F. STUDENT-FACULTY RESEARCH: SUMMER AND ACADEMIC YEAR

Summaries, Articles, Photo Gallery and Research Descriptions

DURING THE PAST 5 YEARS

FOR THE COLLEGE OF SCIENCE & MATHEMATICS

592 PUBLICATIONS

455 UNDERGRADUATE STUDENTS
are co-authors on those publications

43% OF 2020 PUBLICATIONS
have undergraduate student co-authors

UNDERGRADUATE RESEARCH

IN THE COLLEGE OF SCIENCE AND MATHEMATICS

We estimate that half of approximately 2,500 undergraduate students in the College of Science and Mathematics are involved in undergraduate research each year. Our summer research program, supported by the Frost Fund and external grants, continues to be a sought-after experience by students. Many students make significant annual commitments to research not only in the summer but throughout the academic year, and publication data suggests their efforts are resulting in increasing achievement.

For example, in the last five years, research in the College of Science and Mathematics has yielded 592 publications, 181 of which had a total of 455 undergraduate co-authors. In the first three of these years, 26% of publications had undergraduate co-authors. However, during 2019, 40% were co-authored by undergraduates and for 2020, 43 of the 100 publications had 138 undergraduate co-authors. This represents strong external validation of our undergraduate research efforts and demonstrates the increasing commitment and quality of involvement of undergraduates in faculty mentored research.

2021 FROST SUMMER RESEARCH

A THRIVING AND PRODUCTIVE PROGRAM

Summer research represents a very special experience for our students and hundreds have participated since establishment of the Frost Fund in 2017 and before. Summer 2020 posed an exceptional challenge with the requirement of isolation due to the COVID pandemic. However, beginning in the fall, the university was able to establish safety protocols that allowed students and faculty mentors to return to their labs and research venues even though most of formal instruction during the 2020-21 academic year was presented remotely.

Our summer 2021 research program was conducted normally with the exception that students wore masks when indoors. We didn't hold significant social events, and the end of summer department symposia, where students presented their work, were conducted remotely by Zoom.

The Frost 2021 Summer Research Program involved 421 undergraduates. Of these 276 were full time; 198 were Frost Summer Research Fellows supported with $3,500 stipends and 78 were supported by a variety of external grants. The remaining 145 were either volunteers or part-time participants, some supported by

2021 FROST SUMMER RESEARCH PROGRAM TOTALS

421 UNDERGRADUATE STUDENTS
involved with Frost Summer Research

198 FROST RESEARCH FELLOWS

97 FACULTY RESEARCH MENTORS

RESEARCH PARTICIPATION BY DEPARTMENT

THE FOLLOWING DATA SHOWS THE NUMBER OF STUDENTS AND FACULTY MENTORS

421 TOTAL UNDERGRADUATE PARTICIPANTS

BIOLOGICAL SCIENCES	PARTICIPANTS
FROST RESEARCH FELLOWS	49
FACULTY MENTORS	29
FULL-TIME RESEARCH STUDENTS SUPPORTED BY GRANTS	33
PART-TIME AND VOLUNTEER RESEARCH STUDENTS	34
TOTALS	**145**

BIOLOGICAL SCIENCES GRANT FUNDING SOURCES:

- National Science Foundation
- Santa Rosa Creek Foundation
- STEM Teacher and Research (STAR) Program
- CSU Council on Ocean Affairs, Science & Technology (COAST)
- Cuesta College Research Internship Program
- Doris A. Howell Foundation
- CSU Program for Education & Research in Biotechnology (CSUPERB) Research Scholar Award
- Robert Noyce Teacher Scholarship Program / National Science

CHEMISTRY + BIOCHEMISTRY	PARTICIPANTS
FROST RESEARCH FELLOWS	50
FACULTY MENTORS	23
FULL-TIME RESEARCH STUDENTS SUPPORTED BY GRANTS	36
PART-TIME AND VOLUNTEER RESEARCH STUDENTS	8
TOTALS	**117**

CHEMISTRY AND BIOCHEMISTRY GRANT FUNDING SOURCES:

- ACS Petroleum Research Fund
- Lawrence Livermore National Lab
- Middlebury College
- Western Coatings Technology Center
- Golden Gate Society for Coatings Technology
- Cal Poly Research, Scholarly, and Creative Activities Grant Program (RSCA)
- CSU Program for Education & Research in Biotechnology (CSUPERB)

KINESIOLOGY + PUBLIC HEALTH	PARTICIPANTS
FROST RESEARCH FELLOWS	20
FACULTY MENTORS	10
FULL-TIME RESEARCH STUDENTS SUPPORTED BY GRANTS	3
PART-TIME AND VOLUNTEER RESEARCH STUDENTS	67
TOTALS	**80**

KINESIOLOGY AND PUBLIC HEALTH GRANT FUNDING SOURCES:

- National Institutes of Health (NIH) / Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD)
- Public Interest Technology University Network (PIT-UN)
- American Diabetes Association (ADA)
- National Science Foundation (NSF) / Louis Stokes Alliances for Minority Participation (LSAMP)
- Cal Poly Strategic Research Initiatives (SRI) Program
- Community Health Resources (CHR)

LIBERAL STUDIES	PARTICIPANTS
FROST RESEARCH FELLOWS	10
FACULTY MENTORS	6
FULL-TIME RESEARCH STUDENTS SUPPORTED BY GRANTS	0
PART-TIME AND VOLUNTEER RESEARCH STUDENTS	0
TOTALS	**16**

MATHEMATICS	PARTICIPANTS
FROST RESEARCH FELLOWS	20
FACULTY MENTORS	7
FULL-TIME RESEARCH STUDENTS SUPPORTED BY GRANTS	0
PART-TIME AND VOLUNTEER RESEARCH STUDENTS	0
TOTALS	**27**

MATHEMATICS GRANT FUNDING SOURCES:

- National Science Foundation (NSF)

PHYSICS	PARTICIPANTS
FROST RESEARCH FELLOWS	XX
FACULTY MENTORS	XX
FULL-TIME RESEARCH STUDENTS SUPPORTED BY GRANTS	XX
PART-TIME AND VOLUNTEER RESEARCH STUDENTS	XX
TOTALS	**XX**

PHYSICS GRANT FUNDING SOURCES:

- National Science Foundation (NSF)
- Alfred P. Sloan Foundation
- Helmsley Charitable Trust
- U.S. Department of Energy
- Central and Northern California Ocean Observing System (CeNCOOS): Integrating Marine Observations
- Restore America's Estuaries (RAE) / National Estuary Program Coastal Watersheds Grant (NEP CWG)
- Southern California Coastal Ocean Observing System (SCCOOS)
- Loughborough University

STATISTICS	PARTICIPANTS
FROST RESEARCH FELLOWS	XX
FACULTY MENTORS	XX
FULL-TIME RESEARCH STUDENTS SUPPORTED BY GRANTS	XX
PART-TIME AND VOLUNTEER RESEARCH STUDENTS	XX
TOTALS	**XX**

STATISTICS GRANT FUNDING SOURCES:

- National Science Foundation (NSF) / Louis Stokes Alliances for Minority Participation (LSAMP)
- Santa Rosa Creek Foundation
- National Institutes of Health (NIH)
- Cal Poly Mustang Success Center

FOCUSING ON

PEOPLE, HEALTH AND EMPOWERMENT

Even before public health and the inequities in the U.S. healthcare system became headline news, Cal Poly's Center for Health Research was exploring ways to increase access to health care on the Central Coast. With base funding from the university's Strategic Research Initiatives program, they developed Mi Gente, Nuestra Salud, which translates to My People, Our Health.

The year-old program aims to give marginalized community members in Santa Maria and Guadalupe the resources and knowledge they need to take ownership of their health. As research assistants for the program, Frost Research Fellows and students from a variety of majors discover firsthand who the barriers that many people face to accessing healthcare and what efforts are sometimes necessary to connect communities to healthcare.

"This is a wonderful opportunity for our student researchers to be part of creating a community-centered healthcare network from the ground up," said Suzanne Phelan, a kinesiology and public health professor who co-leads the project. "The Frost Fund support is so important because it allows these students to spend the summer collecting data in the field they're passionate about instead of having to take a summer job that doesn't further their careers."

In previous public health surveys from sources such as the census and the city of Santa Maria, data wasn't collected for certain groups in the community for multiple reasons. Perhaps people spoke only Mixteco, rather than Spanish or English, or never had the opportunity to become literate, or maybe they were undocumented and feared that their responses might put them in danger.

Students and their faculty mentors developed a survey to fill in the gaps in the existing data sets.

"Before the project started, the students looked into what we know about the health status of the Santa Maria community," said Marilyn Tseng, an epidemiologist and professor in the Kinesiology and Public Health Department. "We were trying to capture those voices that aren't captured in typical surveys." Tseng co-leads the project with Phelan and Cuesta College professor Mario Espinoza-Kulick.

After creating the survey, students discovered what it takes to reach out to a marginalized population. They translated the survey into Spanish and took paper copies to people waiting in their cars to pick up food at a distribution site at Allan Hancock College. Sometimes they read the surveys aloud to community members. When they saw that the survey was too long for people to finish, they changed the questions based on community feedback.

"This research method centers and respects the people with whom you're doing research," Tseng said. "It's listening to the participants for what they think is important."

The data the students collected will be used to identify the community's major health needs and decide how to address them. As they move forward together, students, faculty, staff and community members will become partners in public health.

"I'm proud of my work in MGNS because we designed the project to empower community members to play a role in their own wellbeing and let them show us where resources need to be allocated," said student researcher Irma Torres. "We are attempting to do something about these disparities, not just show that they exist."

“

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~ Irma Torres, ‘21 graduate of public health

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Joyce Lin (left) and Brady Berg (right).

THE HEART OF RESEARCH

Every time your heart beats, a myriad of mathematical equations are in play. For instance, cardiac output is VO2 = Q(Ca -Cv). Mean arterial pressure = diastolic pressure + 1/3 x pulse pressure. Those equations are our lifeblood, literally.

Conversely, when a heart stops beating, other lesser known mathematical equations come into play — and that is what Frost Summer Undergraduate Research groups led by math professors Joyce Lin and Elena Dimitrova are focused on. Their research may potentially provide useful information on the physiological parameters related to cardiac arrhythmia. With heart attacks occurring every 40 seconds in the U.S., according to the Centers for Disease Control and Prevention (CDC), a better understanding of what causes them could prove valuable to the prevention of sudden cardiac arrests and fatalities.

Essentially, the research required a two-pronged approach. One team — with third-year computer science student Srirag Vuppala and Frost Research Fellow and fourth-year math student Aidan Chandrasekaran — worked on developing a mean-field derivation for a microdomain model, an effort well-matched with Lin's expertise. A second team — with Lin, master's student Joseph McGuire and Brady Berg, a Frost Research Fellow and fifth-year student double-majoring in math and biomedical engineering — worked on developing a novel model for cardiac tissue using agent-based modeling, an effort well-matched with Dimitrova's expertise.

The first team studied electrical activity within cardiac tissue — in particular, targeting microdomain information. Microdomains are small regions of a cell

FOCUSING ON	
JOYCE LIN & ELENA DIMITROVA	FROST RESEARCH FACULTY
BRADY BERG	FROST RESEARCH FELLOW
AIDAN CHANDRASEKARAN	FROST RESEARCH FELLOW
JOSEPH MCGUIRE	GRADUATE RESEARCHER
SRIRAG VUPPALA	UNDERGRADUATE RESEARCHER

> Even though this work is labeled as math, it's really an intersection between math, biology and computer science — more of interdisciplinary type research, and that's exciting.
>
> *~Aidan Chandrasekaran*
> *Frost Research Fellow and fourth-year math student*

Srirag Vuppala (left) and Aidan Chandrasekaran (right).

membrane with distinct structures and functions. "These tiny features of the cells, the intracellular and extracellular spaces, contribute a non-negligible amount to how electrical activity moves through the heart," explains Lin.

A previous graduate student had generated equations describing heart tissue by homogenizing a microdomain model established by Lin. Next, Chandrasekaran and Vuppala translated those equations into computerized numerical solutions. This process involved altering equations mathematically for writing specialized code. Developing that code allowed them to further the simulation process — an important step in producing useful modeling and analysis. Armed with the resulting experimental data to compare to already-published models and simulations, the group plans to write up their own manuscript to be published.

The second group are building agent-based modeling for electrical activity in cardiac tissue, and are the first known researchers to do so. Their agent-based modeling takes the form of computational simulations of cardiac tissue microdomain activity. In the case of their specific research effort, the agent would be ions.

With these microscale models, the group strives to recreate and predict cellular behavior related to heart attacks. "It's an attempt to very realistically mimic the system, knowing that everything is based on local rules," said Dimitrova. "In this way, we can capture emergent behavior, which is very difficult to capture otherwise."

By creating a computer simulation rather than a mathematical model, they can see results and data with more efficiency, shortening a months-long process that normally would use a system of partial differential equations.

"Brady and Joseph are particularly well-suited for this work because they're pretty advanced," said Lin. McGuire is in his second year of graduate work, and Berg has the research experience of a graduate student. While Berg is technically an undergraduate, he has worked with a previous Frost Summer Undergraduate Research group led by math professor Dana Paquin.

As each of the four students have found, hands-on research can leave an imprint on many areas — their professional paths, their enthusiasm and scientific breakthrough possibilities.

For Chandrasekaran, his perspective was broadened from taking theoretical knowledge from the abstract to applied usage, and from working with a fusion of disciplines. "I had to learn about the heart, and then incorporate math into it," said Chandrasekaran. "Even though this work is labeled as math, it's really an intersection between math, biology and computer science — more of interdisciplinary type research, and that's exciting."

Vuppala felt similarly, but for a different reason. "This research on cracking what causes a heart attack could potentially be very helpful to a person who can use our findings to develop something that could basically eradicate heart disease and remove the possibility of heart attacks," said Vuppala. "The possibility of that — it's pretty exciting for me."

Indeed, such a breakthrough would be exciting for all of us, with origins traced back to four talented Cal Poly students, two exceptional professors and one impactful summer research program.

From left: Joseph McGuire, Brady Berg, Elena Dimitrova and Joyce Lin.