a first-come-first-served basis. online forums will be established for support, and to collect suggestions regarding what is desired for further development under ppp. tutorials and videos about example applications of the ppp will be added to the galaxy project wikipedia training channels. additionally, a significant part of this work will involve educating temple university seniors, philadelphia area high school teachers, and their students about the power of bioinformatics in modern biology through summer workshops. information about ppp, and associated developments can be accessed at <https://bio.cst.temple.edu/~hey/software/software.htm>.

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Matched Words: diversity

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Title: EAGER: Collaborative Research: Enhancing Asian American and Pacific Islander Participation and Belonging in the Geosciences

Awardee: University of Hawaii

Amount: \$12,763.00

Abstract: asian americans and pacific islanders (aapi) represent one of the fastest growing demographics in the u.s. today and yet lag in participation and representation in geoscience graduate programs compared to other stem fields. thus, new programs are needed that specifically recruit aapi stem undergraduates to geoscience graduate programs and enhance belonging of aapi geoscientists as a whole. the proposed activities will focus on minority serving institutions (msis) that serve aapi. this project will expose as many as 1,000 undergraduates from msis in geoscience-adjacent stem fields to geoscience research and careers, provide a new research internship opportunity and create national cross-career stage connections between aapi geoscientists to produce a cohort of geoscience leaders from a group often left out of **\*\*diversity\*\*** discussions. aapi scientists desire to relate their work to local populations and problems relevant to their communities; therefore, diversifying geoscience graduate programs with those identifying as aapi will have a direct impact on communities facing important geoscience problems of the 21st

century such as climate change, natural hazards, and resource scarcity. this project supports pilot programs to enhance participation and belonging for asian american and pacific islander (aapi) communities in geosciences. the proposed activities include: 1) establishing a researcher visit program to recruit undergraduate aapi into geosciences via visits to aapi-serving msis from geoscience researchers; 2) a pilot research internship program for undergraduates at these institutions to carry out research with aapi mentors; 3) organizing virtual and in-person events and a career development workshop to enhance belonging, identity, and leadership within the aapi geoscience community across career stages and sectors. the outcomes of this combination of the proposed activities will help to develop geoscience programs, and create a cohort and community of belonging, access, justice, equity, **\*\*diversity\*\***, and inclusion (bajedi) leaders of aapi geoscientists. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Collaborative Research: Enhancing Asian American and Pacific Islander Participation and Belonging in the Geosciences

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Matched Words: diversity

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Title: The Rising Stars in Cell Biology Symposium

Awardee: Johns Hopkins University

Amount: \$10,892.00

Abstract: this award provides support for a one-day meeting ?the rising stars in cell biology symposium? to be held on april 29, 2022 at johns hopkins university. the purpose of the meeting is to provide an opportunity to early career scientists (undergraduate, post baccalaureate, graduate students, and postdoctoral fellows) from diverse backgrounds within the greater baltimore area to present their research and network with their peers. the format of the meeting will comprise of one



keynote talk, selected oral presentations, poster sessions, and career development platforms. in the short-term, this meeting will provide an opportunity to trainees to highlight their exceptional research, boost their confidence, expose them to a wide array of leading-edge research within cell biology, which may lead to increased recruitment of under-represented minority (urm) students into graduate programs or postdoctoral positions across the participating institutions. in the long-term, this meeting will attract urm scholars to science, technology, engineering and mathematics (stem), specifically to life sciences and to generate a vibrant and supportive environment that encourages retention of urm scientists in academia. this meeting is motivated by the recognition of socio-economic disparity and the need for opportunities truly available to urm scholars. the award will defray the basic organizing expenses to reach a wide group of trainees as well as institutions that predominantly serve urm scholars in the greater baltimore area. in particular, the award will provide support for the meeting participants in the form of travel vouchers, working meals, poster printing, and childcare assistance. availability of opportunities provided by the meeting will showcase the trainees' work and form a peer network, which will encourage urm scholars to continue their academic pursuit and help increase **diversity** at higher ranks within academia. additionally, with the participants from diverse backgrounds but sharing the common interest in cell biology, this meeting is expected to foster scientific collaborations at the forefront topics and advance research forward. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Collaborative Research: Enhancing Asian American and Pacific Islander Participation and Belonging in the Geosciences

Awardee: University of California-Riverside

Amount: \$10,456.00

Abstract: asian americans and pacific islanders (aapi) represent one of the fastest growing

demographics in the u.s. today and yet lag in participation and representation in geoscience graduate programs compared to other stem fields. thus, new programs are needed that specifically recruit aapi stem undergraduates to geoscience graduate programs and enhance belonging of aapi geoscientists as a whole. the proposed activities will focus on minority serving institutions (msis) that serve aapi. this project will expose as many as 1,000 undergraduates from msis in geoscience-adjacent stem fields to geoscience research and careers, provide a new research internship opportunity and create national cross-career stage connections between aapi geoscientists to produce a cohort of geoscience leaders from a group often left out of \*\*diversity\*\* discussions. aapi scientists desire to relate their work to local populations and problems relevant to their communities; therefore, diversifying geoscience graduate programs with those identifying as aapi will have a direct impact on communities facing important geoscience problems of the 21st century such as climate change, natural hazards, and resource scarcity. this project supports pilot programs to enhance participation and belonging for asian american and pacific islander (aapi) communities in geosciences. the proposed activities include: 1) establishing a researcher visit program to recruit undergraduate aapi into geosciences via visits to aapi-serving msis from geoscience researchers; 2) a pilot research internship program for undergraduates at these institutions to carry out research with aapi mentors; 3) organizing virtual and in-person events and a career development workshop to enhance belonging, identity, and leadership within the aapi geoscience community across career stages and sectors. the outcomes of this combination of the proposed activities will help to develop geoscience programs, and create a cohort and community of belonging, access, justice, equity, \*\*diversity\*\*, and inclusion (bajedi) leaders of aapi geoscientists. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Collaborative Research: Enhancing Asian American and Pacific Islander Participation

and Belonging in the Geosciences

Awardee: CUNY Hunter College

Amount: \$10,300.00

Abstract: asian americans and pacific islanders (aapi) represent one of the fastest growing demographics in the u.s. today and yet lag in participation and representation in geoscience graduate programs compared to other stem fields. thus, new programs are needed that specifically recruit aapi stem undergraduates to geoscience graduate programs and enhance belonging of aapi geoscientists as a whole. the proposed activities will focus on minority serving institutions (msis) that serve aapi. this project will expose as many as 1,000 undergraduates from msis in geoscience-adjacent stem fields to geoscience research and careers, provide a new research internship opportunity and create national cross-career stage connections between aapi geoscientists to produce a cohort of geoscience leaders from a group often left out of **\*\*diversity\*\*** discussions. aapi scientists desire to relate their work to local populations and problems relevant to their communities; therefore, diversifying geoscience graduate programs with those identifying as aapi will have a direct impact on communities facing important geoscience problems of the 21st century such as climate change, natural hazards, and resource scarcity. this project supports pilot programs to enhance participation and belonging for asian american and pacific islander (aapi) communities in geosciences. the proposed activities include: 1) establishing a researcher visit program to recruit undergraduate aapi into geosciences via visits to aapi-serving msis from geoscience researchers; 2) a pilot research internship program for undergraduates at these institutions to carry out research with aapi mentors; 3) organizing virtual and in-person events and a career development workshop to enhance belonging, identity, and leadership within the aapi geoscience community across career stages and sectors. the outcomes of this combination of the proposed activities will help to develop geoscience programs, and create a cohort and community of belonging, access, justice, equity, **\*\*diversity\*\***, and inclusion (bajedi) leaders of aapi geoscientists. this award reflects nsf's statutory mission and has been deemed worthy of support through

evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Collaborative Research: Enhancing Asian American and Pacific Islander Participation and Belonging in the Geosciences

Awardee: CUNY Hunter College

Amount: \$10,300.00

Abstract: asian americans and pacific islanders (aapi) represent one of the fastest growing demographics in the u.s. today and yet lag in participation and representation in geoscience graduate programs compared to other stem fields. thus, new programs are needed that specifically recruit aapi stem undergraduates to geoscience graduate programs and enhance belonging of aapi geoscientists as a whole. the proposed activities will focus on minority serving institutions (msis) that serve aapi. this project will expose as many as 1,000 undergraduates from msis in geoscience-adjacent stem fields to geoscience research and careers, provide a new research internship opportunity and create national cross-career stage connections between aapi geoscientists to produce a cohort of geoscience leaders from a group often left out of \*\*diversity\*\* discussions. aapi scientists desire to relate their work to local populations and problems relevant to their communities; therefore, diversifying geoscience graduate programs with those identifying as aapi will have a direct impact on communities facing important geoscience problems of the 21st century such as climate change, natural hazards, and resource scarcity. this project supports pilot programs to enhance participation and belonging for asian american and pacific islander (aapi) communities in geosciences. the proposed activities include: 1) establishing a researcher visit program to recruit undergraduate aapi into geosciences via visits to aapi-serving msis from geoscience researchers; 2) a pilot research internship program for undergraduates at these institutions to carry out research with aapi mentors; 3) organizing virtual and in-person events and a career development workshop to enhance belonging, identity, and leadership within the aapi

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Matched Words: diversity

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Title: Collaborative Proposal GEOPATHs:IN Recruiting through location-based Curriculum and Field and Laboratory Research Experience for High School Students, Teachers and Undergraduates

Awardee: Nevada System of Higher Education, Desert Research Institute

Amount: \$9,770.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). improvements to stem k-12 education and increasing the number and **\*\*diversity\*\*** of young people headed into stem careers have been identified as national priorities. this project seeks to address aspects of both of these priorities in the context of geoscience education and workforce **\*\*diversity\*\***. the project will encourage high school students including many from historically excluded groups, to become involved in the geosciences or other stem disciplines by 1) engaging them in lesson plans developed by participating teachers to explain the local landscape and natural environment in which they live, 2) offering them opportunities to participate in geoscience research projects at the university of nevada, las vegas and 3) by building personal connections between students and faculty at unlv. to facilitate interactions with high school students pis will build long term relationships with high school earth science teachers by hosting summer workshops in which teachers will be provided with information about the local geology and natural environment and assist them in creating lesson plans for their classrooms. the activities will build up to a culminating experience where the teachers and high school students have an opportunity to claim their own identity as budding geoscientists. this project will encourage high school students including

many from historically excluded groups to become involved in the geosciences or other stem disciplines. the program will strengthen the relationship between the university of nevada (unlv) and the local community, including the local school district. project objectives will be accomplished through a comprehensive program that will include: 1) building a professional earth science learning community to facilitate collaboration between local high school teachers and unlv faculty/students; 2) generating high school earth science curriculum materials based on the local geologic resources that will provide stem education opportunities while also introducing potential career paths in the earth sciences; 3) creating a service learning course that will pair undergraduate "geoscience ambassadors" with high school classes that are utilizing the newly developed curriculum materials; and 4) engaging highly motivated high school students, high school teachers, and unlv undergraduate students in high profile, locally relevant scientific research questions in a way that leverages cutting edge analytical equipment in the unlv geoscience department. the workshop curriculum content and materials will be designed in consultation with curriculum experts so that they mesh well with the teachers' needs and address concepts outlined in the nevada academic content standards for science. resultant outcomes will bear benefits to teacher and student participants, faculty and the community as the project demonstrates how to build the geoscience workforce at the local level. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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curriculum content and materials will be designed in consultation with curriculum experts so that they mesh well with the teachers' needs and address concepts outlined in the Nevada academic content standards for science. Resultant outcomes will bear benefits to teacher and student participants, faculty and the community as the project demonstrates how to build the geoscience workforce at the local level. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Online Workshop on Synchrotron X-Ray Needs for Soft Matter Far From Equilibrium; June/July 2021

Awardee: Cornell University

Amount: \$9,071.00

Abstract: This grant will support a highly interdisciplinary on-line workshop identifying important fundamental questions related to soft matter far from equilibrium and how to employ x-ray tools to answer these questions. Much of the richness of the world around us ? and in fact life itself ? arises from conditions and processes far from equilibrium. And yet in contrast to systems at or near-equilibrium, our understanding of the basic principles of far-from-equilibrium systems is in its infancy. Non-equilibrium processes are particularly relevant in soft-matter systems, with huge impacts on areas ranging from health to energy to manufacturing. X-ray scattering studies, particularly using synchrotron radiation, are uniquely able to probe the three-dimensional, atomic-scale structure of soft matter over a wide range of time- and spatial scales, providing critical information needed to elucidate the fundamental processes and later to control them. Non-equilibrium processes are particularly relevant in soft-matter systems. Since their structures are based on weak interaction forces, including dipolar, hydrogen bonding, pi-pi, or screened electrostatic interactions, even small external perturbations can substantially alter the behavior of



soft matter. in macromolecular systems, for example, structural relaxation times can be very long. as a result, they often retain a memory of the preparation or processing conditions, a key to the large **\*\*diversity\*\*** of macromolecular structures and many technological innovations. furthermore, in analogy to biology, the study of soft dissipative systems with an ability to produce energy and convert it from one form to another has led to the emergent field of active matter. in recent years, efforts have intensified to study non-equilibrium processes in soft matter systematically in order to explore the entirely novel phenomena associated with transient structure, order, and dynamics, and to improve our fundamental understanding of them. synchrotron-based x-ray radiation has emerged as a particularly useful tool to contribute to this understanding. this workshop will: 1. identify important science questions related to "soft matter far from equilibrium" during advanced manufacturing processes such as roll-to-roll printing of highly structured materials; 2. determine how these questions can be addressed using synchrotron-based x-ray capabilities; 3. identify critical needs for and characteristics of synchrotron-based x-ray resources to support this research; and 4. identify the broader impacts of providing such resources to the soft matter community. the outcomes of the workshop will be captured in a workshop report to be submitted for publication. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: Proposal for a SUMMIT to Plan a Conference Workshop for Minoritized Geoscientists

Awardee: University of Washington

Amount: \$8,784.00

Abstract: this project aims to host a four-day summit with fifteen leaders from geoscience organizations with a demonstrated interest in improving belonging, accessibility, justice, equity, **\*\*diversity\*\***, and inclusivity (beajedi). the summit will provide these leaders with opportunities to

share successful strategies for improving beajedi in geoscience. leaders at the summit will design a conference where ~100-300 geoscientists network, present their research, and share successful strategies for improving beajedi in geoscience. the summit will thus begin the process of increasing interagency and interpersonal sharing, design, and refinement of the strategies used to strengthen beajedi in geoscience. the main goal of this project is to host a four-day summit with 15 leaders from the largest and or influential geoscience organizations with a demonstrated interest in improving belonging, accessibility, justice, equity, **\*\*diversity\*\***, and inclusivity (beajedi) in geoscience. summit participants will collaboratively design a conference workshop while sharing successful strategies for improving beajedi for geoscientists of color. this designed workshop will be primarily attended by geoscientists and will allow attendees to present research and network. the workshop will also include surveying and interviewing attendees to collect information that are germane for successfully recruiting and retaining people of color within geoscience. the questions that the surveys and interviews seek to answer are: 1. what attracts people of color to geoscience? 2. what are the experiences of geoscientists of color? 3. what do full belonging, accessibility, justice, equity, **\*\*diversity\*\***, and inclusivity look like to geoscientists of color? alongside developing a novel method of answering the questions listed above, this project's broader impacts are strengthened by including a mentorship component. the summit will pair early-career researchers interested in beajedi issues with established and experienced individuals. the early-career researchers will gain conference proposal writing experience while expanding their network. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: EAGER: Collaborative Research: Enhancing Asian American and Pacific Islander Participation and Belonging in the Geosciences

Awardee: University of California - Merced

Amount: \$8,483.00

Abstract: asian americans and pacific islanders (aapi) represent one of the fastest growing demographics in the u.s. today and yet lag in participation and representation in geoscience graduate programs compared to other stem fields. thus, new programs are needed that specifically recruit aapi stem undergraduates to geoscience graduate programs and enhance belonging of aapi geoscientists as a whole. the proposed activities will focus on minority serving institutions (msis) that serve aapi. this project will expose as many as 1,000 undergraduates from msis in geoscience-adjacent stem fields to geoscience research and careers, provide a new research internship opportunity and create national cross-career stage connections between aapi geoscientists to produce a cohort of geoscience leaders from a group often left out of \*\*diversity\*\* discussions. aapi scientists desire to relate their work to local populations and problems relevant to their communities; therefore, diversifying geoscience graduate programs with those identifying as aapi will have a direct impact on communities facing important geoscience problems of the 21st century such as climate change, natural hazards, and resource scarcity. this project supports pilot programs to enhance participation and belonging for asian american and pacific islander (aapi) communities in geosciences. the proposed activities include: 1) establishing a researcher visit program to recruit undergraduate aapi into geosciences via visits to aapi-serving msis from geoscience researchers; 2) a pilot research internship program for undergraduates at these institutions to carry out research with aapi mentors; 3) organizing virtual and in-person events and a career development workshop to enhance belonging, identity, and leadership within the aapi geoscience community across career stages and sectors. the outcomes of this combination of the proposed activities will help to develop geoscience programs, and create a cohort and community of

belonging, access, justice, equity, **\*\*diversity\*\***, and inclusion (bajedi) leaders of aapi geoscientists.

this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Doctoral Dissertation Research in Economics: An experimental analysis of the role of group identity in leadership effectiveness

Awardee: George Mason University

Amount: \$8,327.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). understanding the role of leaders in mitigating cooperation failures in groups especially when group members have distorted incentives is a relevant issue in economics. this research project will use economic theory and experimental methods to study whether beliefs and decisions of group members vary according to whether the leader shares the same group identity as the followers. the project will combine insights from behavioral economics, social psychology, leadership, and management studies to compare the effectiveness of ingroup and outgroup leaders. social identity theory suggests that a shared group identity between leaders and followers could increase trust in an ingroup leader's effectiveness in fostering cooperation. the research design will investigate whether ingroup bias can lower overall cooperation and efficiency in groups with outgroup leaders. ingroup bias can become a challenge for effective diverse leadership. this research will help to fill in gaps in knowledge of the detrimental effects of ingroup bias and will have broad impacts on the study of leadership. further, the results of this research project will shed light on identity-based discrimination which can provide important inputs into policies that improve **\*\*diversity\*\*** and inclusion in leadership. in a novel laboratory experimental design, the project uses identity manipulations within a leadership game. groups play a public goods game where the leader encourages cooperation within each group following a two-fold identification strategy which

creates artificial group identities. laboratory subjects acting as followers decide whether to follow a leader's cooperation suggestion in a group task. the main hypothesis is that the ingroups will exhibit favoritism towards ingroup leaders and discrimination against outgroup leaders. the difference in a group's cooperation levels under ingroup and outgroup leadership will help in isolating the effects of shared group identity on leadership effectiveness. extending this to a second study where the leaders use a reward mechanism to incentivize higher cooperation it can be observed whether a reward mechanism can bridge the gap between ingroup and outgroup leader effectiveness. the project makes two contributions. it provides an interdisciplinary approach to studying the interaction effects of group identity and leader effectiveness. second, the results will allow researchers to understand the ramifications of shared social identities between leaders and followers and prevent the negative consequences that may arise out of the lack of inclusion of diverse leaders. overall, the results will have policy implications for both organizations and policy makers. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: EAGER: Collaborative Research: Enhancing Asian American and Pacific Islander Participation and Belonging in the Geosciences

Awardee: Bellevue College

Amount: \$4,752.00

Abstract: asian americans and pacific islanders (aapi) represent one of the fastest growing demographics in the u.s. today and yet lag in participation and representation in geoscience graduate programs compared to other stem fields. thus, new programs are needed that specifically recruit aapi stem undergraduates to geoscience graduate programs and enhance belonging of aapi geoscientists as a whole. the proposed activities will focus on minority serving institutions (msis) that serve aapi. this project will expose as many as 1,000 undergraduates from msis in

geoscience-adjacent stem fields to geoscience research and careers, provide a new research internship opportunity and create national cross-career stage connections between aapi geoscientists to produce a cohort of geoscience leaders from a group often left out of \*\*diversity\*\* discussions. aapi scientists desire to relate their work to local populations and problems relevant to their communities; therefore, diversifying geoscience graduate programs with those identifying as aapi will have a direct impact on communities facing important geoscience problems of the 21st century such as climate change, natural hazards, and resource scarcity. this project supports pilot programs to enhance participation and belonging for asian american and pacific islander (aapi) communities in geosciences. the proposed activities include: 1) establishing a researcher visit program to recruit undergraduate aapi into geosciences via visits to aapi-serving msis from geoscience researchers; 2) a pilot research internship program for undergraduates at these institutions to carry out research with aapi mentors; 3) organizing virtual and in-person events and a career development workshop to enhance belonging, identity, and leadership within the aapi geoscience community across career stages and sectors. the outcomes of this combination of the proposed activities will help to develop geoscience programs, and create a cohort and community of belonging, access, justice, equity, \*\*diversity\*\*, and inclusion (bajedi) leaders of aapi geoscientists. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Collaborative Research: A Workshop for Evaluating the Value and Scope of a Biological Repository of Antarctic Specimens

Awardee: Ohio University

Amount: \$1,657.00

Abstract: this workshop will bring together antarctic marine freshwater and terrestrial biologists, students, and experts in specimen curation to assess the value of, need for, and scope of a

biological repository of antarctic specimens, including tissue samples. currently, some us collected antarctic specimen collections are housed in various museums, repositories, and labs. these collections are not easily discoverable on the internet, and how well they represent the bio\*\*diversity\*\* of antarctica is largely unknown. the workshop coordinators will advertise the conference broadly and recruit underrepresented groups to participate. participants will assess current repositories and determine how to make antarctica biological samples more accessible in a unified location (or through better coordination). this effort will benefit the broader community of biologists working with antarctic organisms by providing opportunities to conduct antarctic science by investigators and their students that might otherwise not be possible due to the logistical and budget challenges for deployments. following workshop activities, a final report will be published on the outcomes of the efforts. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: CAREER: Precipitation Pathways and Deformation Micromechanisms of Refractory Superalloys (RSAs)

Awardee: University of Miami

Amount: \$0.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). part 1: non-technical summary the disruptive potential of a superior class of high-temperature structural materials is immense, and would revolutionize the energy sector and aerospace industry while advancing our military technologies. for example, such materials would enable stationary gas turbines (which produce 40% of all u.s. electricity) and aerospace gas turbines (which account for 5% of man-made global warming) to operate at higher temperatures. higher engine temperatures provide greater engine efficiency and boost power output from powerplants and aviation, contributing to a stronger economy while reducing greenhouse gas emissions and enabling tactical superiority for military aircraft. the recent discovery of refractory high entropy superalloys (rsas) that possess excellent combinations of high strength and ductility at room-temperature and elevated temperature is extremely promising, especially as normal refractory alloys are typically brittle under ambient conditions. the proposed research identifies

knowledge-gaps regarding deformation mechanisms, microstructure stability at high temperatures and addresses these gaps through advanced materials characterization, mechanical testing and simulation, including national laboratory facilities. such analysis and understanding are critical for accelerated materials development to realize next-generation powerplants and aerospace engines. this project not only meets demands for advanced materials but synergistically reduces talent gaps in science and engineering. the university of miami college of engineering is collaborating with the phillip and patricia frost museum of science, which receives approximately 700,000 visitors annually. the collaboration serves to increase awareness and interest in metallurgy, and its impact on lowering co2 and energy footprints of air travel and electricity production, through integration of ongoing research and education initiatives.

part 2: technical summary    the project goal is to study the precipitation, strengthening and deformation mechanisms of refractory high entropy superalloys (rsa) by specifically testing the hypotheses that (i) the precipitation formed on quenching is due to spinodal decomposition, which raises concerns regarding long-term stability of the two-phase microstructure, and that (ii) the excellent mechanical properties are due to co-deformation of both phases via activation of the  $a\langle 111 \rangle$  slip system, given the preferred  $a\langle 001 \rangle\{001\}$  mechanism does not satisfy the criterion for polycrystalline ductility. the application of in-situ small-angle x-ray and neutron scattering to determine the time dependent fourier transform of the composition variation, and thereby directly test for spinodal decomposition, while simultaneously monitoring for phase transformations in a wide-angle detector, significantly contributes to the understanding of precipitation pathways in alloys. in-situ neutron diffraction during elastic loading provides fundamental data (such as phase stiffnesses) necessary for phase field simulations regarding microstructure evolution. in-situ diffraction during plastic deformation combined with tem dislocation analysis probes the deformation micromechanics and reveals why rsas exhibit a combination of strength and ductility, whereas refractory (single-phase) alloys are typically brittle at ambient temperature. the fundamental research regarding phase evolution, spinodal decomposition and slip systems within body-centered cubic alloys is significant across multiple alloy systems, essential for

the development of rsas, and necessary to advance high-temperature metallurgy. the stem talent gap is addressed through a tight integration of research and education. the development of an undergraduate course that offers an educational opportunity to perform research alongside faculty and industry engineers enhances materials education in south florida. the lack of **\*\*diversity\*\*** in stem is addressed through a multi-step program, where u. miami is ideally located in a majority-minority city and educates a highly diverse student body. significant awareness and understanding in metallurgy is generated through partnership with the frost science museum, where statistical surveys monitor success of these education and outreach activities. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Travel: Math Circles Around the World Conference

Awardee: Kansas State University

Amount: \$0.00

Abstract: this nsf award supports the travel of u.s. based mathematicians to the international conference "math circles around the world" scheduled to take place in st. petersburg, russia, july 1?3, 2022, as a satellite to the international congress of mathematicians. the conference is dedicated to mathematics enrichment programs and research experiences for school students. over the next decades these programs will have a major impact on the future development of stem disciplines in the united states. early engagement of school students in advanced math activities is today?s investment in the future of science and technology. participation of the us delegation will inspire more active engagement of professional mathematicians into math outreach programs and help advocate recruitment and retention of diverse populations to math programs for school students. in the long run this experience will have a very positive impact on the scientific community in the united states. conference participants will review existing practices of dissemination of

mathematics, advertise the achievements of math circle programs in the usa, develop deeper understanding of the context of mathematical culture in different countries, establish new international collaborations, and acquire practical skills that include recruitment and retention of more diverse population into stem education. the project seeks to broaden the **\*\*diversity\*\*** of participation of the meeting and to increase international visibility of the us-based leaders of math circles. mathematicians at an early stage of their careers and underrepresented groups will especially benefit from the travel support for this conference. more information about the conference is found at the website: <https://www.mathcirclesworld.org> this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Matched Words: diversity

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Title: CAREER: Peatland Geomorphology: Quantifying Geomorphological Changes across SE Asia  
Peatlands

Awardee: University of Oregon Eugene

Amount: \$0.00

Abstract: this project will determine how a process resulting from human activities (peat degradation due to deforestation) influences natural hazards (flooding) and climate change (carbon dioxide emissions). peatlands are wetlands where waterlogged conditions slow plant decomposition to such an extent that dead plants accumulate to form peat. under natural conditions peat domes grow over time, storing carbon underground and minimizing the risk of coastal flooding. in contrast, damaged peatlands are compacting, which results in a lowering of the ground elevation and in greenhouse gas emissions. this project proposes to integrate multiple satellite- and ground-based datasets with artificial intelligence tools to address a question of high societal importance: ?at what rates will thousands of years of accumulated peat carbon be released to the atmosphere and on what timescale will large coastal areas in southeast asia become permanently flooded?? retrospectively,

in louisiana, it was shown that the impact of hurricane katrina would have been less severe without the preceding decades of peat degradation. this project will proactively quantify when and where flooding will become the most severe in southeast asia and improve our understanding of peatland dynamics worldwide. knowledge from this work will enable forecasting future peat decomposition rates and flooding hazards, and refine estimations of carbon dioxide fluxes. these results will inform outreach efforts aimed to empower local communities through education, boost engagement of scientists in public communication, and increase undergraduate **\*\*diversity\*\*** through early exposure to hands on research. the goals of this project are to establish the capability to predict the fate of tropical peatlands and their carbon in response to environmental changes and to develop effective ways to engage the population on the importance of peatlands. the central hypothesis of this project is that peat degradation rates are controlled by the landscape morphology and land use history. to test it, this project will rely on three main tasks: 1) identify the controls on peat degradation rates across southeast asia by combining morphology (light detection and ranging data), deformation (interferometric synthetic aperture radar data validated by fieldwork), and land use timeseries (multi-spectral optical data); 2) develop a machine learning model accounting for the controls on degradation rates to predict the timing and amplitude of future degradation, carbon dioxide emissions, and the associated flooding; and 3) increase awareness on the importance of peatlands by sharing socially responsive outreach material. the developed techniques will provide a critical framework for worldwide peatland geomorphology studies. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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Title: Doctoral Dissertation Research in Economics: Residential Segregation and Neighbor-Based Informal Hiring

Awardee: Columbia University

Amount: \$0.00

Abstract: this award is funded in whole or in part under the american rescue plan act of 2021 (public law 117-2). place-based job policies, such as informal neighborhood job search, are common tools to promote local job growth and reduce regional economic inequality. it is however not clear what makes a neighborhood good for job search. this research project will study one such mechanism---the use of neighbor networks in job search. it explores which type of neighborhood---segregated or integrated, by race and by education---is more conducive to a successful job search. disentangling the neighborhood effects on job search is difficult partly because people self-select into neighborhoods. the researchers use a policy experiment on refugee that were randomly assigned to neighborhoods throughout the country to overcome the self-selection problem. the project can help shed light on how local social connections can be harnessed for effective resettlement and faster integration of these special immigrants into the labor market at the destination. second, in answering this question, this research project will be a step towards understanding the relationship between neighborhood **\*\*diversity\*\*** and prosperity. the results of this research can provide guidance on improving the functioning of labor markets, especially for those in segregated neighborhoods. the results could therefore help guide policies to reduce unemployment in low income segregated neighborhoods. identifying neighborhood effects in general is challenging because of residential sorting. different individuals may choose to live in different places for reasons unobservable to the econometrician. to overcome this selection issue and obtain causality, the project will exploit a refugee settlement program that randomly dispersed refugees across the country, conditional on a set of demographic characteristics and housing availability. this natural experiment introduces conditionally exogenous variation in the demographic composition at the neighborhood level for new and incumbent residents. the project will complement this natural experiment with granular geographical data that accommodate the resizing/redefining of neighborhoods. this flexibility and the policy-induced variation will allow causal estimation of the impacts of neighborhood segregation on the use of neighbor networks in job

search. in so doing, the research will help bridge two areas of economic literature ? neighborhood effects and networks-based informal hiring ? that heretofore have developed largely in isolation from each other. the results of this research will provide guidance on improving the functioning of labor markets, especially for those in segregated neighborhoods. the results could therefore help guide policies to reduce unemployment in low income segregated neighborhoods. this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

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Matched Words: diversity

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Title: Use-Inspired Climate Change Solutions: A TOS-ASLO Workshop Series

Awardee: Oceanography Society

Amount: \$0.00

Abstract: the oceanography society (tos) and the associated sciences for limnology and oceanography (aslo), the two largest professional societies of aquatic scientists in the us will hold a

series of community-driven information collecting events to identify interdisciplinary and convergent challenges the nation and world are facing due to climate change. a focus will be to crowdsource research directions and solutions to mitigate the threats posed by climate change in such a way that major impacts to society and the economy will be realized within a quick time frame. outreach to the limnology and oceanographic communities will be spearheaded by a task force of thought leaders with a membership reflecting diverse interdisciplinary expertise, gender **\*\*diversity\*\***, career stage, and ethnicity. activities will be professionally facilitated and will be tied to identifying solutions that target sustainability science. results of the community outreach will include a synthesis of workshop/communication venue results as well as the mining of information from recent professional society abstracts to augment the in-person/virtual conversations and input. broader impacts of the work will be to surface transformational, global ideas that accelerate use-inspired, entrepreneurial, and nature-based solutions to the threats the nation and world are facing due to a warming world which is driving climate change. as such, the potential societal impacts are great. other impacts include aquatic science community building; support of the development of early-career scientists; enhancing interdisciplinary, inter-agency, and international collaborations; and providing vehicles for connections between government, academic, and the private sector that link scientists in developed and developing nations in accelerating the design and implementation of use-inspired climate change solutions.

climate change and its impacts on the environment, society, patterns of land use, locations of communities, etc. are serious problems facing the nation and the world. the two us premier professional societies of aquatic scientists (the oceanographic society and the associated sciences of limnology and oceanography) will use their network of thousands of scientists to obtain input and crowdsource ideas for solutions to tractable issues being caused by climate change. these professional societies will jointly hold meetings, surveys, and conversations with members, nationally and internationally, to identify possible areas in which convergent science that crosses disciplines and stakeholder groups and where major advances in a short time frame can be made. the two professional societies will generate a report that will be submitted to the national science

foundation.    this award reflects nsf's statutory mission and has been deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Matched Words: diversity

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