2025 Arizona Astrobiology Symposium

Symposium Program Booklet

Friday, March 21st and Saturday, March 22nd

ISTB4, Arizona State University

Tempe, AZ

In Person Meeting

Organizing Committee
Galen Bergsten, University of Arizona
Searra Foote, University of Arizona
Lily Robinthal, University of Arizona
Samuel Courville, Arizona State University
Chanel Vidal, Arizona State University
Hannah Zigo, Arizona State University

Funding & Institutional Support
ASU School of Earth and Space Exploration

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Zoom Links

TBD

Code of Conduct

This symposium is open to all and participation is predicated on following our community agreements. Any misconduct or violation of these community agreements will result in removal from the symposium and may involve a report to your home institution. These community agreements apply to engagement in person, virtually, in Slack, and on social media.

The **members of the organizing committee serve as the community care facilitators** for this symposium. Symposium organizers will be wearing yellow ASU lanyards to help identify them. If you are targeted by or observe discrimination, please communicate the issue to either of them if you're looking for support.

Community Agreements:

1. We are responsible for creating and promoting safe environments for learning. These environments honor privacy and confidentiality and are characterized by integrity, respect, equity, trustworthiness, and transparency.
2. We will treat others with courtesy, respect, and fairness.
3. We will foster an inclusive environment by challenging behavior or culture that is traditionally exclusive.
4. We will act with honesty and hold ourselves and our community accountable for our actions.
5. We will acknowledge the names and roles of those who have aided in our work and made contributions to activities, publications, and achievements.
6. We will refrain from personally critical comments directed at each other, and we will clearly distinguish professional comments from opinions.
7. We are dedicated to learning from each other, and we will listen to each other in curious, genuine ways that promote understanding and transformation.
8. We will ask open-ended questions in conversations of conflict instead of trying to assert an opinion or viewpoint, and we will not interrupt or speak over each other.
9. We will recognize our privilege or power within spaces and use that power to center marginalized voices.
10. Community accountability:
    a. We will be aware of our surroundings and social situations.
    b. If a situation makes someone uncomfortable, or it looks like someone is being targeted, we will recognize that this is a problem and we will be part of a solution to help.
    c. We will take action to diffuse the situation while staying safe (e.g., checking in with the targeted individual(s), recruiting help from friends, diffusing the situation by distracting those causing harm, telling symposium leadership what is happening).
    d. If we are uncertain if there is a problem, we will check in with the targeted individual(s) to see if they are okay or need help.
    e. If we feel comfortable and recognize that there is an issue, we will call out the inappropriate behavior.

Plenary I: Friday, March 21

Dr. Pierre Haenecour, University of Arizona

"From Ancient Earth to Stardust: My Journey into Planetary Science and Astrobiology"

Originally from Brussels, Belgium, he earned both his bachelor's and master's degrees in Geology and Geochemistry from the Free University of Brussels before moving to St. Louis, Missouri. There, he completed a second master's degree and a Ph.D. in Earth and Planetary Sciences at Washington University in St. Louis.

As Victor Hugo once wrote, “Where the telescope ends, the microscope begins. Which of the two has the grander view?” Pierre embodies this philosophy, using ion and electron microscopes to analyze circumstellar and interstellar dust grains, as well as organic molecules in unequilibrated planetary materials. His research explores the fundamental building blocks of our solar system and investigates how bioessential components on asteroids may have contributed to the origins of life on Earth.

In his talk, Pierre will share his journey—from studying ancient Archean rocks to unraveling the secrets of presolar dust grains and organics in asteroidal and cometary samples.

Plenary II: Saturday, March 22

Dr. Teddy Kareta, Lowell Observatory

“Near-Jupiter Comets and the Habitability of the Galilean Moons”

The surfaces of Jupiter's Galilean Satellites are covered in impact craters, and understanding their respective impact histories is critical to assessing their astrobiological potential, but what do we know about the properties of the objects that impact them? In this talk, I will present an overview of what we know about the comets and Centaurs which get close to Jupiter -- their compositions, their thermal histories, and their chaotic trajectories -- and how exciting recent advances in comet and impact science as well as the upcoming Legacy Survey of Space and Time by the Vera Rubin Observatory are facilitating significant advancements in our understanding of just how friendly these water-rich worlds are to life.

Dr. Teddy Kareta is a postdoctoral researcher at Lowell Observatory, where he and his students use telescopes, spacecraft data, orbital integrations, and laboratory studies to understand the modern properties and evolutionary histories of the Solar System's small bodies -- its comets, asteroids, and trans-Neptunian objects. When he's not at work, he enjoys biking and doing nature photography around the Southwest.

Meeting Schedule

Friday - March 21			
12:00 pm	1:00 pm	Lobby	Check In
1:00 pm	1:15 pm	Marston Theatre	Introductory Remarks
1:15 pm	2:00 pm	Marston Theatre	Plenary I
2:00 pm	2:15 pm	Lobby	Break
2:15 pm	2:50 pm	2nd Floor + Basement	Meteorite Vault Tour A, Terahertz Instrumentation Lab Tour B
2:50 pm	3:00 pm	Lobby	Break
3:00 pm	3:35 pm	2nd Floor + Basement	Meteorite Vault Tour B, Terahertz Instrumentation Lab Tour A
3:35 pm	4:00 pm	Lobby	Break
4:00 pm	5:00 pm	Room 240	*Workshop: Maximizing Your Symposium Impact

Saturday - March 22			
8:00 am	8:50 am	Crater Carpet	Check In
8:50 am	9:50 am	Crater Carpet	Poster Session I
9:50 am	10:00 am	Crater Carpet	Break
10:00 am	11:45 am	Marston Theatre	Oral Session I
11:45 am	12:50 pm	Crater Carpet	Lunch Break
12:50 pm	1:50 pm	Crater Carpet	Poster Session II
1:50 pm	2:00 pm	Lobby	Break
2:00 pm	3:30 pm	Marston Theatre	Oral Session II
3:30 pm	4:00 pm	Lobby	Break
4:00 pm	4:15 pm	Marston Theatre	Closing Remarks
4:15 pm	5:00 pm	Marston Theatre	Plenary II

1st Floor: Lobby
2nd Floor: Room 240
3rd Floor: Crater Carpet

*Whether it's your first time at a symposium or you're looking to refine your approach, this interactive session will help you make the most of the experience. Learn how to effectively present your research, network with peers, and communicate your findings in ways that resonate with your audience. This workshop will equip you with the tools to enhance both your presentation skills and your overall symposium experience.

Presenter Information

Poster Session I		
#1	David Brown	The Vatican-Potsdam-NEP PEPSI High-Resolution Spectroscopic Survey
#2	Apruva More	Isotopic Tracers and Stellar Sources: Importance of Classical Novae and Red Giants in Presolar Grain Formation
#3	Searra Foote	A New Era in Exoplanet Characterization with the Habitable Worlds Observatory: Improving Parameters for Better Mission Yields
#4	Zollee Williams	Biosignature Analysis of Mirabilite From a Mars-analog Site
#5	Jordyn Robare	Distinguishing Biosignatures Using Thermodynamic Calculations
#6	Karla Paredes Aguilar	Alkaline Lakes as Planetary Analogs: Astrobiological Insights From an Alkaline Lake

Oral Session I: Techniques for Investigating Habitability Across the Solar System and Beyond			
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10:15 am	10:30 am	Oketa Basha	Readout of MKID Arrays for Habitable Worlds Observatory (HWO) using a Polyphase Filterbank Algorithm
10:30 am	10:45 am	Kayla Smith	The Influence of Clouds and Deuterium-Burning on Brown Dwarf Habitable Zones
10:45 am	11:00 am	Jeremy Scott	NOTT: Unveiling Hot Exozodiacal Dust and Exo-Planets with L-Band Nulling Interferometry at the VLTI
11:00 am	11:15 am	Lily Robinthal	Clearing the Air: Solar System Bodies as Windows into the Impact of Aerosols on Exoplanet Atmospheric Retrievals
11:15 am	11:30 am	Jingyu Wang	Development of Photochemical and Radiative Transfer Models for the Atmosphere of Venus and Exo-Venuses
11:30 am	11:45 am	Tracee Jamison-Hooks	FPGA-based Signal Processing for Atmospheric Dual Differential Absorption Radar (ADDR)

Poster Session II		
#7	Sukaina Al-Hamedi	Metabolic Capacity of *Sulfurimonas denitrificans*, a Chemolithoautotrophic Sulfur Oxidizer - Implications for Potential Life Processes on Ocean Worlds
#8	Shashank Avinash Araokar, Justin Kobrin, and Simon Abshear	Updated Orbital Parameters for Qatar-4 b Using MicroObservatory and EXOTIC
#9	Samuel Courville	Dynamic Habitability of Ceres
#10	Kadin Pulliam	Exploring the Dynamics of Cell Morphology and Organic Carbon Concentration
#11	Jothiradithya (Sai) Konduru	Probing Supermassive Dark Stars: Evidence from High-Redshift JWST Observations
#12	Connor Wilson	How Do Clades Rise to Planetary-Scale Impacts on Habitability? A Case Study in the Land Plants
#13	Skylar Catania	Cultivation on Mars: Improving Soil Fertility of MGS-1 using Green Compost Amendment

Oral Session II: Origins and Viability of Life Beyond Earth			
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2:15 pm	2:30 pm	Emma Guinan	A Panspermia Origin For Venus Cloud Life
2:30 pm	2:45 pm	Alexander Sastokas	Experimental Evolution Reveals Biophysical Constraints on Cell Size and Density
2:45 pm	3:00 pm	Veronica Klawender	Viability of Methanogens in the Ice Shell of Europa
3:00 pm	3:15 pm	Parker Crossland	Single-Cell Resolution of Rare Adaptive Mutations in Evolving Microbial Populations: Implications for Astrobiology
3:15 pm	3:30 pm	Rizal Hariadi	Hydrodynamically-Active Oily Ocean Surface as a Cradle for the Emergence of Life

Poster Session I Abstracts

David Brown, Vatican Observatory

“The Vatican-Potsdam-NEP PEPSI High-Resolution Spectroscopic Survey”

The Vatican-Potsdam-NEP (VPNEP) survey is a high-resolution optical spectroscopic survey of TESS stars around the Northern Ecliptic Pole, comprising 352 dwarf stars and 715 giant stars, all cooler than type F0 and brighter than V=8.5. It is a collaboration between the Leibniz Institute for Astrophysics in Potsdam and the Vatican Observatory, employing the high-resolution PEPSI spectrograph and the Alice B. Lennon VATT telescope, respectively, for those institutions. Its aim is to obtain high-resolution spectra that will allow detailed determination of the parameters of such stars: surface temperature, log10g, metallicity, microturbulence, and, especially, chemical composition, amongst many quantities. The aim is to provide detailed stellar information of such stellar targets for the benefit of future studies. One such possible study is obtaining a deeper understanding of the chemical relation/correlation between a star and its orbiting exoplanets, giving an idea of the evolutionary status of such a stellar system, of interest to astrobiology.

Apurva More, Arizona State University

"Isotopic Tracers and Stellar Sources: Importance of Classical Novae and Red Giants in Presolar Grain Formation”

Classical novae likely play a significant role in enriching the interstellar medium and the early Protosolar nebula with dust that contains unique isotopic signatures. This study compares isotopic yields from Carbon-Oxygen (CO) and Oxygen-Neon (ONe) nova models (Starrfield et al. 2020, 2024) with the isotopic compositions found in Presolar grains to identify those originating in classical novae. We focus on key isotopic tracers, such as 16,17,18O, 28,29,30Si, 24,25,26Mg, and the ratio of 26Al/27Al as indicators of nova nucleosynthesis and grain formation processes. Starrfield et al. (2024) suggest that material ejected during a nova outburst in TCrB mixes with surrounding material from the white dwarf and its binary companion. By incorporating observational data from red giants in binary star systems (Hinkle et al. 2016) and using mixing models that include both solar-composition companion material and nova ejecta, we investigate the resulting dust compositions. This work sheds light on the mixing mechanisms responsible for isotopic variations in circumstellar and interstellar dust, advancing our understanding of the stellar histories embedded in presolar grains.

Searra Foote, University of Arizona

"A New Era in Exoplanet Characterization with the Habitable Worlds Observatory: Improving Parameters for Better Mission Yields"

The under-development NASA Habitable Worlds Observatory (HWO) would provide breakthroughs in exoplanet science. However, the most effective approaches to detecting and characterizing Earth-like worlds with HWO are unclear yet essential for mission development. We aim to better model and understand detection metrics by leveraging EXOSIMS (Exoplanet Open-Source Imaging Mission Simulator), a versatile exoplanet yield modeling tool for direct imaging missions. An essential element of yield modeling is representing planetary brightness with illumination and viewing geometry, encapsulated in a planetary phase function. For Earth, its true phase function is non-Lambertian, deviating from the idealized Lambertian currently in EXOSIMS, particularly at phase angles larger than 90 degrees (i.e., beyond quadrature). This difference can lead to an underestimation of Earth's brightness in current yield tools, significantly impacting projected yields. To address this discrepancy, we implement a more realistic treatment of Earth's phase function in EXOSIMS, based on observed albedo and reflectance data. Results demonstrate an increase in predicted yields of Earth-like planets for an HWO-like mission, especially for detections at phase angles near and beyond quadrature. These improvements underscore the measurable impact of phase functions on yield and the need for more precise calculations to maximize mission success.

Zollee Williams, Arizona State University

"Biosignature Analysis of Mirabilite From a Mars-analog Site"

NASA launched its Mars 2020 mission where the Perseverance rover landed at Jezero Crater with the goal of understanding Mars habitability and to search for evidence of ancient life. In addition, the rover is collecting and caching samples for future geological and astrobiological analysis when returned to Earth. Therefore, it becomes imperative for scientists to develop methodologies and increase our background knowledge of biopotential analysis of terrestrial Mars-analog minerals. A diverse range of sulfates have been detected on Mars. However, hydrated sulfate minerals, like mirabilite (Na2SO4 x 10 H2O), lack detailed studies of terrestrial biosignature preservation potential. Here we show diverse organic materials preserved in mirabilite from Mars-analog evaporite environments. We found well-preserved primary fluid inclusions that trap environmental fluids and potential organics during crystal formation. Furthermore, we developed a surface sterilization protocol suitable for DNA extraction from hydrated sulfate minerals. DNA quantified from these samples showed abundant concentrations of around 200-300 ng/mL. Extracted DNA will be sequenced to determine microbial community composition and diversity. Our results demonstrate the ability for hydrated sulfate minerals to trap and preserve abundant organic materials over varying geologic time. Our developed methods can be applied to any sulfate mineral collected and brought back from the potential future Mars Sample Return mission, and it additionally accounts for any potential terrestrial contamination.

Jordyn Robare, Arizona State University

“Distinguishing Biosignatures Using Thermodynamic Calculations”

The search for alien life often involves efforts to detect organic molecules, which have been found on many extraterrestrial bodies. Organic synthesis can occur through biotic or abiotic processes. Therefore, methods for distinguishing biosignatures from abiotic products will enhance life-detection missions. Earth-based life harnesses energy-releasing reactions to power biosynthesis reactions, which themselves often require energy. Using thermodynamic calculations, we can quantify the change in energy to synthesize an organic compound in its environment. If an organic molecule is detected in an abundance that is thermodynamically unstable (would cost energy), then it is possible that life coupled its synthesis to other energy-releasing reactions. Such a compound would be possibly biotic. On the other hand, if an organic molecule is detected in an abundance that is thermodynamically stable (would release energy), then it is plausibly abiotic. Enceladus’s plume, where CHNOPS-containing compounds were detected by Cassini, serves as a case study for this sorting method. When reduced carbon compounds are used as the carbon source, hypothetical organic synthesis reactions would be possibly biotic, while those from oxidized carbon sources would be plausibly abiotic. This difference in interpretation highlights the need to consider the full geochemical picture when searching for biosignatures.

Karla Paredes Aguilar, University of Arizona

“Alkaline Lakes as Planetary Analogs: Astrobiological Insights From an Alkaline Lake”

The OSIRIS-REx mission has revealed evidence of aqueous mineral alteration in samples from asteroid Bennu, providing insight into its past environment, the potential for habitability in the early solar system, and the origins of life on Earth. Terrestrial alkaline lakes serve as valuable analogs for understanding such past aqueous environments on planetary bodies. Last Chance Lake, a sodium-carbonate-rich soda lake with exceptionally high phosphate concentrations, a key element for life, offers an opportunity to investigate mineral precipitation and water chemistry under high-pH conditions. This study integrates mineralogical, geochemical, and compositional analyses, including X-ray diffraction (XRD), ion chromatography, inductively coupled plasma mass spectrometry (ICP-MS), ion chromatography,and scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM-EDS), to characterize the lake’s evaporites and brine chemistry. XRD analysis identified halite, trona, and thermonatrite, minerals also present in Bennu samples. ICP-MS detected dissolved phosphorus in the lake water, highlighting the potential for phosphate availability in extraterrestrial brine systems, such as those on Bennu’s parent body, Ceres, or Europa. The presence of sodium salts in Bennu samples suggests that their parent bodies underwent prolonged aqueous alteration, possibly in briny environments. These findings underscore the importance of alkaline lakes as terrestrial analogs for understanding the geochemical evolution of small bodies in the solar system and provide insight into the persistence of brines in extraterrestrial settings.

Oral Session I Abstracts

Alicia Allen, Northern Arizona University

“Using JWST to Search for Water-Ice in the Asteroid Belt”

To understand the origin of water and subsequent life on Earth, we often look to small-bodies in our Solar System and the hypothesis that water was delivered to Earth via impact(s). This project aims to test the hypothesis that Earth’s water was delivered via an asteroid impact by looking for the presence of water-ice on Main Belt asteroids (MBAs). Using the NIRCam instrument on JWST, we observe MBAs in two wavelengths, which allows for performing spectral band math to determine if the asteroid has an absorption feature attributed to hydration at 3.0-μm. We then compare these results to the well-classified spectra of asteroids with known hydration features caused by solar wind OH implantation, exogenous carbonaceous material, water-ice, or combinations of these. With the inclusion of publicly-available JWST archival data, we seek to analyze up to 10% of the asteroid belt for features indicative of the presence of water-ice. Objects found to have 3.0-μm features will be linked to upcoming LSST observations to determine orbits and create a map of how water is distributed in the Main Belt. We can then compare these orbits to those of Near-Earth Object source regions to estimate probabilities of water delivery to Earth via these populations.

Oketa Basha, Arizona State University

“Readout of MKID Arrays for Habitable Worlds Observatory (HWO) using a Polyphase Filterbank Algorithm”

We are presenting the design and implementation of a Polyphase Filterbank (PFB) algorithm in Spaceflight Hardware Description Language (HDL) specifically for the readout of Microwave Kinetic Inductance Detectors (MKIDs) in space qualified electronics. MKIDs are a revolutionary superconducting detector technology, offering high sensitivity, frequency domain multiplexing, and the potential for large format arrays qualities that make them perfect for future astrophysics missions like the Habitable Worlds Observatory (HWO) and the Origins Space Telescope. Missions which need high contrast imaging and photon-counting capability in cryogenic environments, MKIDs are the enabling technology. Traditionally to obtain the frequency content of an incoming time-domain signal, a Fast Fourier Transform (FFT) algorithm is typically used. However, this method does not meet the requirements for MKID detector readout electronics because the detector’s vulnerability to spectral leakage. The algorithm of choice here is the Polyphase Filterbank (PFB). The PFB can be visualized as a customizable digital filter surrounding each frequency bin of the FFT, effectively mitigating spectral leakage. Here we present a resource-efficient, space-flight-ready HDL implementation of the PFB, which will target the Xilinx Kintex Ultrascale FPGA. The design handles wide bandwidth and high detector multiplexing density, allowing us to read out thousands of resonators through a single coaxial cable while keeping power dissipation per pixel to a minimum.

Kayla Smith, University of Arizona

"The Influence of Clouds and Deuterium-Burning on Brown Dwarf Habitable Zones"

We compute a new set of equilibrium temperatures for planets orbiting brown dwarfs. Unlike most previous work that used analytic scaling relationships for the brown dwarf luminosity vs. time, we use the outputs of sophisticated brown dwarf evolution models that account for the effects of deuterium burning, cloud formation and dissipation, and the most recent atmospheric opacities. Cloudy brown dwarfs cool more slowly than cloudless brown dwarfs, allowing planets orbiting them to remain in the habitable zone for millions of years longer than previous estimates. Similarly, we find that during the deuterium-burning phase of brown dwarfs, planets at the same orbital radius but orbiting brown dwarfs of different masses can remain in the habitable zone for the same duration, creating deuterium "sweet spots" for habitability around brown dwarfs near the deuterium-burning limit. For example, at 0.01 AU a planet orbiting both a 12 MJ and a 20 MJ brown dwarf stays in the habitable zone for ~170-180 Myr because of the greater fractional impact of deuterium burning on the cooling of the lower mass brown dwarf. The size of the effect decreases with decreasing orbital radius, causing higher orbital radii to have a more pronounced deuterium burning effect. These results are not captured by the analytic approximations to the cooling used in most previous work on substellar habitable zones. We report on these and other findings from the application of modern evolution models to the problem of habitability of planets orbiting substellar objects.

Jeremy Scott, University of Arizona

"NOTT: Unveiling Hot Exozodiacal Dust and Exo-Planets with L-Band Nulling Interferometry at the VLTI"

The Nulling Observations of exoplaneTs and dusT (NOTT) is a high-contrast visitor instrument to the Very Large Telescope Interferometer and part of the Asgard instrument suite. It provides spectrally dispersed (R = 40-400) null measurements in the L band (3.5-4.0 um) at a spatial resolution of ~3 milliarcseconds. When operated in dust detection mode, NOTT rejects starlight while being sensitive to the poorly understood hot exozodiacal dust distributions very close to the host star. Such dust may pose significant challenges to the detection of exo-Earth planets as the sub-micron grains efficiently scatter visible light causing increased coronagraphic leakage, and this light adds photon noise as it traverses the habitable zone when being deposited or removed. Characterization of hot exozodiacal dust thus has important implications in the search for life sustaining planets. When operated in planet detection mode, NOTT produces complementary nulled outputs, which when subtracted, suppresses symmetric signal and first-order phase errors providing enhanced starlight rejection. These features make NOTT uniquely suited for the of study young Jupiter-like exoplanets at angular separations close to the snow line. In this presentation I will discuss the NOTT instrument, its different operating modes, and its advantages for the detection of exoplanets and hot exozodiacal dust.

Lily Robinthal, University of Arizona

“Clearing the Air: Solar System Bodies as Windows into the Impact of Aerosols on Exoplanet Atmospheric Retrievals”

Dust, hazes, and clouds are ubiquitous in the atmospheres of both solar system bodies and exoplanets. Understanding the impact of these aerosols on atmospheric spectra is key to deriving accurate information from exoplanet atmospheric retrievals. At present, these aerosols are heavily simplified in exoplanet inference models, which could limit model efficacy. Fortunately, we have the opportunity to use pre-existing solar system observations to validate and improve exoplanet-focused approaches to representing aerosol structures. We are deriving aerosol profiles from occultation data of solar system worlds with known atmospheric composition, such as Titan and Mars. These profiles provide an opportunity for ground-truth verification of exoplanet atmospheric characterization tools and allow us to improve our retrieval pipelines. We aim to understand if simplified model representations produce results that resemble real hazes and, if not, where we can improve, as well as determine what impact these simplifications have on retrievals. We use occultation data from Cassini’s UVIS instrument and MAVEN’s IUVS instrument to construct atmospheric profiles for Titan and Mars, respectively. Going forward, we will continue this process using occultation data of Venus, Earth, Saturn and Pluto to expand our catalog of ground-truth calibrations for models and retrieval pipelines.

Jingyu Wang, University of Arizona

“Development of Photochemical and Radiative Transfer Models for the Atmosphere of Venus and Exo-Venuses”

Exoplanet Venus analogs (exo-Venuses) are expected to be characterized in the near-term by the James Webb Space Telescope (JWST). Such observations offer the opportunity to test rocky exoplanet atmospheric climate and photochemistry models in novel regimes, vital for refining them and building the robust modeling infrastructure that will be required to interpret anticipated observations from upcoming facilities like the Habitable Worlds Observatory (HWO) in search of signs of life. However, many uncertainties remain in current understanding of Venusian atmosphere, which is the cornerstone of studying exo-Venuses. Therefore, we plan to construct new Venus photochemical and radiative transfer models based on existing models for temperate terrestrial planets. We will adapt the MIT Exoplanet Atmospheric Chemistry model (MEAC) by updating and extending the chemical network to include Cl species, incorporating particle scattering and UV absorber by parameterized absorption, and employing new data from laboratory experiments (ExCITE-PM collaboration). We will calculate atmospheric structure from the Linearized Flux Evolution radiative transfer model (LiFE) and couple the models to self-consistently compute photochemistry and climate. In addition to interpreting anticipated observations of exo-Venuses and testing atmospheric models in general, our models can also be used to investigate anomalies in Venusian atmosphere, which signal unknown chemistry not yet incorporated into atmospheric models. We plan to open-source our models, once developed and validated, to enable community validation and extension.

Tracee Jamison-Hooks, Arizona State University

"FPGA-based Signal Processing for Atmospheric Dual Differential Absorption Radar (ADDR)"

The ASU digital signal processing technology lab aims to design a Field Programmable Gate Array (FPGA) algorithm for an atmospheric dual-band Differential Absorption Radar (DAR) system being developed at the Jet Propulsion Laboratory (JPL). The dual-band DAR operates at both V-band (65-70 GHz) and G-band (155-174GHz)and measures humidity and pressure profiles with high vertical resolution. The long pulse repetition interval (PRI) needed to improve coherent integration drives the number of samples and subsequently increases significantly the FFT lengths, placing a heavier burden on the FPGA's memory–an essential trade-off. Establishing a chirp bandwidth of 10MHz results in a nominal range resolution of 15 meters. Since the target range for remote sensing is about 10 km in height, only a section of the spectrum needs to be stored in the Block RAM (BRAM). This will allow for detection of high-level clouds, and retrieval of humidity and pressure profiles in an airborne ready device. Here we describe the fixed-point implementation of the dual DAR algorithm, emphasizing its computational efficiency for low resource utilization.

Poster Session II Abstracts

Sukaina Al-Hamedi, Arizona State university

"Metabolic Capacity of Sulfurimonas denitrificans, a Chemolithoautotrophic Sulfur Oxidizer - Implications for Potential Life Processes on Ocean Worlds"

Chemolithoautotrophic sulfide oxidizers (CSOs) are primary producers in low-energetic environments, obtaining energy from coupling oxidation of reduced inorganic sulfur species with the reduction of various electron acceptors. CSOs play crucial roles in various marine and terrestrial subsurface environments, like oxygen minimum zones (OMZs). Although microbially driven sulfur redox chemistry is well established as a key component of geochemical cycles, our knowledge of the specific microorganisms performing these processes is constrained by challenges associated with laboratory culturing of CSOs. Consequently, fully elucidating the role of CSOs in geochemical cycles remains a challenge until these gaps regarding their physiology and metabolic capacity are addressed.Interestingly, CSOs serve as model organisms for studying potential biological metabolisms on extraterrestrial "ocean worlds" due to their ability to utilize inorganic substrates as their sole energy source in the absence of light and oxygen. Thus, research on CSOs also has important implications for extraterrestrial exploration. This study examines the growth of Sulfurimonas denitrificans (Sd), a model CSO, under different temperatures, sulfide concentrations, and other environmental parameters relevant to key OMZs and ocean worlds to develop a comprehensive dataset on Sd metabolic capabilities. This work was performed via batch culturing. Cultures of Sd were prepared under anaerobic conditions, with samples extracted daily to measure growth via optical density. I report an optimal growth temperature for Sd between 21-26°C and an optimal sulfide concentration below 1 mM. Understanding Sd's interactions with sulfur-based substrates refines our knowledge of sulfur cycling and its interconnectivity with associated microbial communities, especially in OMZs.

Shashank Avinash Araokar, Justin Kobrin, and Simon Abshear, Arizona State University

"Updated Orbital Parameters for Qatar-4 b using MicroObservatory and EXOTIC"

Observing exoplanet transits is one of the best methods we have to derive orbital parameters of these planets. However, over time, any observed ephemeris becomes stale and is necessary to update regularly to save future observation costs for advanced telescopes. In Spring 2024 as part of the Exoplanet Research Experience at ASU, we collaborated with NASA's Exoplanet Watch, a citizen science project, to study the exoplanet Qatar-4 b. We obtained 59 nights of images for Qatar-4 b using the ground-based MicroObservatory telescope network managed by the Harvard-Smithsonian Center for Astrophysics (CfA). We used Exoplanet Watch's EXOPlanet Transit Interpretation Code (EXOTIC) Python Library to extract 17 significant light curves from the data set. Our study reduced the propagated uncertainty of Qatar-4b's mid-transit time significantly compared to previous studies. This effort underscores the importance of citizen science participation in exoplanet research by demonstrating that repeated observations taken by smaller, ground-based telescopes can meaningfully assist space-borne telescopes in transit-time photometry and assist in the better scheduling of future observations.

Samuel Courville, Arizona State University
“Dynamic Habitability of Ceres"

Ceres, a dwarf planet and the largest object in the asteroid belt, has surface mineralogy that indicates an aqueous past. Observations from NASA's Dawn mission suggest that Ceres likely hosted a global subsurface ocean in its early history, which was the site of pervasive aqueous alteration of accreted material. Environmental constraints placed on Ceres surface mineralogy, combined with Ceres’s large abundance of carbon, suggest that the dwarf planet may have been habitable for microbial life. We present the first coupled chemical and thermal evolution model tracking Ceres’s ocean environment through time. The dehydration of silicates and the destabilization of carbonates in Ceres’ core, if core temperatures reached $\gtrsim$700 K, would have produced conditions favorable for habitability. The metamorphic volatiles would have introduced redox disequilibrium into the ocean, a source of chemical energy for chemotrophs. We find that this period would have occurred between ~0.5–2 Gyrs after Ceres’s formation. Since then, Ceres’s ocean has likely become a cold, concentrated brine with fewer sources of energy, making it less likely to be habitable at present.

Kadin Pulliam, Arizona State University
“Exploring the Dynamics of Cell Morphology and Organic Carbon Concentration”

The environments that microbial life exists within vary over time, and microbes are capable of adapting to these changes to survive. Characterizing the physical adaptations microbial organisms employ in response to changing conditions is integral to better understanding how microbial life can adapt to extreme circumstances on other planetary bodies. In an effort to investigate the relationship between cell density, size, and shape with changing organic carbon concentration and temperature, Pseudomonas putida cultures were grown under different conditions then analyzed. The physical responses of these P. putida cells were quantified by staining fixed samples to perform cell counts and make measurements using ultraviolet fluorescence microscopy and DAIME, a microscopy image software. Cell physicality did not significantly change in carbon ideal conditions at 30 degrees Celsius, but cell physicality did significantly change over time in carbon limited conditions and at 15 degrees Celsius. Our work visually communicates how P. putida cells physically respond to variable organic carbon supply and temperature in their environment.

Jothiradithya (Sai) Konduru, Arizona State University

"Probing Supermassive Dark Stars: Evidence from High-Redshift JWST Observations"

Supermassive Dark Stars (SMDS), theoretical first-generation stars powered by dark matter annihilation, hold the key to transforming the science of cosmic evolution and supermassive black hole formation. With JWST photometric observations, I identified six high-redshift ($z > 11$) SMDS candidates with a novel photometric selection technique. Their small flux radii (≤ 0.04 arcseconds) exclude early galaxy models, as SMDS theory predicts. To verify these detections, I conducted a chi-squared (χ^2) statistical test, showing fair to strong conformity ($0.9 < p < 0.95$) between model predictions and observed flux for five candidates. IDs 901 and 2145 exhibit strong conformity to SMDS theory. Independent confirmation by Katherine Freese, detecting similar SMDS candidates in the JADES survey, confirms these detections. Small flux radius variability and photometric redshift errors were identified but have negligible impact on overall classification. Future follow-up spectroscopic and morphological studies will further verify candidates. This work provides strong evidence that SMDS could have been the dominant driver of early cosmic structure formation and supermassive black hole evolution, opposite to traditional galaxy formation chronologies.

Connor Wilson, University of Arizona

"How Do Clades Rise to Planetary-Scale Impacts on Habitability? A Case Study in the Land Plants"

The evolution of planetary habitability through time is likely a key control on the distribution of biospheres in the universe. A central question is how and when life itself impacts habitability. On Earth, the rise of the land plants (Embryophyta) had dramatic impacts on the Earth system, altering surface processes, changing the climate, and remaking terrestrial ecology. Evolution towards larger body sizes (a common pattern across the tree of life, known as Cope's rule) is hypothesized to be one of the driving forces behind the changing role of plants in the Earth system. Here, using a combined Earth system modeling--ecophysiology approach, we investigate how the contribution of plants in the Earth system has changed through deep time due to Cope's rule. We modify a dynamic vegetation model using estimates of maximum plant size derived from fossils to calculate how Cope's rule impacted terrestrial plant biomass through time. Downstream effects on terrestrial silicate weathering and organic carbon burial are also calculated and compared to other Earth system fluxes. Our analyses indicate that evolutionary trends in body size were a major determinant of how and when the land plants rose to be a planetary-scale force on the Earth system.

Oral Session II Abstracts

Sam Nasreldine, University of Arizona
“Assessing Biotic Scenarios to Explain Enceladus Plume Observations”

Enceladus promising candidate for life in the solar system (water, heat, organics). H2-methanogens powered by H2 produced by serpentinization have been showed as a possible biotic explanation to match plume composition. However, recent studies cast skepticism on the plausibility for sustained serpentinization as a source of H2. This raises the question: does the particularly high astrobiological interest for Enceladus rely entirely on the assumption that serpentinization (i.e chemical alteration of rocks) still occurs and has done so for a certain amount of time? Or can other scenarios for a biosphere in Enceladus's ocean be considered under the current knowledge of Enceladus's interior, past history, and plume composition?

Emma Guina, Arizona State University
“A Panspermia Origin For Venus Cloud Life”

Decades of study have hinted at the astrobiological potential of Venus’s cloud layers. The usual story is that the Venusian surface was clement in the past, and as the climate changed, life migrated into the last habitable niche—the altitudes above ~50 km with Earth-like temperatures and pressures today. Here, we explore the alternative possibility that life was delivered to Venus’s clouds from Earth or Mars (“panspermia”). This requires a microbe-containing bolide to enter the atmosphere without experiencing complete sterilization and then be dispersed at high altitudes in fragments small enough to dwell in the clouds. We adapt a widely used model of bolide-atmosphere interaction to investigate the fate of bolides delivered to Venus from Earth and Mars. Starting at the top of the atmosphere, bolides suffer ablation and fragmentation. Aerodynamic drag spreads these fragments horizontally, forming a “pancake” with an increased effective cross-section, causing rapid deceleration. An airburst occurs when the bolide deposits its highest amount of kinetic energy into the atmosphere. Observations of terrestrial meteorites provide scaling laws for the distribution of post-airburst fragment sizes. Inspired by the “Venus Life Equation,” presented by Izenberg et al. (2021), we present a framework for calculating the rate at which panspermia delivers microbes to the clouds of Venus. Our best estimate is an average of ~10 microbes per Earth-year. Whether these microbes can survive and thrive in their new home remains an open question.

Alexander Sastokas, Arizona State University
"Experimental Evolution Reveals Biophysical Constraints on Cell Size and Density"

Experimental evolutions allow extensive study of how extreme environmental changes shape fitness-related phenotypes. However, few evolution experiments have explored how biophysical constraints shape phenotypic outcomes. To address this gap, we conducted a large-scale experimental evolution to investigate and push the biophysical limitations of cell size, in order to study how cell size constrains other phenotypes. We performed a massively parallel experimental evolution using a barcoded library of over 300,000 unique Saccharomyces cerevisiae isolates, subjecting cells to size-selection pressure. Through this evolution, we uncovered a diverse array of mutations associated with increased cell size, including changes in ploidy, chromosomal duplications, and single-nucleotide mutations. These mutations predominantly affect membrane transport, vacuole size, and mitochondrial function. Despite differences in the genetic mechanisms driving cell size increase, we observed a consistent trend: as cell size increased, cell density decreased. Extending our analysis beyond S. cerevisiae, we found that cell density appears to be correlated with cell size across the tree of life, reinforcing our observed trend whereby cell density decreases in larger cells. Our study demonstrates how experimental evolution can reveal biophysical constraints in cellular evolution when exposed to extreme environments. Additionally, our study of a scaling relationship between cell density and cell size, noticed across the tree of life, can play an important factor in predicting how new environments can affect or change in cell biology.

Veronica Klawender, University of Arizona
"Viability of Methanogens in the Ice Shell of Europa"

In the search for extraterrestrial life, one major obstacle is the definition of habitability, given the fact that certain metabolic processes are more viable in some environments than others. One method of overcoming this obstacle is to evaluate certain terrestrial metabolisms in the chosen environment, using constrained parameters for both the habitat and organism. These parameters can include the measured or expected temperature, pressure, pH, and salinity of an exoplanet environment, and the correlating known ranges of each for a given terrestrial organism. The Quantitative Habitability Framework (QHF) is a program created to efficiently compare habitat and metabolic conditions, and predict the viability of a metabolism in that environment given a distribution of parameters (Apai et al. in prep). This study utilizes the QHF to evaluate the probability of survival of a population of psychrophilic methanogens within the ice shell of Europa in lenses of liquid water which may form beneath chaos regions. Given the recent launch of the Europa Clipper, the existing simulations predicting conditions on Europa, and the abundance of literature on extremophilic methanogens, this exercise of the QHF can inform future research missions as to easy-access locations across Europa which have the potential to harbor life. We find that using basic environmental parameters a population of methanogenic organisms like those on Earth show a highly variable viability in the simulated environment which is strongly affected by the potential distributions of pH and temperature within the ice shell.

Parker Crossland, Arizona State University

“Single-Cell Resolution of Rare Adaptive Mutations in Evolving Microbial Populations: Implications for Astrobiology”

Understanding how microbial populations adapt to extreme environments is crucial to both evolutionary biology and astrobiology. Traditional sequencing methods often fail to capture low-frequency variants, limiting our understanding of rare but impactful genetic changes. These limitations are particularly significant when studying microbial adaptation in harsh environments, where rare genotypes can be key to survival and ecological resilience. We introduce Fluorescent Labeling for Intracellular Genomics (FLInG) to overcome these challenges. This novel method combines intracellular genome amplification with fluorescence-activated cell sorting (FACS) to enable single-cell whole-genome sequencing of rare adaptive variants. By preserving haplotype information and linking mutations to individual cells, FLInG provides unprecedented resolution in tracking rare adaptive mutations that would be missed with traditional bulk sequencing. We demonstrate the power of FLInG by applying it to experimental evolution in Saccharomyces cerevisiae, revealing adaptive mutations conferring drug resistance that were undetectable using conventional sequencing approaches. This ability to resolve rare genotypes at the single-cell level has broad implications, including refining population genetics models and advancing our understanding of evolutionary dynamics. FLInG’s potential extends beyond terrestrial applications, making it a valuable tool in astrobiology. By enabling the study of microbial adaptation in extreme environments, such as acidic hot springs that serve as analogs for Mars, FLInG can help us investigate how microbial life might persist and adapt in extraterrestrial settings. This method offers a new way to explore genetic diversity in extremophiles and reconstruct evolutionary trajectories, providing insights into the potential for life in environments beyond Earth.

Rizal Hariadi, Arizona State University

Hydrodynamically-Active Oily Ocean Surface as a Cradle for the Emergence of Life”

Geophysical settings that support the synthesis of the building blocks of life, concentrate information-carrying molecules, and enable simple forms of self-replication and Darwinian evolution are candidates for the birthplace of life. In this context, tide pools, closed basins, and hydrothermal vents are attractive, as experimental work in prebiotic chemistry suggests these settings can support the synthesis of complex organic compounds. However, organic compounds produced in these environments are prone to dispersal and burial, hindering the accumulation necessary for the initiation of Darwinian evolution. Here, we propose and provide experimental support for an oily, hydrodynamically active ocean surface as the setting where life could have emerged—an environment capable of supporting the birth, growth, self-replication, and death of oil droplets. We hypothesize that oil formed from organic compounds produced through the maturation of buried micrometeorite organic carbon, in a process analogous to modern oil formation from biological sources. These hydrocarbons, having lower density than water and rock, seep upward through pores and fractures to form oil slicks on the ocean surface, which are confined by ocean gyres far from shore, allowing accumulation. Hydrodynamic forces from rainfall or breaking waves generate oil droplets whose surfaces offer anchoring points for molecular machinery. Through growth by scavenging organic compounds and by hydrodynamic fission, these droplets provide a system in which natural selection can act on droplet composition, with individuality preserved as long as droplet fusion is suppressed. A global geophysical perspective points to this energetically active, oily ocean surface as the birthplace of life, mirroring modern analogs of oil slicks produced by natural seeps. Laboratory experiments confirm key elements of this hypothesis—droplet formation, growth, and fission—and reveal that raindrop impacts can encapsulate seawater within oil droplets, suggesting a route from oil droplet life to modern biology.

Additional Resources

Contact Information

Organizers
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Links
Website: azabsymposium.github.io
Email: arizonaastrobiology@gmail.com
Slack:https://join.slack.com/t/arizonaastrobiology/shared_invite/zt-29bcmm93p-HagmE0QCYVXbARW60yMrlg
Instagram: @azabsymposium

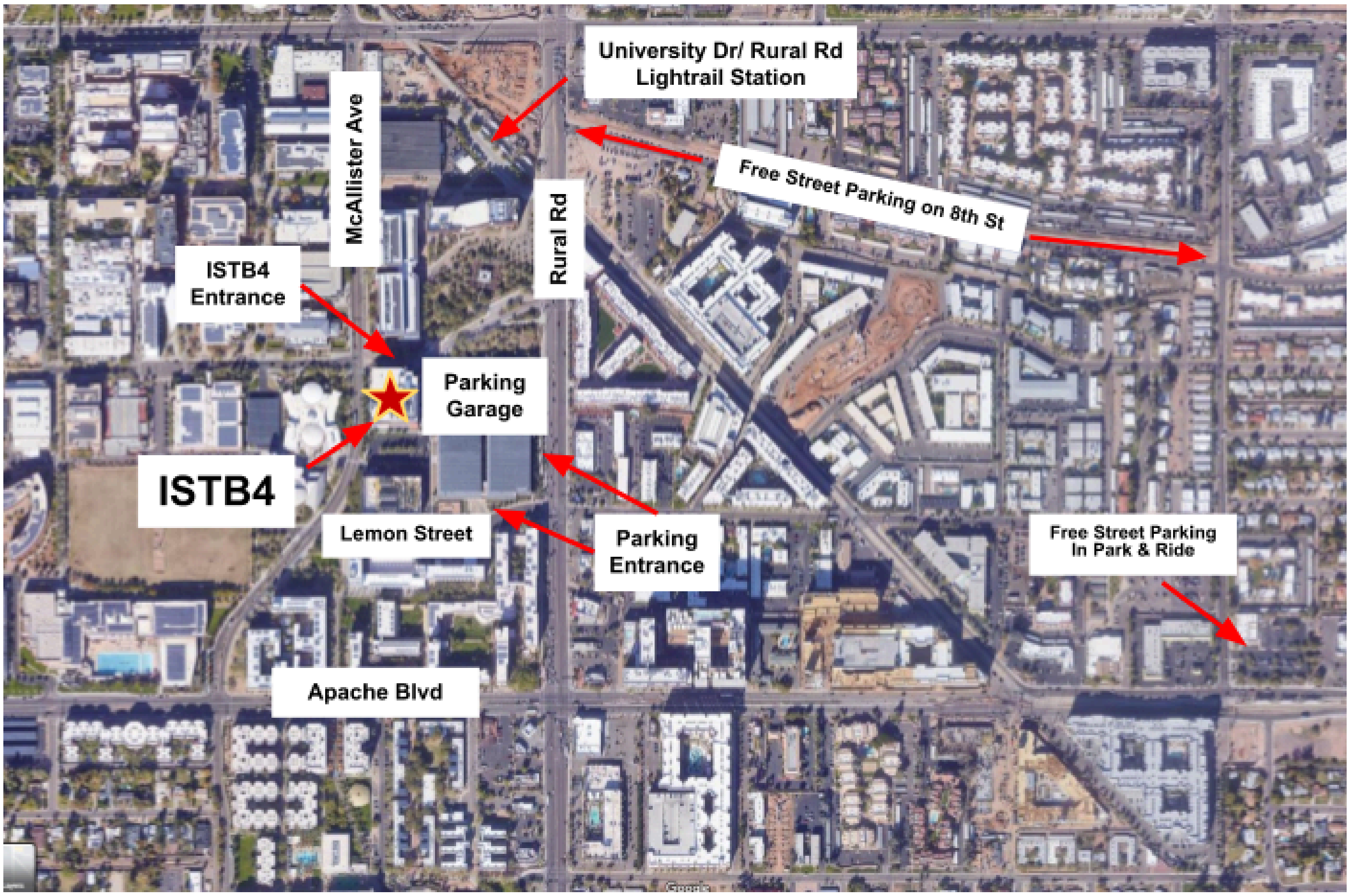
Accessibility

ISTB4 is a modern building with no stairs to the entrance, and has easily locatable elevators. Requests for accommodations and/or accessibility information can be submitted anonymously through this form: https://forms.gle/vQdFrCy3ma1VWX6E9

Location and Parking

For those attending in person, all symposium events will take place on the ASU Tempe campus in building ISTB4 (781 S Terrace Rd, Tempe).

Parking on campus is $16/day (Parking Garage in image below). Free parking can be found along 8th Street and at the Dorsey/Apache park and ride (~12 min walk).



Meal + Drink Options

Food Delivery
DoorDash, UberEats, GrubHub

Within ISTB4	
Vending machines (drinks and snacks)	Accepts cash and cards First floor near the restrooms
Water fountains	On every floor near the restrooms

Coffee + Refreshments		
Place	**Location**	**Hours**
Charlie's Cafe	Biodesign Bldg, 727 E Tyler St	Friday: 7 am – 5 pm Saturday: Closed
Dutch Bros Coffee	1037 S Rural Rd	Friday: 5 am – 2 am Saturday: 5 am – 2 am
Starbucks	Hassayampa Res. Bldg	Friday: 9 am – 3 pm Saturday: 9 am – 3 pm

Near ISTB4 (~5 minute walk)		
Place	**Location**	**Hours**
Einstein Bros Bagels	1100 S McAllister Ave, Tempe, AZ 85281	Friday: 7:30 am – 3 pm Saturday: Closed
Taco Boys	1015 S Rural Rd #101	Friday: 10 am – 1 am Saturday: 10 am – 1 am
Board & Brew	1015 S Rural Rd #105	Friday: 10:30 am – 9 pm Saturday: 10:30 am – 9 pm
The Halal Guys	1015 S Rural Rd #104	Friday: 9 am – 5 pm Saturday: Closed
Ahipoki Bowl	1015 S Rural Rd	Friday: 11 am – 9 pm Saturday: 11 am – 9 pm

Thai Basil	1111 S Rural Rd	Friday: 11 am – 10 pm Saturday: 11 am – 10 pm
Subway	Hassayampa Res. Bldg	Friday: 10 am – 10 pm Saturday: 10 am – 9 pm

Memorial Union options (~10 minute walk) 301 E Orange St., Tempe, AZ 85281 * can pre-order at some locations with GrubHub	
Place	**Hours**
Pei Wei	Friday: 10 AM–6 PM Saturday: Closed
QDOBA Mexican Eats	Friday: 10 AM–8 PM Saturday: 10 AM–8 PM
Burger King	Friday: 7 AM–9 PM Saturday: 10 AM–4 PM
Subway	Friday: 7 AM–10 PM Saturday: 10 AM–9 PM
Einstein Bros Bagels	Friday: 7 AM–2:30 PM Saturday: 11 AM–2 PM

Code of Conduct Additional Information

Misconduct

1. Title IX Violation
    a. The collective term used for incidents involving discrimination, harassment, sexual harassment, sexual violence, stalking, dating violence, domestic violence, and/or retaliation.
2. Discrimination
    a. Whether intentional or not, unequal or unfair treatment as it relates to marginalized identities, including but not limited to:
        i. Race, Gender, Sexual orientation, Ability, Religion, Age, National origin, Documentation status, Education
3. Harassment
    a. Unwanted actions, words, or physical conduct, which may include epithets, slurs, or negative stereotyping based on identity. Harassment often makes the receiving person feel uncomfortable or unsafe and has the purpose or effect of violating, marginalizing, and interfering with an individual, their dignity, or their work performance, creating an intimidating, threatening, hostile, degrading, humiliating, or offensive environment.
    b. Harassment can also include microaggressions, which are everyday verbal, nonverbal, and environmental slights, snubs, or insults which communicate hostile, derogatory, or negative messages to target persons based on their marginalized identity. Microaggressions are less overt and may also occur in well-intentioned individuals who are unaware that they have engaged in an offensive act or made an offensive statement.
4. Violence
    a. Sexual, Physical, Verbal, Emotional
5. Stalking
    a. Repeatedly following, harassing, threatening, or intimidating another person via phone, mail, electronic communication, or social media.
6. Bullying
    a. The repeated use of force, threat, or coercion to abuse, intimidate, or purposefully dominate others based on a real or perceived power imbalance. These actions can include abusive criticism, humiliation, the spreading of rumors, physical and verbal attacks, isolation, undermining, and exclusion of individuals through any means.
7. Retaliation
    a. Adverse employment, academic consequences, or other actions against anyone reporting a violation of this policy.

Support for those affected by misconduct

1. If you are targeted or observe discrimination at the symposium (in person or virtual) you can communicate it to any of the symposium organizers.
    a. We will have a private conversation removed from the symposium spaces (both in person and virtually).
    b. We will listen, validate, and affirm you and your experience, and if you are not the person who was harmed, we will ask you if the person who was harmed would also like to receive our support.
    c. We will ask if the person who was harmed would like the person who did the harm to be held accountable, and if so, what that would look like.
    d. We will not speak to or act directly with the person who did the harm without explicit consent from the person who was harmed.
2. We recognize that not everyone is protected if they report their experience. So, if you would like to **report misconduct anonymously, please fill out this google form:** https://forms.gle/PT1sWKRjgWwCDK256
    a. The information provided in this report will not be disseminated and access to the form will be limited to the community care facilitators.
    b. Any personal information provided will be kept confidential and the person who did the harm will not be approached without explicit consent from the person who was targeted.
    c. All information reported will be deleted upon completion of the symposium.
3. For those affected by the above misconduct, please seek affirmation and support from your community and those you can trust.
    a. We know communicating about experiences is not an option for everyone and another way to receive support is through already established relationships with close friends and/or (chosen) family.

Emergency Resources

If you are in need of help at any point during the symposium, please refer to the following resources.

1. In the event of a medical emergency or life-threatening situation, please call 911 immediately.
2. Don't Call the Police Phoenix Resources
    a. Alternatives to calling the police and resources for supporting the immediate needs of people in crisis in AZ
3. Crisis Response Network
    a. 24/7 AZ crisis call, text, and online chat lines as well as warm line interactions with crisis intervention specialists
    b. Mobile crisis dispatchers available to provide immediate in person assistance if necessary
4. La Frontera Arizona
    a. 24/7 AZ crisis, sexual assault, and veteran hotline
    b. Mobile Crisis Team is available to provide face to face services in Tempe if immediate assistance is necessary
5. StrongHearts Native Helpline
    a. 24/7 confidential and anonymous culturally-appropriate domestic and sexual violence call or online chat helpline for Native Americans
6. 988 Suicide & Crisis Hotline
    a. 24/7 national call or text crisis line with resources for specific marginalized identities
7. THRIVE Lifeline
    a. 24/7 international text-based crisis line staffed by and for people with marginalized identities in STEMM
8. Direct Communication in Conflict
    a. How to have an effective conversation when in conflict with another person.