UNIVERSITY OF CALIFORNIA, MERCED

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2026 SURI Research Symposium

Presenter Abstract Booklet
Undergraduate Research Opportunities Center

Celebrating undergraduate inquiry, discovery, and the research community at UC Merced.

2026

SURI

Contents

Presenters are grouped alphabetically by research program and then by presenter last name.

UROC LEADERSHIP & STAFF

Patricia Soto, PhD

DIRECTOR

BIOGRAPHY

Patricia Soto, PhD, is the Director of Undergraduate Research at UC Merced. Formerly a professor of physics at Creighton University, she built a thriving molecular biophysics research group composed entirely of undergraduates. Her students co-authored peer-reviewed publications, shared their discoveries at national conferences, and launched successful careers in science, medicine, and industry. Recognized with numerous awards throughout her international academic journey, Dr. Soto now brings this experience to UC Merced, dedicated to creating transformative research opportunities for students across all disciplines. Nationally, she advances undergraduate research and education in the biophysics and physics communities. Her vision is to inspire students whose curiosity, creativity, and integrity will shape the future of knowledge.

UROC LEADERSHIP & STAFF

Hannah Escobar, MS

PROGRAM COORDINATOR

BIOGRAPHY

As a UROC Program Coordinator, Hannah is thrilled to bring her experience to the team. With a B.A. in Criminal Justice Law Enforcement from Stanislaus State University and nearly five years in education, she has a strong foundation in guiding and advocating for students. After earning her M.A. in Higher Education from Grand Canyon University, Hannah's passion for student success and inclusive practices continues to shine. Raised in the vibrant and diverse borough of Brooklyn, New York, she brings a deep appreciation for equity and cultural awareness to her work. Outside the office, Hannah enjoys spending time with her fiancé and their two cats, Spring and Summer, as they prepare for their upcoming wedding this November.

UROC LEADERSHIP & STAFF

Diana Hernandez Garcia, MPA

COORDINATOR

BIOGRAPHY

Diana Hernandez Garcia is a Coordinator for UCDC, UC LEADS, and SURF. She was born in Guadalajara, Mexico, and raised in Hawthorne and later Bakersfield, California. She earned a B.S. in Geology and an MPA at CSU Bakersfield. In her previous position, Diana was a Science Assistant at the National Science Foundation (NSF). Her favorite activity while at NSF was leading the Summer Scholars Internship Program, of which she is an alumna. Diana is grateful to have joined UROC, as she loves working to expand experiential learning opportunities for students through undergraduate research and internships.

UROC LEADERSHIP & STAFF

Aliyah McGuire, MS

COORDINATOR

BIOGRAPHY

Aliyah McGuire is a Coordinator for UROC-H, SOAR, CAMP, and UCCS. She completed her B.A. in International Studies - Linguistics at UC San Diego and later earned her master's degree in International and Multicultural Education from the University of San Francisco. She is interested in the lived experiences of students of color, the knowledge gained and produced through those stories, and is dedicated to access work in education. When not working, she can be found absorbing stories from books, video games, and podcasts or spending time with her loved ones.

UROC LEADERSHIP & STAFF

Horacio Aguilar

OUTREACH ADVISOR

BIOGRAPHY

As the UROC Outreach Advisor, Horacio is passionate about supporting underserved and underrepresented students from California's Central Valley. A native of Delhi - a small town just thirty minutes from Merced - Horacio is committed to giving back to the communities that shaped his upbringing. He holds a bachelor's degree in Business Marketing from California State University, Monterey Bay, and brings valuable experience from his time at institutions such as UC Berkeley and the Oakland Athletics organization. In his current role, Horacio is focused on expanding the reach and impact of the UROC program. Outside of work, he enjoys staying active, seeing his Packers run the North, or watching his San Francisco Giants blow a 3-1 lead.

GRADUATE MENTOR

Oyinkansola Amao

GRADUATE MENTOR

Chemistry and Biochemistry

BIOGRAPHY

Oyinkansola Amao is a rising second-year Ph.D. student in Chemistry and Biochemistry at the University of California, Merced. She holds a B.S. in Bioengineering with an emphasis in Biotechnology from the University of California, Merced. Her current research focuses on expressing and engineering heat shock proteins from heat-loving archaea in the Ceballos Lab, with the goal of building scalable production systems for these proteins in yeast. Known as chaperonins, these proteins self-assemble into ring-shaped complexes that protect other proteins from damage under extreme conditions. By re-engineering these complexes to bind and deliver enzymes, her work aims to enable new tools for agricultural and biotechnology applications, such as enhancing enzyme delivery in animal feed.

GRADUATE MENTOR

Eric Brooks

GRADUATE MENTOR

Bioengineering

BIOGRAPHY

Eric Brooks is a first-year Ph.D. student in the Bioengineering Graduate Program at the University of California, Merced, where he is co-advised by Professors Joel Spencer and Kara McCloskey. His research investigates how circulating bone marrow-derived progenitor cells home to and seed the thymus, the primary lymphoid organ responsible for T cell development, and how this process is disrupted following total body irradiation, a conditioning regimen commonly used before bone marrow transplantation. To address these questions, Eric is developing intravital two-photon microscopy techniques to visualize progenitor cell trafficking within the murine thymus and engineering a primary human cell-derived thymus-on-a-chip microfluidic platform to model thymic homing in vitro. His work aims to identify the cellular and molecular mechanisms underlying impaired thymic homing and to inform therapeutic strategies that enhance thymic regeneration and immune reconstitution following bone marrow transplantation.

GRADUATE MENTOR

Jonathan Chavez

GRADUATE MENTOR

Environmental Systems

BIOGRAPHY

Jonathan Chavez is a Ph.D. student in the Environmental Systems program in the Lopez-Arias Lab at the University of California, Merced. He holds a B.S. in Civil Engineering from UC Merced. His Ph.D. dissertation focuses on the sustainability and resilience of Ultra High-Performance Concrete (UHPC) for harsh marine environments, seismic resistance, and radiation shielding.

GRADUATE MENTOR

Precious Nyabami

GRADUATE MENTOR

Environmental Systems

BIOGRAPHY

Precious Nyabami is a first-year graduate student in Environmental Systems at the University of California, Merced, where she works in Dr. Asmeret Berhe's lab. Her research focuses on the persistence of carbon in post-wildfire ecosystems, particularly the role of soil mineralogy. Before beginning her Ph.D., she worked for three years in the Bay Area as a research associate and associate scientist. She values every opportunity to connect with fellow scientists, whether they are just starting out or further along in their journeys.

GRADUATE MENTOR

Daniel Valenzuela

GRADUATE MENTOR

Chemistry and Biochemistry

BIOGRAPHY

Daniel Valenzuela earned his B.S. and Ph.D. in Chemistry and Biochemistry at the University of California, Merced. He is also a proud UROC alumnus. His dissertation research focuses on the redox behavior and photocatalytic applications of gold nanoparticles, providing new methods and mechanistic insights into the thermodynamic and photocatalytic properties of metallic nanoparticles. These nanoscale catalysts exhibit unique chemical reactivity, and his work aims to support the development of more sustainable chemical processes driven by solar energy while minimizing hazardous waste.

Student Presenter Abstracts

Student profiles begin on the following page. Research abstracts are organized by program and presenter last name.

BOBCAT STEM SCHOLARS

Marissa Lopez

The Role of SAG-1 Membrane Anchoring in the Humoral Immune Response to Toxoplasma gondii

Faculty Research Mentor: Kirk Jensen

ABSTRACT

Toxoplasmosis, caused by the intracellular parasite Toxoplasma gondii, can infect warm-blooded animals, including humans. While rarely severe in healthy hosts, T. gondii infections pose significant risks to vulnerable populations including fetuses from pregnant women and immunocompromised individuals. Surface Antigen 1 (SAG-1) is the most abundant protein found on the surface of the parasite and is a significant target of the host's immune response, making it a strong candidate to test vaccine design principles . Former research conducted in our lab has demonstrated that SAG-1 anchorage plays an important role in triggering an immune response. In efforts to further investigate this, we will collect plasma from mice previously immunized with SAG1-GPI (attached), SAG1-TM (attached), and SecSAG-HA (not-attached, secreted) mRNA vaccines, that vary by whether the SAG-1 antigen is attached to the surface of cells or not. Using serotyping western blot and flow cytometry, we will evaluate the ability of antibodies to recognize and bind to different cells that express these three SAG-1 constructs, T. gondii and human HEK cells. By exposing parasite strains or cell lines expressing membrane-anchored SAG-1 or secreted SAG-1 , we can assess differences in antibody binding and cross-reactivity to SAG-1 antigens that differ by membrane attachment. These experiments will allow us to determine whether membrane anchorage enhances antigen recognition and promotes stronger humoral responses. Ultimately, this work will help clarify whether the observed lack of response in SecSAG-immunized mice is due specifically to the absence of membrane anchorage, providing further insight for optimizing mRNA vaccine strategies against T. gondii.

BOBCAT STEM SCHOLARS

Sithu Tun

Optimizing Expression and Purification of Soybean Lipoxygenase-1 for Structural and Spectroscopic Studies.

Faculty Research Mentor: Michael C. Thompson

ABSTRACT

Soybean lipoxygenase-1 (SLO) is a non-heme iron enzyme that serves as an important model for understanding proton-coupled electron transfer (PCET) in enzyme catalysis. SLO uses a non-heme iron center to catalyze lipid hydroperoxidation, and cycles between the Fe(III) and Fe(II) oxidation states. Structural and spectroscopic studies of SLO, aimed at better understanding its catalytic cycle, require a reliable supply of high-quality protein, making efficient expression and purification an essential part of this research. This project focused on evaluating the expression and purification workflow to identify factors limiting protein yield, purity, and reproducibility. We identified several limitations in our current purification strategy, including unwanted proteolytic cleavage and inefficiencies in our chromatography procedures. Initial improvements were made by increasing the concentration of protease inhibitors, optimizing imidazole concentrations during purification in affinity columns, and addressing issues with the chromatography columns. Future work will focus on implementing an improved size exclusion column to obtain higher purity SLO for crystallographic and spectroscopic studies.

BOLDLY FORWARD RESEARCH FELLOWSHIP

Denise Angulo

Roots and Identity: The impact of Grandparent Socialization on Grandchildren Identity

Faculty Research Mentor: Mayra Bámaca

ABSTRACT

Latinos in the U.S. face challenges involving racial discrimination, deportation, and hostile political climates. One developmental process, Ethnic-racial identity (ERI), can help individuals cope by promoting cultural pride, belonging, and resilience (Yip, 2018). Studies examined how Ethnic-racial socialization (ERS) encourages ERI by helping youth understand discrimination, build resilience, and maintain connections to their culture (Hughes et al., 2006). Most studies examine parents as drivers of ERS, and less attention has focused on grandparents, despite their prominent influence in Latino families (Chen & Guzman, 2022). Burgeoning evidence suggests that grandparents are vital agents of ERS. For example, Jackson et al. (2020) noted that grandparents were often the primary source of cultural exposure. Moreover, research suggests that relationship quality can influence the association between ERS and ERI. Constante et al. (2020) found that family cohesion shaped the association between ERS and ERI among Latinx adolescents. This study examined whether grandparent ERS (cultural socialization and advocacy) was associated with grandchild ERI (resolution) and whether relationship quality (affection) moderated these associations. Findings showed that grandparent cultural socialization ($\beta = .1958$, $p = .0010$) and advocacy ($\beta = .1212$, $p = .0172$) were positively associated with ERI resolution. In addition, grandparent affection strengthened the associations between cultural socialization, advocacy, and ERI resolution ($\beta = .1279$, $p = .0014$ and $\beta = .0957$, $p = .0088$, respectively). This study expands understanding of Latinx college students' ERI and emphasizes the need to understand grandparents as contributors to culture, emotional development, and ethnic identity.

BOLDLY FORWARD RESEARCH FELLOWSHIP

Kenechukwu Chibuogwu

The Pediatric Communication Gap in Valley Fever Public Health Messaging: A Readability and Content Analysis

Faculty Research Mentor: Clarissa J. Nobile

ABSTRACT

Coccidioidomycosis, commonly known as Valley fever, is a fungal infection caused by Coccidioides species that primarily affects the lungs and, in severe cases, can lead to meningitis and death. Although Valley fever can affect individuals of all ages, public health messaging often emphasizes occupational and demographic groups at higher risk of exposure, such as construction workers, military personnel, pregnant people, and older adults, while the pediatric population remains underrepresented and accessible educational resources for the general public remain limited. Recent reports of increasing pediatric Valley fever cases highlight the importance of evaluating whether current public health messaging reflects this changing epidemiology. In this study, we conducted a content analysis of Valley fever educational resources from six endemic states and additional regional sources to examine the content for intended audience, accessibility, readability, and language availability. We also evaluated whether resources included information specific to children and adolescents. Our analysis showed that pediatric content was uncommon and that many materials were difficult for the general public to access because of high readability and limited language availability. Overall, these findings identify a significant gap in pediatric Valley fever awareness material and suggest that public health communication around Valley fever needs to be made more accessible, inclusive, and responsive to current disease patterns.

BOLDLY FORWARD RESEARCH FELLOWSHIP

Rihanna Clayton

Investigating IFNAR1 and IFNAR2 Signaling in the Host Response to Aspergillus fumigatus Infection

Faculty Research Mentor: Kelly Shepardson

ABSTRACT

There has been an increased number and severity of cases of influenza and SARS-CoV-2-infected patients acquiring aspergillosis due to Aspergillus fumigatus (Af). This suggests that viral infection creates a transiently suppressed immune environment permissive to fungal infection. Despite antifungal therapies, mortality remains high, highlighting the need to better understand immune mechanisms that influence disease outcomes. We recently discovered that type I interferon signaling through IFNAR1 and IFNAR2 regulates damage responses during infection. However, the mechanisms by which type I interferon signaling shapes the immune response remain unclear. Therefore, understanding how this pathway regulates the damage response during pulmonary A. fumigatus infection will allow us to understand the role of type I signaling in anti-fungal immunity and controlling pulmonary tissue damage.

BOLDLY FORWARD RESEARCH FELLOWSHIP

Diego De Luna

Characterizing Archaeal HSP α and β Assembly via SDS & Native PAGE

Faculty Research Mentor: Ruben M. Ceballos

ABSTRACT

Heat Shock Proteins (HSPs) are stress response group II chaperonins, which form large (~1 MDa), 18-mer “molecular cages”. HSP complexes assist in folding nascent proteins and refolding misfolded proteins. HSP monomers are expressed as three subtypes: HSPa, HSPb, and HSPg. HSPa and HSPb are known to be upregulated in hyperthermophilic archaea (e.g., Sulfolobales) during high temperature stress. Our lab has recently reported that, in addition to thermal stress, HSPs are resilient in low pH (>3.5) - another type of stressor to which Sulfolobales are subjected. It has been suggested that HSPs may not only be “heat shock” protein but instead more generalized stress proteins that may also upregulated during other forms of cell stress. Several species of the family Sulfolobaceae are known be productively infected by Sulfolobus Spindle-shaped Viruses (SSVs), which is another type of stressor. Our lab is attempting to determine if HSPs are also upregulated during fusellovirus infection. Thus, we seek to determine: (a) if lower-order (<18 mer) complexes are readily formed in the cell; and, (b) the relative abundance of HSPs and their complexes in cells during SSV infection versus uninfected (control) conditions. Poly-Acrylamide Gel Eletrophoresis (PAGE) is a key method used in protein biochemistry research. There are multiple types of PAGE, including: SDS-PAGE and Native PAGE. Each addresses a different set of research questions. For this summer project, I examined HSP complex formation in uninfected cells of S. solfataricus strain P2 (DSM1617) and those infected with SSV1 and, separately, SSV8 in single-virus/single-host infection assays.

BOLDLY FORWARD RESEARCH FELLOWSHIP

Riley DeLoatch

Maximum Compressive Load of 3D-Printed Geometries

Faculty Research Mentor: Francesco Danzi

ABSTRACT

3D printing is becoming more common because it allows parts with different shapes to be made quickly and with less material waste. As more 3D-printed parts are used in engineering, it is important to understand how their shape affects their strength. In this study, three different 3D-printed sample shapes were tested using a Mark-10 force tester to see how they performed under compression. Each sample was placed in the testing machine and compressed while force data was collected. The goal of this project is to learn how the shape of a 3D-printed part affects how much force it can handle. All samples were printed and tested using the same method so that the results could be compared fairly. The data collected from these tests will help show how different shapes respond to compression and may help improve the design of stronger and more reliable 3D-printed parts. This research can also provide useful information for future studies that test other shapes, materials, and printing settings to better understand how these factors affect the strength and performance of 3D-printed parts.

BOLDLY FORWARD RESEARCH FELLOWSHIP

Crystal Espinoza-Baeza

Correlates of Substance Use Among Latinx College Students

Faculty Research Mentor: Mayra Bámaca

ABSTRACT

Substance use continues to be a serious public health concern among college students in the United States because of its associations with poor academic performance and adverse mental and physical health outcomes. Despite these risks, limited research has examined how multiple ecological factors contribute to substance use among college students, particularly within Latinx populations. Using Bronfenbrenner's Bioecological Systems Theory, we examined individual and ecological predictors of substance use (i.e., alcohol use, tobacco use, and cannabis use). Specifically, we investigated whether gender, nativity status, adverse childhood experiences (ACEs), perceived discrimination, mental health, financial strain, family support, and friend support predicted substance use. Participants included 350 undergraduate students recruited from the University of California, Merced. Correlation analyses indicated that more ACEs, depression, and anxiety were associated with prior substance use. However, when all variables were accounted for in a multiple regression model, only ACEs and perceived friend support remained significant predictors of prior substance use. Specifically, greater exposure to ACEs was associated with the use of substances, whereas higher levels of perceived peer support were associated with a lower likelihood of ever using substances. Findings suggest that childhood adversity and peer relationships play important roles in understanding substance use among Latinx college students. Findings also highlight the important role of social support networks in the prevention of substance use behaviors in college. Substance use prevention efforts could be centered on strengthening Latinx college students social support networks, especially among students with a history of ACEs.

BOLDLY FORWARD RESEARCH FELLOWSHIP

Emily Francisco

Do Self-Selected Pleasant Scents Affect Mouse-Based Target Selection? An Exploratory Fitts' Law Study

Faculty Research Mentor: Ahmed Sabbir Arif

ABSTRACT

Target selection is one of the most common interactions on desktop computers, typically performed using a mouse. At the same time, the use of pleasant scents through diffusers has become increasingly popular in workplaces to enhance comfort and well-being. However, little is known about whether ambient pleasant scents influence fundamental computer interaction tasks. In this work, we conducted an exploratory Fitts' law study to investigate the effect of self-selected pleasant scents on mouse-based target selection. Ten participants completed a multidirectional target selection task in two counterbalanced sessions: one in the presence of a self-selected pleasant scent and one without any scent. Participants were instructed to select circular targets arranged in a circle as quickly and accurately as possible. Results showed no significant differences in either movement speed or selection accuracy between the two conditions, with performance remaining nearly identical regardless of scent presence. While these findings suggest that self-selected pleasant scents neither improve nor impair mouse-based target selection, the small sample size limits the generalizability of the results. Future work with larger and more diverse participant samples, a broader range of scents, and longer exposure durations is needed to validate these findings and examine whether scent influences other aspects of computer use. Such understanding could inform the design of multisensory work environments and human-computer interfaces by identifying when pleasant scents can be incorporated without compromising user performance.

BOLDLY FORWARD RESEARCH FELLOWSHIP

PHOTO NOT PROVIDED

Ethan Garrido

Automated Optical Characterization of Nanodiamonds Using Robotic-Assisted Positioning

Faculty Research Mentor: Michael Scheibner

ABSTRACT

Nitrogen-vacancy centers in nanodiamonds are typically used as quantum sensors in research. However, characterizing these nanodiamonds requires both careful optical excitation and photoluminescence analysis, a process that is slow and manually intensive. This project investigates whether low-cost robotic automation and optical feedback can streamline nanodiamond characterization creating a semi-autonomous workflow capable of locating, evaluating, and classifying nanodiamonds based on photoluminescence.

BOLDLY FORWARD RESEARCH FELLOWSHIP

Sarah Green

Using Waste to Enhance Coastal Resilience: Rice Husk Ash Concrete Against Seawater Damage

Faculty Research Mentor: Marina Lopez-Arias

ABSTRACT

As the frequency and severity of coastal disasters increase, coastal infrastructure becomes more vulnerable to deterioration. Chloride and sulfate ions in the marine environment contribute to the premature degradation of concrete systems. A potential solution to extend the service life of these concrete systems in marine environments is Ultra High-Performance Concrete (UHPC). UHPC is a high-strength construction material with increased durability due to its dense microstructure, which increases its resistance to seawater ingress. However, its high cement content yields significant economic and environmental burdens linked to high production cost and substantial CO_2 emissions. Rice Husk Ash (RHA), an agricultural waste, has gained traction as a sustainable supplementary cementitious material (SCM) in concrete mix designs. Thus, this study investigated the mechanical performance and microstructure characteristics of UHPC and Normal Strength Mortar (NSM) with 10% of cement replaced by RHA. Samples were exposed to aggressive sulfate (50 g/L) and chloride (35 g/L) solutions, with additional water-cured controls. The 28-day equivalent compressive strength tests showed that under water exposure, the UHPC sample with RHA matched the regular UHPC in strength (110.95 MPa, 110.90 MPa). The samples exposed to sulfate maintained or exceeded the strength of their unexposed controls. X-ray computed tomography (CT) was used to create a 3-dimensional model to analyze specimen pore structure and crack propagation. Scanning electron microscopy (SEM) was further used to identify relevant compounds and damaging mechanisms. Marine disasters put many coastal communities at risk, highlighting the urgency of developing sustainable and resilient marine infrastructure.

BOLDLY FORWARD RESEARCH FELLOWSHIP

Thaddeus Hendrickson

Investigating the Reversibility of Aza-Nazarov Photocyclization in Benzoyl Methyl Pyrazinium Molecules for Functional Material Applications

Faculty Research Mentor: Ryan Baxter

ABSTRACT

This research investigates the optical properties of a group of benzoyl methyl pyrazinium molecules before and after photocyclization, as well as the reversibility of the reaction. The molecules begin in the uncyclized form (BMT) and upon exposure to UV light (280–400 nm) undergo aza-nazarov photocyclization to form the cyclized product (PIMT). To investigate reversibility the cyclized molecules were treated with bases and heated to promote deprotonation and potentially reverse the cyclization. Understanding the reversibility of this reaction allows us insight into the versatility of these molecules and their potential use as precursors for the development of functional materials.

BOLDLY FORWARD RESEARCH FELLOWSHIP

Precious Ige

Using Micro-Computed Tomography to Examine the Effects of Glyphosate on Bone Mineral Density

Faculty Research Mentor: Jennifer O. Manilay

ABSTRACT

Roundup is the most extensively used herbicide internationally due to its strong pesticide abilities. Roundup, a glyphosate containing herbicide is considered nontoxic to human beings by regulatory agencies, however, recent studies have shown that glyphosate exposure can cause negative effects on humans endocrine, neurological, and skeletal system, specifically bone marrow density. We hypothesize that chronic exposure to glyphosate negatively affects bone mineral density. To test our hypothesis, we exposed C57BL/6j mice to glyphosate (250mg/kg/body weight) for 90 days through drinking water. We then harvested the humerus and calvaria, scanned the bones in a micro-computed tomography scanner, and analyzed the images using the Analyze 15.0 direct software. Preliminary data suggests that exposure to glyphosate can result in trabecule bone being rarer and also lead to osteoporosis. However, our results show different findings. In the female mice a trend is noticeable, with glyphosate exposure causing a statistically significant increase in the bone mean BMD and the cortex mean BMD of bones. Although an increase in bone mineral density is normally considered a good thing, a significant increase can imply different conclusions. A microarchitectural and biomechanical assessment is needed to make further conclusions. In the male mice the vehicle males have a bone mean BMD value of 730.961mg/cc compared to 742.4 the glyphosate exposed mice. Based on our results, glyphosate exposure seems to have a greater effect on female mice than male mice.

BOLDLY FORWARD RESEARCH FELLOWSHIP

Kelsey Lowe

SMARCC2 IDR is Necessary for IEG Transcription

Faculty Research Mentor: Ramendra Saha

ABSTRACT

Neuronal gene transcription is an essential molecular process that converts chromatin DNA into messenger RNA. To access chromatin for transcription, certain chromatin remodelers are necessary to create easier access for RNA polymerase II to transcribe the DNA into pre-mRNA. One such chromatin remodeler is the neuronal BAF (nBAF) complex, an ATP-dependent nucleosome remodeler comprising 12-15 subunits that are modularly assembled to aid RNA polymerase II during the productive elongation phase of transcription [1]. nBAF is essential for regulating gene expression and transcription, especially activity-induced transcription of immediate-early genes (IEGs). Within nBAF's subunits, regions of intrinsically disordered proteins, called IDRs, are found in relatively high abundance. Unlike most proteins, IDRs lack stable secondary or tertiary structure and consist of multiple, varied conformations that allow for flexible protein interaction. The goal of this project was to determine how the nBAF complex affects activity-induced neuronal gene transcription of IEGs and to investigate the role of IDRs in this process. We inhibited and targeted BAF subunits to assess the effects of their knockout on transcription levels of IEGs. We also observed variation in transcription levels of the BAF subunit SMARCC2 when its C-terminal domain IDR was truncated. Our results have shown not only that inhibiting subunits within the nBAF complex significantly reduces IEG transcription levels, but also that IDRs in SMARCC2 are necessary for IEG transcription.

BOLDLY FORWARD RESEARCH FELLOWSHIP

Noah Markman

Plasmonic enhancement of Cesium tin iodide with gold nanoparticles.

Faculty Research Mentor: Sayantani Ghosh

ABSTRACT

This study investigates plasmonic enhancement of near-infrared photoluminescence from PTM-passivated CsSnI3 nanocrystals by comparing their photoluminescence with and without hollow and solid gold nanoparticles. Cesium tin iodide (CsSnI_3)-PTM nanocrystals will undergo localized surface plasmon resonance (LSPR) when coupled to hollow gold (Au) nanoparticles, resulting in a large increase in near-infrared photoluminescence (PL). These same nanocrystals will not undergo this change with solid Au nanoparticles and will have consistent PL compared to the nanocrystals measured with no Au. Cesium tin iodide ink was made and put on glass substrates that were then spin-coated at 2000 rpm for 30 seconds. These samples were then put on a hot plate at 360 degrees Celsius for 20 seconds to create a crystalline structure. They were scraped onto another glass substrate to form nanocrystal powder. A spectrometer was used to measure the photoluminescence of the nanocrystals alone, the nanocrystals with the hollow gold, and the solid gold. We found that the hollow gold coupled with the cesium tin iodide showed an enhancement in photoluminescence, while the solid gold showed a negligible difference. This is what we expect since the gold's localized surface plasmon resonance (LSPR) must overlap with the cesium tin iodide's absorption spectrum. Because of the hollow gold's structure, it can be tuned for different LSPR peaks, thus working as an ideal enhancer for photoluminescence.

BOLDLY FORWARD RESEARCH FELLOWSHIP

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Dorian Noriega

Investigating the effects of cannabidiol exposure and substrate stiffness on micropatterned endothelial monolayer contractility

Faculty Research Mentor: Roberto Andresen Eguiluz

ABSTRACT

Cannabidiol (CBD) is a non-psychoactive phytocannabinoid isolated from Cannabis sativa that has been shown to have anti-inflammatory and anti-cancer effects in both animal models and in vitro cell models. In cancer, tumors can cause increased local tissue stiffening and increased vascularization due to the secretion of growth factors that recruit the endothelial cells, which form the inner lumen of the vasculature. However, whether CBD exposure alters endothelial cell mechanics and whether these effects are modulated by substrate stiffness remains unknown. To address this question, human umbilical vein endothelial cells (HUVECs) were seeded on collagen-patterned polyacrylamide hydrogels (PAH) with Young's moduli of 8 and 32 kPa. Then, HUVECs were cultured on micropatterns to confluence before treatment with 1 uM and 10 uM CBD for 24 hours. Using traction force microscopy (TFM), fluorescent bead positions were imaged before and after HUVECs were attached to the PAH, then a MATLAB-based TFM macro was used to quantify cell contractility, cell area, root-mean-squared tractions, and normalized tractions. However, ongoing optimizing is required as first, HUVECs formed cord-like structures rather than confluent monolayers and second, fluorescent beads were not visible beneath the patterned regions, suggesting partial disruption of the polyacrylamide hydrogel surface during fabrication. To address these challenges, hydrogel polymerization and HUVEC seeding time was altered but requires further optimization. This work will provide insight into how CBD and substrate stiffness interact to regulate endothelial cell mechanics, improving our understanding of vascular function in healthy and diseased tissue.

BOLDLY FORWARD RESEARCH FELLOWSHIP

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Jacob Rodriguez

Fabrication of DNA Template for Single Molecule Assay

Faculty Research Mentor: Victor Muñoz

ABSTRACT

Preparation of long DNA templates is essential for biophysical studies involving DNA-binding proteins. Traditionally, linear genomes such as lambda DNA have been widely used. However, when sequence-dependent studies are required, generating DNA templates longer than 20 kb presents significant challenges. Long-range PCR often produces non-specific bands, demands repetitive and labor-intensive preparation steps, and requires modified primers. We propose an alternative approach using plasmid or vector systems to contain long DNA templates, enabling a one-step labeling reaction. Here, we present a potential methodology for preparing long DNA templates by cloning them into a low-copy plasmid using DNA assembly techniques. This strategy would allow bacterial propagation and straightforward plasmid preparation. For screening, we plan to develop a colony PCR method followed by plasmid sequence verification.

BOLDLY FORWARD RESEARCH FELLOWSHIP

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Nikolas Urgiles

Optimization of a Modular Robotic Arm Mount and Electronics Enclosure for Forest Fuel Reduction

Faculty Research Mentor: Ricardo de Castro

ABSTRACT

Mobile robotic systems for forest-management applications require reliable mounting and enclosure systems that can support robotic manipulators and onboard electronics while minimizing vibration, deformation, and platform instability. This project focused on the design, structural analysis, prototyping, and manufacturing of a modular mount and electronics enclosure to integrate a UFACTORY xArm 6 robotic arm with an AgileX Scout 2.0 mobile platform for robotic forest fuel reduction in support of wildland fire management. The design process began with a review of robotic-arm mounts, xArm 6 specifications, Scout 2.0 geometry, payload limitations, and mobile-platform enclosures. An engineering load analysis was then performed to estimate gravitational forces, dynamic moments, fastener loads, thread capacity, rail-interface slip, and vehicle tipping. In conjunction, a materials trade study compared candidate materials based on strength, mass, cost, availability, and manufacturability. Aluminum 6061-T651 was selected because it provided a suitable balance of structural performance, low weight, machinability, and cost. Subsequently, a modular computer-aided design was developed with a rail-engaging lower base, removable split upper sections, dowel-pin alignment features, and M8 bolted connections. A full-scale 3D-printed prototype was produced to verify fit, tolerances, assembly access, rail engagement, and compatibility with the robotic arm and mobile platform. Finite element analysis evaluated stress and deformation under representative static and dynamic loads, after which the final structural components were manufactured from 6061-T651 aluminum. The resulting system provides a foundation for testing robotic fuel-reduction operations in support of safer, more scalable wildland fire management.

BOLDLY FORWARD RESEARCH FELLOWSHIP

Ashe Vaughn

Investigating Neural Entrainment During Musical Beat Perception

Faculty Research Mentor: Ramesh Balasubramaniam, Ph.D.

ABSTRACT

Nozaradan et al. (2011) explained that “feeling the beat and meter is fundamental to the experience of music” (p. 10234). They proposed that beat perception emerges through neural entrainment, a process in which neural activity synchronizes with the periodic structure of an auditory rhythm.

BRAAG

Ashley Agyekum

1,3-Dichloropropene Exposure Levels Among Residents of La Viña: A Community Health Assessment

Faculty Research Mentor: Xuan Zhang

ABSTRACT

This study investigated community exposure to 1,3-dichloropropene (1,3-D), a soil fumigant widely used to control nematodes, centipedes, and other soil-dwelling pests. The compound is injected into the soil prior to planting, followed by drip irrigation after planting. Its use is controversial due to evidence indicating significant health risks upon inhalation. For this study, air samples were collected from La Viña, an agricultural community in Madera County, and from neighboring communities. We used thermal desorption gas chromatography–mass spectrometry (TD-GC–MS) machine to determine the chemical properties found in the collected air samples. We identified which 1,3-D Trans and Cis isomers were present and measured the concentrations of the identified species in air. The two types of analysis techniques used were qualitative analysis to identify which 1-3 D isomers and quantitative analysis was measuring the intensity. Results indicated that La Viña was approximately exposed to an average of 4.1 ppm and does not meet California's regulations on 1,3-dichloropropene. Potential solutions include the implementation of stricter pesticide regulations.

BRAAG

Alecia Daniels

Effects of Combined Biochar and Compost Amendments on Soil Microbial Activity and Plant Productivity in Urban Agriculture.

Faculty Research Mentor: Joshua Garcia

ABSTRACT

Urban agriculture often relies on soils that have been degraded by contamination or poor soil quality; this can limit microbial activity and plant productivity. Organic amendments such as biochar and compost have the potential to improve soil health by enhancing nutrient cycling, microbial communities, and soil structure. This study examines the effects of combined biochar and compost amendments on soil microbial activity and plant productivity at two urban farm sites in Fremont and Oakland, California, which differ in soil properties and lead contamination levels. We hypothesize that soils amended with both biochar and compost will exhibit greater extracellular enzyme activity, microbial abundance, plant tissue protein content, and overall plant productivity than unamended soils. We also expect that soil edaphic properties, including lead concentration, clay content, and environmental conditions, will influence treatment effectiveness, with stronger positive responses anticipated at the Fremont site due to its lower lead concentration and more favorable soil characteristics. Microbial activity will be evaluated through extracellular enzyme analyses, while plant tissue protein assays will assess plant physiological responses. Data will be analyzed using metagenomic sampling and R to identify treatment effects and relationships among soil properties, microbial activity, and plant performance. This research will contribute to a better understanding of how organic amendments can improve soil health and support sustainable management practices in urban agricultural systems.

BRAAG

Zhakeya Hawkins

Wintertime Particulate Matter Variability at the UC Merced Smart Farm.

Faculty Research Mentor: Adeyemi Adebiyi

ABSTRACT

Particulate matter (PM) consists of microscopic solid particles and liquid droplets suspended in the atmosphere and is associated with adverse respiratory and cardiovascular health effects. In agricultural regions, meteorological conditions and farming activities can substantially alter both PM concentrations and particle size distributions, yet their short-term temporal variability remains insufficiently characterized. To address this gap, we conducted continuous PM monitoring at the UC Merced Smart Farm in California's San Joaquin Valley from December 2025 to February 2026 using a 32-bin optical environmental dust monitor with 30-minute resolution. We analyzed four PM size fractions ($PM_{2.5}$, respirable PM, coarse PM [PMc], and PM_{10}) and examined particle size distributions during five distinct high-PM pollution episodes identified over the study period. Daily (24-hour) means, the basis for regulatory comparison, revealed strong variability. Over 68 sampled days, PM_{10} averaged 42.1 µg/m³ and peaked at 299.0 µg/m³ (16 January 2026), exceeding the 150 µg/m³ 24-hour standard on four days. Daily mean $PM_{2.5}$, PMc, and respirable PM peaked at 52.0, 266.7, and 239.9 µg/m³, with $PM_{2.5}$ above its 35 µg/m³ standard on one day. Episode-based analysis further demonstrated shifts in the 32-bin particle-size distributions, indicating that the dominant particle sizes varied considerably across pollution episodes. These findings provide a high-temporal-resolution characterization of PM in an agricultural environment and improve our understanding of how airborne particle size distributions evolve during episodic pollution events.

BRAAG

Camryn Lane

Investigating Rhizosphere Organic Matter Transformations with Infrared Spectroscopy

Faculty Research Mentor: Asmeret Asefaw Berhe and Teamrat Ghezzehei

ABSTRACT

Soil organic carbon (SOC) is central to climate mitigation, but warming and soil degradation are accelerating the global loss of soil organic matter (SOM). Root-derived carbon is a major, persistent contributor to SOM, and suberin, a waxy, carbon-rich compound in root cell walls, has been hypothesized to contribute disproportionately to long-term carbon storage because of its complex chemical structure and presumed resistance to microbial decomposition. How root chemical composition changes as roots decompose in the rhizosphere, and whether this varies by species along a suberin gradient, remains poorly resolved. We used diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS) to track functional group composition in rhizosphere soil from three crop species with differing suberin content (soy, wheat, and rice) over an incubation period following removal of aboveground biomass (0, 10, and 40 weeks), and compared the results with no-plant bulk soil controls. Root litter spectra were compared against rhizosphere soil spectra to distinguish root-derived compounds retained in soil from those lost as CO2. Across species, it was found that simple root compounds decomposed preferentially over complex ones. It was also found that organic matter lost from roots was retained in the soil. These results inform plant breeding and crop selection strategies for increasing SOC and provide empirical grounding for SOC stock models that incorporate root chemistry as a predictor of carbon persistence.

BRAAG

Jania McMinns

Environmental DNA as a Tool for Microbial Fingerprinting Across Habitat Types

Faculty Research Mentor: Claire Lukens and Michael Beman

ABSTRACT

Environmental DNA (eDNA), genetic material shed by organisms into their surroundings, offers an underused tool for characterizing environments through their microbial communities. This project investigates whether trace DNA can create distinct environmental "fingerprints," with the goal of applying this to forensic science, where microbial signatures could help link evidence to specific locations or crime scenes. Water, rock, and soil samples were collected from natural environments in the Sierra Nevada, and DNA was extracted from each sample and quantified using a Nanodrop spectrophotometer to assess yield across sample types. Viable, measurable DNA was successfully extracted from all sample types, meeting expectations at this stage of the project. Variation in DNA yield was driven primarily by differences in sample size rather than microbial community size; for example, the relatively small volume of water samples processed resulted in lower DNA yield, rather than reflecting a smaller microbial community. 16S rRNA sequencing and clustering analysis showed that soil, saprolite, and rock samples from the Sabrina Lake Basin group together, indicating that microbial populations cluster consistently throughout the basin. This suggests it may be possible to link a sample back to a specific object or location within the basin, or vice versa. Further work is needed to determine the resolution of this clustering, whether it reflects broad, region-wide similarity or unique, locality-specific composition, which would ultimately determine its viability as a reliable environmental tracer for forensic applications.

BRAAG

Kpana Ngafuan

Examining Volumetric Water Content in large and small scale agricultural systems in California Central Valley

Faculty Research Mentor: Srabani Das and Rebacca Ryals

ABSTRACT

Measuring soil water content is critical in California's Central Valley, the state's most productive agricultural region, which faces extreme drought, short water supply, and high costs. Volumetric water content (VWC) is the volume of water per total volume of soil and reflects how much water the soil holds at a given time (Voroney, 2019). Water occupies the pore spaces between soil particles when irrigated then drains due to gravity and the remaining water is stored for plant use through evapotranspiration (Zamora, 2026). Monitoring the soil water content improves irrigation scheduling, water use-efficiency and ensures adequate water for crop growth. This study examines VWC at a large scale Agave farm in Merced County and a small scale community garden growing a variety of crops in Fresno County. At a farm in Merced County, with soil texture of Honcut silt loam and Wyman loam per the Natural Resources Conservation Service (NRCS) Web Soil Survey, VWC was measured continuously using TEROS 54 sensors across four depths (15, 30, 45, 60 cm). At a farm in Fresno County with soil texture of Hesperia fine sandy loam, deep, saline-sodic per the NRCS, VWC was calculated gravimetrically from bulk density at two depths (0-15 cm and 15-30 cm). Results from the Merced farm show that VWC ranged from 0.200–0.350 m^3/m^3. Results from the Fresno farm show that it ranged from 0.00201–0.02731 m^3/m^3. Future directions should examine management practices and soil health indicators such as bulk density and porosity at the two sites.

C-SIP

PHOTO NOT PROVIDED

Jasleen Bassi

PCR-Based Identification of Sox17:TAEL Transgenic Zebrafish

Faculty Research Mentor: Stephanie Woo

ABSTRACT

The coordinated movement of endoderm cells during early embryonic development is essential for proper tissue and organ formation. To study these developmental processes, researchers use transgenic zebrafish lines that allow specific genes to be identified and manipulated. This project investigated whether polymerase chain reaction (PCR)-based genotyping can reliably identify zebrafish carrying the Sox17:TAEL transgene used in studies of endoderm cell migration. Fin clip samples were collected from zebrafish, followed by DNA extraction, PCR amplification, and agarose gel electrophoresis to determine the presence or absence of the target transgenes. Representative gel results demonstrated that PCR successfully distinguished transgenic fish from wild-type individuals, providing a reliable method for identifying the appropriate animals for future experiments. These findings support PCR-based genotyping as an effective tool for maintaining the Sox17:TAEL transgenic zebrafish line and ensuring accurate sample selection for developmental biology and optogenetics research.

C-SIP

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Mobina Hosseini

An Investigation of Rabbitpox vCCI E132A Binding Affinity

Faculty Research Mentor: Patricia J. LiWang

ABSTRACT

Chemokines are small signaling proteins which guide immune cells to sites of inflammation. To evade the host immune response, certain poxviruses produce viral CC-chemokine inhibitor proteins (vCCIs) which bind to chemokines and prevent chemokine-receptor signaling. In previous research, the Mousepox vCCI mutant had alanine at amino acid position 132 which was changed to glutamic acid, essentially introducing a specific amino acid found in rabbitpox virus vCCI into the corresponding Mousepox vCCI. Findings indicated that chemokine-binding affinity was improved. However, less is known about reversing this amino acid change and reducing binding ability. This project aims to explore how a targeted amino acid substitution impacts chemokine-vCCI binding behavior. Specifically, in the rabbitpox vCCI (RvCCI), the amino acid at position 132 is changed from glutamic acid to alanine using QuikChange Mutagenesis. After performing miniprep, the protein was expressed using BL21 cells. Next, IPTG was added to induce protein expression and the cells were harvested. After lysing cells, the protein was purified via nickel-affinity chromatography, set for refolding, and subsequently dialyzed. The binding behavior will be measured using Bio-Layer Interferometry by comparing Kd values. It's expected that the mutant will exhibit weaker binding behavior. This project will analyze binding affinity of the wild-type RvCCI and the RvCCI mutant for binding to vMIP-II, a viral chemokine homolog. Such findings demonstrate the ability to alter protein binding behavior, contributing to the future development for treatments and therapies for a wide range of health disorders such as autoimmune disorders and traumatic brain injury.

C-SIP

Aditya Iyli

Computational Identification of Candidate Metamorphic Proteins in Escherichia coli Using Structural Prediction

Faculty Research Mentor: Andy LiWang

ABSTRACT

Metamorphic proteins are an uncommon class of proteins that can adopt two or more distinct three-dimensional structures from a single amino acid sequence. This ability may help organisms respond to environmental stresses, such as changes in temperature, while expanding protein function without requiring additional genes. Despite their biological importance, relatively few metamorphic proteins have been experimentally identified. In our research, we examined candidate metamorphic proteins in Escherichia coli using computational structural prediction. Cold-destabilized proteins identified from proteomics data were prioritized and analyzed with AF-Cluster, which predicts alternative protein conformations and does that by clustering homologous sequences prior to AlphaFold2 structure prediction. We visualized and compared the predicted structures using ChimeraX, RMSD, pLDDT, and structural similarity analyses to identify evidence of alternative folds. Our analyses identified InfA and GroES as promising candidate metamorphic proteins based on predicted conformational changes; including α-helix-to-β-strand transitions in InfA and changes in β-strand orientation in GroES. These candidates have been prioritized for biochemical validation, where experimental studies will confirm whether the predicted structural transitions occur in vitro. Together, our findings did demonstrate that computational approaches can efficiently prioritize proteins for experimental testing while also accelerating the discovery of novel metamorphic proteins.

C-SIP

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Nathan Roehrig

Cartilage protein-dependent viscoelastic organization of synovial lubricants at the interface revealed by passive microrheology

Faculty Research Mentor: Roberto Andresen Eguiluz

ABSTRACT

Collagen type II (Col-II), Collagen type I (Col-II), and Fibronectin (FN) are proteins found at the surface of articular cartilage. Understanding how each of these components influences the mechanical properties of synovial fluid (SF), the native lubricant of synovial joints, is critical to explain the excellent lubrication of healthy joints, and loss of mechanical performance in pathological conditions, added to the design intra-articular treatments. In this work, we employed passive microrheology to measure the apparent viscosity gradients of SF and a recombinant analog of lubricin (the major boundary lubricant in SF) (rEqLub) adsorbed to molecular films of Col-II, Col-I, and FN, from the interface to the bulk solution. Col-II and FN models increased the viscosity of SF at the interface with respect to the bulk, while Col-I did not seem to affect it. Similarly, when we exposed rEqLub to proteins, the same relative effect occurs, but with an increased viscosity with respect to SF. These findings build on previous work from the group, supporting the idea of a correlation between the increased ratio of Col-I in pathology and decreased SF film formation and viscosity.

C-SIP

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Estefan Torres-Briones

Optimizing Expression and Purification of Soybean Lipoxygenase-1 for Structural and Spectroscopic Studies.

Faculty Research Mentor: Aaron Hernday

ABSTRACT

Soybean lipoxygenase-1 (SLO) is a non-heme iron enzyme that serves as an important model for understanding proton-coupled electron transfer (PCET) in enzyme catalysis. SLO uses a non-heme iron center to catalyze lipid hydroperoxidation, and cycles between the Fe(III) and Fe(II) oxidation states. Structural and spectroscopic studies of SLO, aimed at better understanding its catalytic cycle, require a reliable supply of high-quality protein, making efficient expression and purification an essential part of this research. This project focused on evaluating the expression and purification workflow to identify factors limiting protein yield, purity, and reproducibility. We identified several limitations in our current purification strategy, including unwanted proteolytic cleavage and inefficiencies in our chromatography procedures. Initial improvements were made by increasing the concentration of protease inhibitors, optimizing imidazole concentrations during purification in affinity columns, and addressing issues with the chromatography columns. Future work will focus on implementing an improved size exclusion column to obtain higher purity SLO for crystallographic and spectroscopic studies.

CAL-BRIDGE

Fawad Afzal

Metadata-Only Join Discovery for Relational Databases

Faculty Research Mentor: Florin Rusu

ABSTRACT

Modern relational databases are often difficult to interpret because table relationships may be incomplete, implicit, or absent from declared schema constraints. This challenge is harder in several text-to-SQL benchmarks or privacy-sensitive settings where the underlying data is unavailable, requiring join discovery to rely on schema metadata alone. This project studies automatic join discovery, the task of identifying valid join relationships across database tables from schema information. We propose a hybrid matrix-centered pipeline that combines schema parsing, key detection, datatype-based pruning, embedding similarity, low-rank matrix completion, and large language model refinement. We evaluate the method on different benchmarks such as BIRD, TPC-DS, TPC-H, and JOB using precision, recall, F1 score, and the number of LLM-checked candidates. Preliminary results suggest that the proposed method improves metadata-only join discovery while reducing unnecessary LLM-based candidate checks. This work highlights the potential of hybrid schema-reasoning systems to improve database understanding for both human users and AI-driven analysis tools.

CAL-BRIDGE

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John Cedric Alora

Measuring Query Difficulty in Filtered Vector Search

Faculty Research Mentor: Florin Rusu

ABSTRACT

When you search a vector database with a filter attached, for example find movies similar to this one but only ones rated above 8, some queries take much more work to answer than others. A database system can execute these queries in different ways, and the best choice depends on how hard the query is. My research this summer focused on measuring that difficulty. I worked with a recently proposed metric called alpha-hardness, which estimates how many candidates a search has to examine before it collects enough results that pass the filter. I got the authors' implementation running on MoReVec, a movie benchmark with about 550,000 embedding vectors, and computed hardness for 2,300 queries across 23 filters. Along the way I found places where the paper's published formula and its released code disagree, and a few bugs in the released code that silently discarded results. The main finding so far is that MoReVec's standard workload sits in the easy range of the hardness spectrum, which matches what the paper reports for benchmarks built on real data. We are now exploring how to construct harder queries on top of it, which would make the benchmark useful across the full difficulty range. This work connects to Abylay's research on GLS, a correlation-based difficulty signal, and together these measurements are building toward a query optimizer that can look at an incoming query and choose the best execution plan for it.

CAL-BRIDGE

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Jonathan Boaz

Instruction Composition and Compression for Autonomous Vehicles

Faculty Research Mentor: Ross Greer

ABSTRACT

Large language models are increasingly used to generate natural-language driving instructions for autonomous vehicles, but these instructions often contain redundant or unnecessary information. Efficiently compressing driving instructions while preserving the information required for downstream planning remains an open challenge. This project investigates how natural-language driving instructions can be compressed while preserving the semantic information required for downstream autonomous driving models. Building on recent work in instruction-conditioned autonomous driving, this project examines evaluation strategies for determining whether compressed instructions retain the semantic content necessary for downstream driving models. Our goal is to establish a framework for measuring the quality of compressed instructions while maintaining safe and reliable vehicle behavior. This work contributes toward more efficient instruction representations for autonomous driving systems and provides a foundation for future research in language-guided planning.

CAL-BRIDGE

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Matthew Lua

First Principles Modeling of Electronic Structure and Quantum Well Formation in Two-Dimensional Heterojunctions

Faculty Research Mentor: David A. Strubbe

ABSTRACT

Quantum wells are important structures in modern optoelectronic devices such as LEDs, lasers, and electro-optic modulators because they improve efficiency, control emission spectra, and lower threshold currents compared to bulk active regions. In semiconductor heterojunctions, carrier confinement arises from favorable band alignment between adjacent materials. We are probing which two-dimensional transition metal dichalcogenide (TMD) heterojunctions can be designed to engineer quantum well behavior at the atomic scale. Using first principles density functional theory calculations, we have modeled selected TMD combinations, to study their relaxed atomic structures, electronic band alignment, and wavefunction localization, and identified MoTe2-WS2 as a promising heterostructure. By comparing several candidate heterojunctions, we aim to identify systems that exhibit electronic confinement that is consistent with quantum well behavior.

CAL-BRIDGE

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Isaiah Ramirez

Annotating Long-Range Driving Instructions for Autonomous Vehicles

Faculty Research Mentor: Ross Greer

ABSTRACT

To maximize the trustworthiness of human interacting with autonomous machines such as autonomous vehicles (AVs), it is must that human-machine interaction be as robust and reliable as possible. This paper presents doPlan, a novel dataset built on nuPlan, created to extend the boundaries of research in long term natural-language instructional autonomous driving. The dataset contains natural-language instructions and referential tags annotations of the mutli-camera input of the AV. Unlike prior instruction datasets that focus on short, fixed-duration clips, doPlan is designed around variable-length temporal windows sampled from long-horizon driving scenarios. This formulation enables the study of instruction persistence, long-range referential grounding, and instruction-conditioned planning across evolving traffic contexts. At present, we introduce the annotation methodology and tooling underlying doPlan, laying the groundwork for development and evaluation of long-horizon vision-languageaction models for autonomous driving.

CAMP

Isaic Cruse

A Numerical Study of the Dirichlet Problem for the Elliptic Monge-Ampere Equation in 2D

Faculty Research Mentor: Juan Meza

ABSTRACT

We address two numerical methods to solve the Dirichlet problem for the real elliptic Monge-Ampere equation, in two dimensions. The first method is an augmented Lagrangian based method that reformulates the PDE into an optimization problem. The second method is a relaxation algorithm with a least squares formulation. Both methods yield similar results in terms of accuracy. For small dimension, the least squares method is superior in terms of number of iterations and computational time. However, as the dimension grows the augmented Lagrangian method becomes more competitive.

CAMP

Paola Nunez Hernandez

Reliance on Visual Cues during Audiovisual Speech Perception among Heritage Spanish Speakers

Faculty Research Mentor: Kristina Backer

ABSTRACT

During everyday conversations, listeners integrate auditory and visual speech information to improve speech comprehension, particularly in noisy or ambiguous listening environments. Although bilingual language experience has been shown to influence speech perception, relatively little is known about how Heritage Spanish speakers integrate audiovisual (AV) speech cues. Thus, here we investigate how bilingual language experience affects reliance on visual speech cues among Heritage Spanish speakers, using the visual dominance illusion. When listeners are presented with incongruent AV speech (e.g., audio /ba/ paired with a video of the talker uttering /va/), they often report hearing the visually-conveyed phoneme (e.g., /va/), thereby experiencing the visual dominance illusion. In this behavioral study, participants will be presented with incongruent AV speech. The visual speech will be systematically degraded to examine reliance on visual cues under varying levels of visual clarity. Participants will transcribe what they heard on each trial. We will quantify how often they perceive the visual dominance illusion at each level of visual clarity. Participants will also complete objective and subjective measures of language proficiency and experience to assess their English and Spanish language dominance. We hypothesize that participants with more balanced dominance will rely more on visual speech cues and will demonstrate greater susceptibility to the visual dominance illusion, even under degraded visual conditions. By focusing on an understudied bilingual population, this research will contribute to a better understanding of how language experience shapes AV speech perception and may inform future research on bilingual speech processing and communication in diverse language communities.

CAMP

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Mariana Peralta Ocampo

Chemical Vapor Deposition Growth and Raman Characterization of Orthorhombic SnTe Thin Films for Ferroelectric Applications

Faculty Research Mentor: Hui Cai

ABSTRACT

Tin telluride (SnTe) is an IV–VI semiconductor known for its narrow bandgap and cubic rock-salt crystal structure. While SnTe has been studied as a topological insulator, its orthorhombic phase remains relatively unexplored, presenting new opportunities to investigate its ferroelectric behavior. In this study, SnTe films were synthesized via chemical vapor deposition (CVD), with variations in growth parameters, including temperature, precursor positioning, and carrier gas flow rate, to identify optimal conditions for stabilizing the orthorhombic phase. Raman spectroscopy confirmed the formation of orthorhombic SnTe, indicating that the selected CVD conditions effectively promoted the desired crystal structure. Under these optimized conditions, future work will investigate the relationship between growth parameters, structural evolution, and ferroelectric properties. By investigating the properties of this novel material, this study may advance the current understanding of phase behavior and lay the foundation for more sustainable and impactful research on advanced semiconductor materials.

CAMP

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Timothy Pourtarvirdi

Size-dependent dynamics of polystyrene beads in dense bacterial swarms

Faculty Research Mentor: Arvind Gopinath

ABSTRACT

Bacterial swarming is a form of collective surface motility in which densely packed, flagellated bacteria move as a coordinated fluid layer, generating internal flows, vortices, and propagating fronts. The characteristic of swarming is a motility-enhancing ability in which some pathogenic and non-pathogenic bacteria possess. Aiding these bacteria in the overall colonization of surfaces that are rich in nutrients, the biological methods managing swarming have thus far been well comprehended. However, the physical transport mechanisms which come to be through swarming remain far less known. In this project, the idea of how bacterial swarms impact the moving patterns of passive particles was demonstrated and carried out through fluorescent spherical microbeads of varying radii being introduced to developed B. subtilis and S. marcescens swarms. Overnight cultures were inoculated onto 0.5% agar Petri plates and allowed to incubate for a number of hours at 37 degrees Celsius, in order to induce swarming. What followed was volumes of tracer particles being added to the developed swarms, in which brightfield images at 40x objective were captured of the diffusivity and movement of these particles in the swarm. Results indicated that the mean square displacement of each tracer particle radii varied in relation to their diffusivity or movement with the swarm, thus proving the principle of the Stokes-Einstein equation.

CAMP

Jenny Tang

Investigating long-range regulatory activity of super-enhancer like element in Candida albicans

Faculty Research Mentor: Ayush Pandey

ABSTRACT

The opportunistic fungal pathogen Candida albicans can undergo a reversible and heritable white-opaque phenotypic switch that serves as a model for better understanding cellular differentiation and maintenance of cell identity. This differentiation program is controlled by a transcriptional network centered on the master regulator Wor1, which binds an unusually large upstream regulatory region sharing similarities with mammalian super-enhancers, including extended size, dense transcription factor (TF) occupancy, and the ability to form liquid-liquid phase separated condensates. A defining property of mammalian super-enhancers is their ability to activate target gene expression across large genomic distances, but whether C. albicans super-enhancer-like elements retain this long-range activity is unknown. This property was explored using CRISPR-Cas9-mediated genome editing to insert DNA spacers of increasing lengths (1, 2, 4, and 8 kb) between a super-enhancer like region and its target gene (ORF19.6805), with gene expression tracked by a fluorescent reporter. Fluorescence was measured by flow cytometry, and expression levels were quantified to determine whether target gene activation is maintained, reduced, or lost as distance from the super-enhancer like element increases. These findings will help clarify whether long-range gene activation, a hallmark of mammalian super-enhancers, is a conserved feature of the regulatory elements governing fungal cell fate.

CLIMATE SMART AGRICULTURE EDUCATIONAL WORKSHOP

PHOTO NOT PROVIDED

Leonardo Aleman Medina

How do soil amendments of wood biochar, food waste compost, and their mixture affect tomato fruit nutrient quality and yield?

Faculty Research Mentor: Rebecca Ryals

ABSTRACT

The goal of this study is to contribute to existing research on the effects of biochar, compost, and a mixture of both on a locally grown tomato variety in the Central Valley. This study provides insight into how tomato nutrients will be affected by the treatments, providing not only farmers with additional data to improve crop quality and yield but also students, faculty, and staff at the environmental smart farm seeking a more sustainable fertilizer for tomatoes. Furthermore, we will be assessing yields through measuring the weight and size of the tomato fruits at harvest, as well as collecting data for quality throughout the growth cycle using a Nutriscope, which provides live metrics on the health of a plant through a variety of nutrient measurements. This enables us to analyze how effectively our amendments contribute to the health and productivity of our tomatoes.

CV PATH

Emily Arroyo

Quantum Simulation of the Transverse Field Ising Model on IBM Quantum Hardware.

Faculty Research Mentor: Lin Tian

ABSTRACT

The Transverse Field Ising Model (TFIM) is one of the simplest and most fundamental models for studying quantum many-body dynamics. Here, we simulate the dynamics of a two-qubit TFIM on ibm_fez, a 156-qubit IBM quantum processor, by varying the Hamiltonian parameters, including the evolution time, spin-spin coupling strength, and transverse magnetic field. We investigate how these parameters influence the time evolution of the quantum state and compare the experimental results with theoretical predictions. As the evolution time increases, the transverse field decreases, and the coupling strength increases, the system evolves toward configurations in which the two spins become increasingly aligned. The measured qubit-state populations reveal the characteristic dynamical behavior of the TFIM while demonstrating the capability of current superconducting quantum processors to simulate interacting quantum spin systems.

CV PATH

Alexander Buenrostro

Multiphysics Modeling of a Two-Phase Non-Isothermal Zero-Gap Alkaline Water Electrolyzer

Faculty Research Mentor: Abel Chuang

ABSTRACT

Alkaline water electrolyzers are utilized to produce a large majority of the world’s clean hydrogen by using electricity to split water into hydrogen and oxygen. Their reduced cost and simple materials compared to other electrolyzers make them well suited for industrial scale use. However, accurately modeling the temperature, species, and current density distribution in alkaline water electrolyzers remains challenging due to the strong coupling among two-phase flow, electrochemistry, species transport, and heat transfer. Modeling and simulation work can be used to optimize cell parameters to lower energy consumption while reducing the need for costly lab prototypes. In this study, a 3D zero-gap alkaline water electrolyzer was built in COMSOL with coupled multiphysics to investigate species, temperature, and current density profiles at different applied voltage. A voltage loss analysis was also performed to identify the dominant loss mechanism. Activation overpotential was identified as the dominant loss mechanism across the full voltage range. Improvement in reactant concentration and electrochemically active area could increase the exchange current density. The model simulation demonstrated that increasing the electrode's active surface area raised current density by over 50%, compared with only about 5% from higher electrolyte concentration. This suggests that the active surface area is the key parameter for improving nickel-based alkaline electrolyzer performance. Future experimental validation would help confirm these findings.

CV PATH

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Amaylia Cisneros

The Reversal of DEI & The Trump Administration Targeting Women Faculty in Higher Education.

Faculty Research Mentor: Amanda Mireles

ABSTRACT

On January 20th, 2025, President Donald Trump signed Executive Order 14151, which aimed to reverse Diversity, Equity, and Inclusion (DEI) initiatives. The order sought to terminate DEI policies, programs, and resources. These actions not only affect federal agencies but also institutions of higher education that depend on federal funding and support. Universities have faced pressure to remove DEI-related initiatives, while faculty and administrators whose beliefs differ from the administration's policies may experience increased worry, stress, and anxiety revolving around their academic position and their responsibilities. This qualitative study aims to examine how the reversal of DEI and the Trump administration's targeted policies have affected women faculty members in higher education. Focusing on women faculty from both University of California and the University of Texas. These women were from various backgrounds including White, Black, Asian, and Latina, this study helps to understand the changes in their workplace, institutional support, professional responsibilities, and their sense of safety and belonging. Using semi-structured in-depth interviews conducted over zoom, participants were asked a series of questions, and the number of questions varied from participants to participants. Using these methods, the interviews were transcribed to find common themes throughout the discussions. Results indicated that women faculty from both the UC and UT systems are facing funding cuts, being doxxed, and censorship regarding their classes and research. These results suggest that EO 14151 and the Trump administration's policies have affected the way women faculty approach their academic responsibilities, research, and safety.

CV PATH

Juan Delgado Diaz

Capture Geometry Drives Drone-Based 3DGS Reconstruction Quality

Faculty Research Mentor: Brandon Stark

ABSTRACT

Three dimensional Gaussian Splatting (3DGS) has made photorealistic 3D reconstruction fast and accessible, opening applications in infrastructure inspection, campus mapping, and Surveying. But the guidance available to 360 drone operators is not widely available, and there is little practical direction on how to fly. This project asks whether reconstruction quality is limited by the amount of data collected or by the geometry of how it is collected. We conducted controlled captures across several subjects, including statues and monuments, overall campus and the SRE building, using a DJI Mavic 3, an A1 Antigravity drone with a 360° camera, and a smartphone. Frames were extracted with custom Python tools and reconstructed in Postshot, Polycam, RealityScan, and COLMAP based trainers. To evaluate results beyond visual inspection, we developed a Python grading tool that reports point density, surface coherence, flatness ratio, and color balance directly from exported PLY files, flagging failure modes such as nadir collapse and sky contamination. Several findings emerged. A 192 image capture at 100° field of view matched a 672 image capture at 90° in every measured metric while training in roughly thirty minutes instead of overnight, showing that angular diversity carried the quality rather than image count. Camera choice proved subject dependent: 360° cameras performed well on terrain and large structures but fell short of a single view phone camera on small objects. Finally, a geometry driven flight recommender generating passes from 0° to 75° produced visibly better reconstructions than ad hoc altitude selection. Capture geometry is the dominant controllable variable in drone based 3DGS. Planning a small number of angularly diverse passes outperforms brute force image collection, reducing both flight time and compute cost.

CV PATH

Jesus Angel Maldonado Medina

3D Gaussian Splatting: 360 Drone Recorded Footage To 3D Reconstruction Pipeline And Applications.

Faculty Research Mentor: Brandon Stark

ABSTRACT

This research project explores 3D Gaussian Splatting (3DGS) as a newer and more efficient replacement for the previous NeRF (Neural Radiance Fields) to perform 3D reconstruction of outside environments with 360 drone-captured footage. This project breaks down the steps to achieving this 3D reconstruction, explaining how is the user able to utilize media processing open-source software such as FFmpeg to let COLMAP generate cloud points from the features of the scenery to be able to render a 3D Gaussian Splat utilizing the open-source program Brush. Furthermore, this research shows a efficient pipeline that simplifies the process from footage to cloud points through the utilization of a python based web-like application utilizing COLMAP's official PyCOLMAP python library. Due to the speed of this recent technology, 3D reconstruction has been more simpler, and accessible to a more broader audience, the simplicity also allows this process to be executed without the necessity of lab-sophisticated like computers, allowing more people to be able to utilize this technology on their own computers. Lastly, applications for this technology within entertainment industry to rescue/emergency situations are discussed on the paper, unlocking a new path for the next generation of computer vision and computer graphics alike.

CV PATH

Janice Pabros

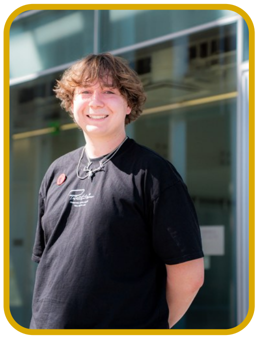
The Diminishing Quality of Women Faculty Experiences in Higher Education

Faculty Research Mentor: Amanda Mireles

ABSTRACT

The Trump administration's executive order (EO) 14151 removed diversity, equity, and inclusivity (DEI) initiatives and withheld funding from institutions to ensure compliance. The impact of EO 14151 on women faculty in higher education has not been fully explored. Although, the qualitative data has revealed the removal of DEI is diminishing the quality of women faculty experiences. This can imply poor women faculty retention—which can further marginalize women faculty and limit representation. A lack of women faculty can impact research, teaching content, and mentorship opportunities. To understand the experiences of the subject group, interviews with women faculty at the University of California and University of Texas systems were conducted over zoom. Additionally, we transcribed the interviews to analyze the data collected to find common themes among participants. Through our findings, we highlighted that women faculty have experienced worries related to job security, surveillance, and self-censorship.

I-BEST REU



Mason Clark

Modelling multicellular self-organization through extracellular strain-mediated elastic interactions

Faculty Research Mentor: Kinjal Dasbiswas

ABSTRACT

Many animal cells actively generate mechanical forces while also sensing mechanical stress in their vicinity. This may drive cell-cell interactions through the deformation of the surrounding elastic medium, leading to self-organized multi-cellular structures, important for tissue morphogenesis and wound healing. Recent experiments on fibroblasts cultured in collagen gels show that cells can collectively contract the collagen matrix beyond a critical cell density to organize into multicellular networks. In this project, we aim to explain the organization of cells into clusters and its impact on the matrix gel's contraction. We model the cells as dynamic units that hop on an elastic extracellular matrix modeled as a triangular network of springs. Cells exhibit purely stochastic dynamics in isolation and a bias towards areas of higher strain, while reversibly deforming the matrix between hops. By computationally solving both the cell dynamics and the elastic force balance of the matrix springs, we show that cells may indeed cluster through such interactions. We quantify the statistics of cell dynamics using the mean squared displacement from trajectories as well as the radius of gyration of the cell clusters, as a function of key model parameters: cell density, cell traction forces and stochasticity of cell dynamics. Eventually, we will explore how the cell clustering correlates with stresses transmitted to the boundary of the spring network, a proxy for the gel contraction. Our results are widely applicable to the mechanobiological scenario of cell-matrix interaction and matrix compaction that may guide applications in tissue engineering and regenerative medicine.

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Yuvraj Gaba

Size-Dependent Interactions Between Giant Unilamellar Vesicles and Swarming Serratia marcescens

Faculty Research Mentor: Anand Bala Subramaniam and Arvind Gopinath

ABSTRACT

Bacterial swarming is a form of collective surface motility in which densely packed, flagellated bacteria move as a coordinated fluid layer, generating internal flows, vortices, and propagating fronts. Prior work has shown that micrometer-scale objects interact with swarms in size-dependent ways: microbubbles track internal fluid flows, passive microparticles show non-monotonic enhanced diffusion, and fixed pillar arrays reorganize bacterial vortex lattices. What has not been studied is how soft, deformable objects alter swarm dynamics. This project introduces giant unilamellar vesicles (GUVs, 1-100 µm in diameter) as a new class of probe in Serratia marcescens swarms. We find that GUV behavior depends on both size and position: the largest GUVs that remain immotile in the most active swarm regions are more likely to rupture, mid-sized GUVs deform and are carried by the local flow, and smaller GUVs move with the swarm but displace to the passive colony edge. We also find that the sucrose buffer alone increases swarm expansion rate, which must be accounted for when interpreting GUV-swarm interactions.

I-BEST REU

Emma Gomez

Buffer Optimization and Crystallization of a Temperature-sensing Kinase

Faculty Research Mentor: Michael C. Thompson

ABSTRACT

CDC2-Like Kinases (CLKs) phosphorylate serine/arginine-rich (SR) proteins, regulating alternative splicing and downstream gene expression. Their kinase activity changes in response to subtle physiological changes in body temperature, enabling them to function as molecular thermometers. This temperature-dependent function is evolutionarily conserved across many eukaryotic species, including mammals, reptiles, insects, and plants. Although previous human CLK structures have been determined, the structural mechanisms for temperature sensing remain elusive. This project aims to investigate the molecular mechanisms underlying the temperature-dependent activity of CLK homologs using the aster leafhopper (Macrosteles quadrilineatus) CLK (MqCLK), as a model system to better understand how CLKs from different species have adapted to distinct physiological temperature ranges. To achieve this goal, we aim to determine the X-ray crystal structures of MqCLK at physiologically relevant temperatures, providing structural insight into the mechanisms underlying temperature-dependent regulation. To address this knowledge gap, MqCLK was recombinantly expressed in E. coli and purified using affinity chromatography and size-exclusion chromatography. Circular dichroism (CD) spectroscopy was used to evaluate structural protein integrity at various temperatures and to optimize buffer conditions for its crystallization. Next, extensive crystallization screening and optimization were performed to identify conditions that yield suitable crystals for structural studies. Purified MqCLK was successfully obtained. Buffer conditions that enhanced MqCLK stability were identified and crystallization screening revealed several promising conditions that are being further optimized. This work establishes a foundation for determining the crystal structure of MqCLK and will advance our understanding of the structural mechanism of CLK's temperature sensing ability, enabling future comparative structural and evolutionary studies.

I-BEST REU

Bohan Huang

Vortex Dynamics in a Microfluidic Device with Particle Tracking

Faculty Research Mentor: Bin Liu

ABSTRACT

Collective vortex formation is an important phenomenon in fluid dynamics and active matter. In this study, we investigated vortex dynamics in a microfluidic device using tracer particles and bacteria to visualize fluid flow. Microscopy videos were analyzed to quantify particle motion and characterize vortex formation under different glycerol concentrations. We focus on how motor speed and fluid viscosity will reduce particle oscillation and create stable vortex formation. These findings improve our understanding of vortex behavior in confined microfluidic systems and provide a foundation for studying transport processes and collective behaviors in biological and active matter systems. Future work will focus on improving automated particle tracking and expanding quantitative analysis of vortex dynamics.

I-BEST REU

Akshay Langhani

Quantifying biological functionality of in-silico vascular networks

Faculty Research Mentor: Ajay Gopinathan

ABSTRACT

Living systems transport materials across space through distribution networks, including vasculature and fungal mycelia. However, the governing principles that drive the self-organization of these networks remain poorly understood. We therefore developed a computational model to investigate how such networks can form. However, the question remains on whether these resulting structures can perform any biological function. Using graph-theoretic measures, we evaluate the functional properties of the simulated networks. We ask how they can reconcile competing demands for physical and transport efficiency, robustness, and low wiring cost. We also examine whether these trade-offs produce Pareto-efficient network structures. This work aims to determine how specific model parameters control structure and functional relationships. This study can give us insights on design principles to engineer robust, resource-efficient, nature-inspired materials capable of transportation.

I-BEST REU

PHOTO NOT PROVIDED

Edgar Nieland Sanchez

Functionalization of Silicon(111) Surfaces with Hexaethylene Glycol O-undec-1-en for nonspecific adsorption

Faculty Research Mentor: Tao Ye

ABSTRACT

the development of nanophotonics, nanoelectronics and biosensors devices, require precise control of biomolecules and their interactions on silicon surfaces, so controlling the interactions between the biomolecule and silicon is essential for making the development of these electronics possible. In this work, Oligo(ethylene glycol)-Terminated Alkenes (OEG) gets functionalized to a piece of silicon(111) to create an Oligo(ethylene Glycol) monolayer to reduce nonspecific adsorption. It is suspected the OEG’s ability to be able to passivate the silicon surface to minimizes nonspecific adsorption of biomolecules can improve surface selectivity. Hexaethylene Glycol O-undec-1-en functionalized surfaces were compared with octadecene functionalized surfaces to compare their effectiveness for reducing nonspecific adsorption.

I-BEST REU

Sandra Oko-Umoh

Interfacial Behavior of Articular Cartilage Extracellular Matrix Protein Mixtures During Synovial Fluid Boundary Lubricant Film Formation and Recombinant Lubricin Retention

Faculty Research Mentor: Roberto Andresen Eguiluz

ABSTRACT

The articular cartilage extracellular matrix (AC-ECM) is a complex network of biomolecules that enables the low-friction, load-bearing function of synovial joints. Collagen type II (Col-II), collagen type I (Col-I), and fibronectin (FN) are key AC-ECM components, contributing to tissue structure. Understanding the mechanisms mediating the assembly of films derived from synovial fluid (SF), the native lubricant of synovial joints, is necessary for explaining the loss of mechanical performance associated with diseases like osteoarthritis. Such insights may also inform the design of biomaterial implants, surface coatings, and intra-articular treatments that interact with SF. Using quartz crystal microbalance with dissipation (QCM-D) this study explores the adsorption, viscoelastic properties, and SF component retention of Col-II, Col-I, and FN mixtures on articular surface models. QCM-D analysis revealed that most 1:1 binary and 1:1:1 tertiary component mixtures containing FN exhibited adsorption, viscoelastic behavior, and SF component retention similar to FN alone across the multi-component base layers, as well as after exposure to dilute synovial fluid (dSF) and recombinant equine lubricin (rEqLub), suggesting a strong influence of FN in regulating the assembly of films contributing to synovial joint boundary lubrication. Col-II/Col-I mixtures generally displayed behavior intermediate between those of the individual collagen components; however, following rEqLub exposure, these mixtures retained less lubricin than either collagen alone. These findings provide new insight into the roles of Col-II, Col-I, and FN in synovial joint protein film assembly, advancing our understanding of boundary lubrication mechanisms and informing future biomaterial, cartilage repair strategies, and osteoarthritis treatment.

I-BEST REU

Monica Quesada

Validating Methods for the Generation of hiPSC-Derived Endothelial Cells

Faculty Research Mentor: Kara E. McCloskey

ABSTRACT

Peripheral artery disease affects nearly 20 million people in the United States, and its most severe form, critical limb ischemia, carries an amputation rate as high as 40% within six months when patients do not receive vascular intervention. Restoring blood flow to ischemic tissue through targeted neovascularization is therefore essential to preventing limb loss. Human induced pluripotent stem cells (hiPSCs) offer a promising foundation for vascular regeneration due to their capacity to differentiate into functional endothelial cells (ECs). Within developing vascular networks, tip-specific ECs are essential for guiding new blood vessel growth during sprouting angiogenesis, but the reliable generation of these cells remains a critical hurdle for clinical application. This study aims to validate a recently published chemically defined 8-day differentiation protocol for generating ECs from hiPSC. Results suggest that, although cell populations containing 30% ECs can be generated using this new protocol, our own laboratory's more rigorous and time-consuming 3-stage induction strategy remains superior (>85-95% ECs). These studies lay the groundwork for further isolation of tip-ECs.

I-BEST REU

Delia Rodriguez

Expression, Purification, and Enzymatic Assay of Phytase and Phytase-Dockerin

Faculty Research Mentor: Ruben M. Ceballos

ABSTRACT

A major focus in agricultural science is improving the feed conversion ratio (FCR) for poultry production. Enzyme supplements are used to facilitate digestion of recalcitrant components of cornmeal- and soymeal-based commercial poultry feed. Phytase is a common enzyme supplement used to breakdown phytate into myoinositol and free phosphate. Phytase is commonly added to pre-processed feed (prior to pelleting), making it vulnerable to deactivation/denaturation at the high temperatures used in the feed production process. Our lab has a patented thermotolerant enzyme sequestration platform (MESP) that protects enzymes under harsh temperature and pH conditions. A major project in the lab is to optimize an MESP-phytase construct for use as a "nanobiotic" in poultry feed to facilitate efficient phytate degradation, thus releasing bioavailable phosphorus. A key step for this project is optimizing protein expression and purification. My summer internship project was focused on developing high-yield expression and purification protocols for producing phytase and phytase-dockerin in an E. coli overexpression system. The latter is used to test the efficacy of MESP systems in protecting phytase-dockerin (Phyt-doc) fusion proteins under conditions simulating feed production processes and the digestive pathway within the chicken gastrointestinal tract (GIT). Specifically, I purified a fusion construct consisting of phytase from Aspergillus ficuum (AF) and dockerin type 1 from Clostridium thermocellum, testing different expression and purification conditions for higher protein yields. Results from this work showed that purification of phytase and Phyt-doc was most effective when using a large salt concentration gradient with a Ni-NTA column.

I-BEST REU

August Scrivner

Comparison of Wear Volume and Wear Scar Diameter as Metrics for Lubricant Performance

Faculty Research Mentor: Ajay Gopinathan

ABSTRACT

Reliable evaluation of lubricant performance is essential for improving the durability of mechanical systems. Wear scar diameter is the standard metric used in tribological testing, but because it is a two-dimensional measurement, it may not fully represent material loss. This study investigates whether wear volume provides a more accurate and sensitive measure of lubricant performance than wear scar diameter alone. Lubricants were tested using a Falex Four-Ball tribometer under ASTM standard conditions. Wear scar diameter was measured using optical microscopy, while wear volume was determined using white light interferometry to generate three-dimensional surface profiles. Results indicate that wear volume is a more accurate and sensitive metric for evaluating lubricant performance, capturing differences in material loss that are not reflected by wear scar diameter alone.

INSITE

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Joshua Corona

Mapping Environmental Conditions Across Florida Aiptasia Habitats

Faculty Research Mentor: Gordon Bennett

ABSTRACT

Aiptasia is a very small sea anemone often employed as a research subject for studying coral symbionts. This project utilizes geographic information systems technology to investigate the coastal environment around Aiptasia study locations on the Florida coast. There are two primary objectives in this research – creation of a geodatabase with integrated environmental data and analysis of changes in sea surface temperature during the last few decades. The key research questions are whether there is variation in physical, water quality, habitat and human use conditions at the different study sites and whether the sea surface temperature trends are different for the Florida coast. Field measurements, satellite products and governmental data will be processed and structured in ArcGIS Pro. The data sets include sea surface temperature, bathymetry, water quality, coastal habitats, watersheds, marine protected areas, currents, and proximity to man-made structures. In the temperature analysis August mean, minimum, and maximum sea surface temperatures from 1985 to 2025 are analyzed with NOAA Coral Reef Watch products. Progress so far shows that satellite temperature data provide consistent coverage across the study area, while water-quality coverage is much more uneven, especially for pH measurements near northern field sites. The completed maps and geodatabase will make it easier to compare environmental conditions among Aiptasia sites, select areas for future sampling, and support later research connecting coastal conditions with differences observed in Aiptasia populations.

INSITE

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Angel Hernandez

Antibiotic Resilience Across the Maturely Diverse Colonization Sites within the Euprymna tasmanica Light Organ

Faculty Research Mentor: Michelle Nishiguchi

ABSTRACT

The light organ of the Australian bobtail squid (Euprymna tasmanica) houses the bioluminescent bacteria known as Vibrio fischeri within its morphologically distinct crypts that differ in developmental maturity. This mutualistic partnership provides the glowing bacteria with shelter and nutrients, while the squid gains the ability to camouflage through counterillumination. This study investigated how the light organ reacts to antibiotic exposure and how the difference in maturity of the crypts influences its resiliency against exposure, aiming to provide insight into how the bobtail squid safeguards its symbionts against outside pressures, such as antibiotic exposure. Newly hatched squid were inoculated with cultured V.fischeri for 24 hours, then washed with filter-sterilized seawater to remove excess bacteria. Luminescence was monitored daily to ensure colonization was successful. A portion of the infected squid were then selected to undergo an antibiotic treatment. Following treatment, luminescence was measured, and treated squid were either fixed in 4% paraformaldehyde, frozen, or left to recover. Fixed animals were dissected, mounted, and imaged at 10x and 20x magnification to observe the crypts. Frozen animals were homogenized, serially diluted, and plated on LBS agar petri dishes. Colonies that grew on the plates were quantified and recorded. Preliminary results revealed that V.fischeri survival was more likely within the first crypt, the most mature crypt, following antibiotic exposure. This suggests that there is greater resistance and protection of symbionts within this region of the light organ and that variability in crypt development plays a role in protection of the bobtail squid’s symbionts.

INSITE

Omar Mora Padilla

Exploring Exaiptasia diaphana: Comparing different metabolite extraction protocols

Faculty Research Mentor: E. Maggie Sogin

ABSTRACT

Rising ocean temperatures due to climate has resulted in dysbiotic interactions and responses between marine organisms and their symbiotic partners (metaorganism). To understand how dysbiosis shifts the metabolome of the marine metaorganism Exaiptasia diaphasia (Aiptasia), we investigated which metabolite extraction protocol yielded more reliable and reproducible results. We collected metabolites from Aiptasia using two lysing matrices, B+D or D alone, then conducted a liquid chromatography tandem mass-spectrometry (LC-MS/MS) analysis. From our analysis, we found that lysing matrix D recovered more metabolites and had a lower relative standard deviation compared to lysing matrix B+D, suggesting lysing matrix D alone consistently captured metabolites better. Our results allow us to establish a reliable and reproducible protocol for analyzing the metabolome of Aiptasia and their symbiotic partners in the context of dysbiosis.

IOT4AG

Itzel Camacho

Self-Healing Missions in Agriculture: A multi-agent architecture for field robots

Faculty Research Mentor: Stefano Carpin

ABSTRACT

Autonomous agricultural robots face many challenges in the field. One is encountering unexpected situations that require human intervention, as the robot cannot reason how to self-correct and continue its mission. Control architectures such as behavior trees help mitigate this by giving the robot a set of actions it can perform; however, an event falling outside those actions again requires human intervention. Large language models offer another path to greater autonomy. This work combines large language models with an Agent-to-Agent (A2A) architecture so the robot can decide how to proceed once it encounters an event the behavior tree cannot handle. The A2A architecture enables a multi-agent system whose agents exchange messages to edit the original mission rather than generate a new one, returning it to the robot where the mission remains viable rather than aborting. A world state agent tracks the robot's status and provides context to the mission planner agent, which uses that information to edit the original plan. The edited plan is sent to an arbiter agent that evaluates whether it is acceptable and, if not, returns it to the mission planner for revision. We evaluate this pipeline in simulation on injected behavior tree errors, prompting a local model, with a cloud model as an alternative, to edit the plan before it reaches the arbiter. The result is a robot that repairs its own plan, skipping an unreachable tree or abandoning the mission when too much is unrecoverable, closing a loop that would otherwise require a human.

IOT4AG

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Dylan Fitchmun

Semantic Segmentation On RGB-D Images For Orchard Navigation

Faculty Research Mentor: Stefano Carpin

ABSTRACT

While the paradigm of sensor fusion is popular in the realm of robotics, navigation of orchards with traditional means of sensor fusion has proven to be unreliable thanks to a variety of factors. Dense canopies might block GPS, and SLAM-based mapping is rendered impractical thanks to the sheer scales of the fields the robot needs to traverse. In order to address this, the VINS-tree (Visual-Inertial Navigation System) was developed. It uses a variety of systems that are more resistant to the typical issues that other sensors tend to have. Among these systems is one that performs semantic segmentation on tree trunks and large branches to reduce the noise that dense foliage or small branches might cause. An earlier attempt to do this used semantic segmentation models to put masks over individual frames of the robot's visual input, represented in 3-channel RGB. However, this proved to be ineffective, as false positives from nearby trees often occurred. In order to address this, I implemented a new model that would take in 4-channel RGB-D (Red, Green, Blue, Depth) input. By letting the model take the depth of the frame into account, it was thought that it could more easily segment the trunk and major branches, as they'd all have a similar depth. In the testing that was conducted, almost no misapplication of masks occurred. The consistent and accurate results of the model indicate that letting segmentation models take 4 channel RGB-D input dramatically improves the accuracy of its masking.

IOT4AG

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Austin Grey

How Prompt Injections Influence LLM-driven Robots

Faculty Research Mentor: Stefano Carpin and Lisa Yeo

ABSTRACT

The increasing adoption of Large Language Models (LLM)-driven artificial intelligence in agricultural robotics is transforming how farmers may utilize autonomous systems in field environments. Rather than operate independently, these robots are expected to function as collaborative assistants that interpret Natural Language (NL) instructions while supporting human decision-making. However, integrating LLMs into robotic control introduces new cybersecurity and safety challenges, particularly through prompt injection attacks that manipulate a robot's intended behavior. This study investigates the effects of prompt injection attacks against an AI-controlled agricultural robot operating in a farm field scenario. A range of prompt injection categories is systematically introduced into the robot's workflow to evaluate their ability to alter mission objectives, induce unsafe actions, expose sensitive information such as Personally Identifiable Information (PII) or access control data, and create hazardous conditions for nearby workers or the robot itself. By examining the output of the robot through its Extensible Markup Language (XML) command output and its actions under simulation, no border boundary movement was observed if given free-reign of its own control but only followed if explicit latitude longitude coordinates were provided. The findings contribute to a better understanding of securing LLM-enabled agricultural robotics and provide insight into designing more resilient AI systems for real-world farming applications.

IOT4AG

Javon Hudgins

Using Spatiotemporal Fusion Imagery to Estimate Tree Crop Growth Behavior and Water Stress

Faculty Research Mentor: Erin Hestir

ABSTRACT

Intensifying climate change and drought conditions throughout California have led to increases in research on the utility of remote sensing and spatial analysis methods for assessment of agricultural health and crop growth behavior. Multispectral UAV imagery has a variety of spatial analysis applications in crop monitoring; however, frequently obtaining high-resolution multispectral imagery for such analyses is expensive, time-consuming, and weather-dependent. Multispectral imagery of agricultural land is captured daily by satellites, but satellite imagery lacks the high-quality resolution needed for detailed crop analyses. This study assesses the applications of spatiotemporal fusion (STFuse) methods in analyses of Merced County pistachio tree-crop water stress and growth behavior. The STFuse methods assessed include unmixing-based methods, namely Unmixing-Based Data Fusion (UBDF) and Flexible Spatiotemporal Data Fusion (FSDAF), and mixing-based methods, namely Regression Model Fitting, Spatial Filtering, and Residual Compensation (Fit-FC) and the Spatiotemporal Adaptive Reflectance Model (STARFM). The performance of these models was evaluated using an STFuse model assessment framework, with results indicating that metrics from mixing-based methods more closely met the RSME benchmarks defined by the assessment. This outcome has important implications regarding efficient and computationally simple applications of mixing-based STFuse methods for the assessment of tree crops.

IOT4AG

Jesse Perez

Aerobiology of Pistachio Pollen and the Potential Role of Supplemental Wind in Precision Agriculture

Faculty Research Mentor: Reza Ehsani

ABSTRACT

There is a research gap between pollen research and research directly involving pistachio pollen. With what papers exist, there is an consensus on what effects pistachio pollination. That wind is the primary driver, environmental conditions matter, pollen concentration decreases with distance, and pollen viability declines over time. However, different models/scales have been used, there isn't an agreed ideal speed, and different environmental conditions in each experiment.

IOT4AG

Deb Ray

Assessing Crop Health under Drought Effects with Spatio-temporal Fusion of Drone and Satellite Imagery

Faculty Research Mentor: Senior Adepoju

ABSTRACT

Drought-affected areas lack water, leading to poor crop growth. Which is why accurate crop health readings are crucial for agricultural drought mitigation. Since frequent drone imagery is expensive and satellite imagery has a low spatial resolution, we combine them over specific date ranges using a custom script, STFuse, to generate spatio-temporal predictions based on reflectance. These predictions enable strategies to mitigate drought effects by identifying variations in crop health across a field through different genotypes. Our work so far demonstrates that the combined imagery doesn't meet the thresholds that we want, as it's not as accurate to the drone imagery as we would like it to be. Further work will have to be done in order to improve it to be closer to the drone imagery.

IOT4AG

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Pranav Yadav

Failure-Triggered VLM Diagnostics for Autonomous Precision Agriculture Missions

Faculty Research Mentor: Reza Ehsani

ABSTRACT

Autonomous orchard robots executing LLM-generated missions can fail in ways that are difficult to diagnose remotely. Building on Carpin et al.'s GPT-4o mission-planning framework, we introduce a vision-language model (VLM) operating locally that activates only on execution failure, producing structured, GPS-tagged diagnostic reports that explain what went wrong and recommend next steps. Over a mission, this automatically builds a record of the robot's difficulties paired with actionable recommendations; in validation testing, the system correctly withheld false diagnoses in 99% of cases where no visual failure cause was present. The result bridges the gap between robot perception and farmer decision-making.

SHARKS SURVIVOR!

Jania Kapoor

Tooth Shape Variation and Stable Isotope Analysis in the Sandbar Shark (Carcharhinus plumbeus)

Faculty Research Mentor: Sora Kim

ABSTRACT

* Tooth morphology is closely linked to feeding ecology, and can be used to gain insight into the ecology of sharks. Stable isotope analysis can give a view into the climate, trophic level, or habitat usage of sharks, but few studies have combined these approaches and applied them to the sandbar shark (Carcharhinus plumbeus). This study investigates the relationship between tooth shape variation and stable isotope composition with the aim of characterizing intraspecific ecological variation. The functional row of the upper and lower dentitions from five C. plumbeus specimens were photographed and digitized using two-dimensional landmark morphometrics. Variation of tooth shape from the anterior to posterior position in the jaws was visualized using general procrustes analysis (GPA) and principal component analysis (PCA). Stable isotope values for $\delta^{13}C$, $\delta^{15}N$, and $\delta^{18}O$ were collected from the same specimens and compared to the morphometric data. PCA revealed that tooth shape differed in accordance with position through the jaw, with more posterior teeth appearing further on the extremes of the principal components. Additionally, isotopic analysis showed some differences between the five specimens, despite the jaws being a similar size, such as one specimen having a higher $\delta^{15}N$, suggesting it may have been eating at a higher trophic level. Further conclusions are yet to be examined. Results suggest differences in diet or habitat use. The limited sample size prevents strong conclusions regarding the relationship between morphometrics and stable isotope analysis. Future studies with larger sample sizes are needed to evaluate these relationships more robustly.

SHARKS SURVIVOR!

Riley Mullis

Stable Isotope Analysis of Eocene Shark Tooth Enameloid to Assess Habitat Use in the English North Sea

Faculty Research Mentor: Sora Kim

ABSTRACT

The English coastline contains an extensive fossil record from the Eocene Epoch, yet most of the data is qualitative and mammalian-focused. This project seeks to add quantitative data about the Eocene in the North Sea based on shark teeth found in a select three localities. Along the English coast the three selected localities - Abbey Wood, Selsey, and London Clay, are yet to have their paleohabitat identified. Using tooth measurements combined with analysis of δ18O from dental enameloid, this project also aims to determine the potential habitat use of Striatolamia macrota, Otodus obliquus, Odontaspis winkleri, Lamna lerichei, Galeocerdo latidens. Stable isotope analysis of δ18O from the Abbey Wood locality and the average anterior tooth crown height, suggest that this location may have been a nursery habitat. Other preliminary results of anterior tooth crown height show that the London Clay locality of Warden Bay may have also been a nursery habitat based on anterior tooth crown height. Anterior tooth crown height may also show that the Selsey locality primarily consisted of adult individuals, though further analysis is needed to confirm.

SUMMER START

Madison Calderon

Investigating the Effects of Tumor-Derived Soluble Signals on Sprouting Angiogenesis

Faculty Research Mentor: Kara E. McCloskey

ABSTRACT

Cancer progression is influenced not only by tumor cells but also by the soluble proteins, cytokines, and growth factors they release into the surrounding microenvironment. These signaling molecules regulate angiogenesis, the formation of new blood vessels from pre-existing vasculature, supplying tumors with the oxygen and nutrients necessary for continued growth. Understanding how tumor-derived soluble signals influence angiogenesis may provide insight into future anti-angiogenic therapies. This study investigated how tumor-derived soluble signals affect endothelial cell behavior during sprouting angiogenesis using a three-dimensional fibrin hydrogel bead assay and a wound healing assay. Human umbilical vein endothelial cells (HUVECs) were cultured on Cytodex microcarrier beads embedded within a fibrin hydrogel and treated with VEGF, VEGF + bFGF, or exposed to A549 and SKOV-3 tumor cells cultured above the hydrogel. Cultures were maintained for 23 days, with sprouting imaged on Day 14 using fluorescence microscopy. Fiji (ImageJ) was used to quantify sprout number and sprout length, while a wound healing assay evaluated endothelial cell migration. Representative images and quantitative analysis demonstrated distinct sprouting behaviors across treatment conditions. VEGF significantly increased endothelial cell migration compared with the control, while A549-conditioned media produced a more variable response. These findings improve our understanding of how tumor-derived soluble signals regulate angiogenesis and may contribute to future anti-angiogenic therapeutic strategies.

SUMMER START

Brody Spellman

Formal Validation of Dimensionality Reduction for ODE Models

Faculty Research Mentor: Ashlie Martini

ABSTRACT

Large systems of ordinary differential equations can be difficult and computationally expensive to simulate, especially when they contain many interacting variables. This project evaluates AutoReduce, a Python package that uses model-reduction methods such as the quasi-steady-state assumption to generate smaller systems that may preserve the important behavior of the original model. I tested AutoReduce on several biological, ecological, and engineering models, including Michaelis-Menten enzyme kinetics, protein expression, an SEIRVD infectious disease model, and an induction motor model. For each example, I simulated the full system, generated reduced models, and compared their behavior using numerical error measurements and interactive plots. I also developed documented Jupyter notebooks and submitted new examples to the AutoReduce GitHub repository. The results show that AutoReduce can generate many possible reduced systems, but only a small number closely match the original model over the full simulation. Some reduced models accurately reproduce only the early-time or steady-state behavior, which may still be useful when a specific time range is most important. The project also found that common error measurements may not fully describe accuracy for oscillating systems and that models with time-dependent inputs require additional manual simulation. Overall, AutoReduce is most effective for systems with fixed parameters and clearly separated timescales, but careful validation is necessary before a reduced model can be considered reliable.

TUSCEB

Samathasri Boggula

Characterizing Mitochondrial Dynamics Across Mouse Thymocyte Development

Faculty Research Mentor: Jennifer O. Manilay

ABSTRACT

Pesticides are widely used in modern agriculture to improve crop yields and protect against disease and pests, making them especially important in agricultural regions like California's Central Valley. However, growing evidence suggests that some pesticides may also affect non-target biological systems. In particular, glyphosate is a herbicide associated with oxidative stress, inflammation, and mitochondrial dysfunction in animal cells, while pyraclostrobin, a fungicide that inhibits Complex III of the mitochondrial electron transport chain in fungi, has also been shown to impair mitochondrial function in mammalian cells. Since mitochondria regulate cellular metabolism, signaling, proliferation, and survival, mitochondrial function provides a sensitive gauge for investigating the effects of environmental toxicants on the immune system. T cells are essential to adaptive immunity, recognizing pathogens, coordinating immune responses, and establishing long-term immunological memory. These cells develop in the thymus through tightly regulated stages that require dynamic metabolic remodeling and healthy mitochondrial function. Consequently, pesticide-induced alterations cannot be accurately interpreted without first establishing normal mitochondrial behavior during thymocyte development. This study optimized a dual MitoTracker staining protocol for use with our flow cytometer and antibody panel to assess mitochondrial mass and membrane potential across thymocyte developmental stages. The optimized protocol successfully reproduced expected differences in mitochondrial membrane potential between DN3 and DN4 thymocytes, validating its use for stage-specific mitochondrial analysis. This procedure can now be applied to investigate how glyphosate and pyraclostrobin alter mitochondrial function during thymocyte development and to identify developmental stages that are most susceptible to pesticide-induced mitochondrial dysfunction and impaired adaptive immune responses.

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Delaney Chen

The Impact of miRNA on Bacterial Growth

Faculty Research Mentor: Hirosha Geekiyanage

ABSTRACT

miRNAs are short, 21-22 nucleotide long noncoding segments of RNA that have the capability to silence gene expression by base-pairing to the 3’ UTR region of a mature mRNA. miRNAs can cleave or degrade the mature mRNA as a result of its complementarity. miRNA have been found primarily in eukaryotic organisms where they are stabilized and transported in association with argonaut proteins. Previous studies performed by Andrew Ore revealed that E. coli transfected with a certain miRNA miR-A resulted in a slower growing strain when compared to E. coli transfected with miR-B or miR-C, exhibiting potential antibacterial properties. The goal of this project is to expand on previous observations to determine the impact of miRNA on bacterial growth. *For confidentiality, the miRNAs that were tested will be referred to as miR-A, miR-B, and miR-C

TUSCEB

Gannon Connors

Effects of cannabidiol and cannabidiol diacetate on endothelial cell sprouting

Faculty Research Mentor: Kara E. McCloskey

ABSTRACT

Cannabidiol (CBD) is a widely used compound in the self-medication of chronic conditions like anxiety, stress, or pain. Studies have shown that CBD exhibits contradictory effects such as being cytotoxic yet also having antioxidant, anti-inflammatory, and vasodilatory properties in endothelial cells. Additionally, inconsistencies in CBD dosages, delivery vehicles and cell types in literature make it challenging to compare studies. We hypothesize that current contradictory evidence may be a result of CBD’s instability in oxygen-rich environments. Here, we measure the effects of CBD and a synthetic, more stable analog, cannabidiol diacetate (CBD-DA) on the viability and angiogenic capacity of human umbilical vein endothelial cells (HUVECs). Treatments at either 0, 1μM, 6μM and 10μM CBD or CBD-DA are provided to sprouting HUVECs using a fibrin bead assay as a 3D model for 24 hours and then imaged every other day for 14 days. Results show increasing concentration of both CBD and CBD-DA led to decreased sprout numbers and lengths. This suggests a concentration-dependent anti-angiogenic effect on HUVECs. Insight into the context-dependent effects of CBD and CBD-DA therapies on endothelial is important for vascular health.

TUSCEB

Jennifer Garcia Villa

Generation of Induced Pluripotent Stem Cells from Toothbrushing

Faculty Research Mentor: Kara E. McCloskey

ABSTRACT

Induced pluripotent stem cells (iPSCs) hold significant potential for regenerative medicine enabling patient-specific models of cells derived from a patient's own somatic cells. Current methods for establishing human iPSC lines face challenges in cell collection and reprogramming efficiency. Here, we aim to source patient cells non-invasively via cheek swabs to collect buccal cells, rather than invasive methods like skin punch biopsies or blood collection. Reprogramming is achieved using transcription factors Oct4, Sox2, Klf4, and c-Myc delivered using the non-integrating Sendai virus (SeV) to which avoids risk of insertional mutagenesis. To improve reprogramming efficiency, we examined the incorporation of a DNA polymerase alpha (Polα) inhibitor. Results indicate that the cell proliferation of buccal cells is low compared with fibroblasts, and seeding more Buccal cells combined with Pola inhibition enhances generation efficiency of human iPSCs. Collectively, we are developing novel culturing methods that combine non-invasive cell sourcing and Polα inhibition to generate iPSCs more reliably, with the goal of enabling unlimited stem cell production for regenerative medicine.

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Charlotte Han

Investigating the Regulatory Role of Extracellular microRNAs in Intercellular Communication

Faculty Research Mentor: Hirosha Geekiyanage

ABSTRACT

MicroRNAs (miRNAs) are small, non-coding RNAs that regulate gene expression by base-pairing to target messenger RNAs (mRNAs). In addition to their intracellular functions, extracellular miRNAs have emerged to play an important role in intercellular communication and may also have great significance in disease progression and RNA-based therapeutics. However, the ability of extracellular miRNAs released from donor cells to regulate protein expression in recipient cells remains incompletely understood. This study investigates whether extracellular miRNAs secreted by transfected mammalian cells can be transferred to long range cells and influence their protein expression. Mouse neuroblastoma (N2a) cells were transfected with lipid nanoparticle-delivered miRNAs or scramble controls. Following transfection, cultures were treated with DNase before conditioned media were collected, centrifugation was used to remove cellular debris, and transferred to recipient cells. Recipient cells were then analysed by Western blots to evaluate protein expression differences. Successful transfection was confirmed by fluorescent microscopy, setting up the experimental foundation for extracellular miRNA delivery studies. This work provides an in vitro model for investigating extracellular miRNA-mediated cell-to-cell communication and lays the foundation for determining how secreted miRNAs regulate gene expression in recipient cells. These findings may contribute to a better understanding of extracellular miRNA signaling and support the future development of miRNA-based therapeutic strategies.

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Jazmin Magana-Alvarez

Establishing a MitoTracker Green Flow-Cytometry Workflow to Characterize Planarian Neoblasts

Faculty Research Mentor: Nestor J. Oviedo

ABSTRACT

Planarian neoblasts are adult stem cells responsible for tissue maintenance and regeneration, yet they comprise functionally distinct populations that may not be fully resolved by DNA-content analysis alone. Previous studies have linked lower MTG fluorescence with more pluripotent neoblast states and higher MTG fluorescence with increased mitochondrial mass and differentiation-associated cell states. These findings suggest that mitochondrial mass may provide an additional marker for characterizing neoblast heterogeneity and distinguishing functionally distinct cell states. This project presents a proposed flow-cytometry framework that integrates DNA-content analysis with MTG-based measurement of mitochondrial mass. The workflow draws on published methods for planarian tissue dissociation, nuclear and MTG staining, and analysis of the X1, X2, and Xins populations to identify MTG-low and MTG-high subpopulations. Published gating strategies and quality-control criteria provide the basis for the proposed analytical framework. After future experimental validation, this framework will enable comparisons between control and PTEN knockdown planarians to determine whether PTEN-associated abnormalities are accompanied by changes in neoblast composition or mitochondrial-state profiles. PTEN knockdown has been associated with neoblast hyperproliferation, impaired differentiation, and abnormal tissue outgrowth in planarians. Overall, this work provides a methodological foundation for investigating whether mitochondrial mass can serve as an additional marker of stem-cell state and help identify neoblast populations associated with PTEN-related abnormalities.

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Kacie Ng

Effects of disseminated Valley fever infection on early mouse hematopoietic stem cell differentiation

Faculty Research Mentor: Katrina K. Hoyer

ABSTRACT

Valley fever is a fungal respiratory disease caused by inhalation of Coccidioides spp. spores. While most infections are controlled by the host immune system, a small subset of patients progress to severe, disseminated disease, with around half involving the skeletal system. Because immune responses are essential for fungal control, we hypothesize that hematopoietic stem cells (HSCs) in the bone marrow play a key role in successful clearance of Coccidioides. Although emergency hematopoiesis is well characterized, little is known about how disseminated fungal pathogens influence the earliest stages of hematopoietic distinction into blood cell lineages. Here, we examined HSC differentiation during systemic Coccidioides infection by assessing common lymphoid progenitors (CLPs) and common myeloid progenitors (CMPs) in an in vivo mouse model. Attenuated C. posadasii Δcts2/Δard1/Δcts3 mutant was cultured, arthroconidia harvested and fluorescently labeled with AlexaFluor488. Eleven weeks old C57BL/6J mice received retro-orbital injections of 1x106 arthroconidia under anesthesia. At 48 hours, bone marrow and spleen were harvested, processed into single cell suspension, and stained with lineage and progenitor markers. CLPs, CMPs, and fluorescently labeled C. posadasii were detected by flow cytometry, enabling correlation of fungal localization with changes in hematopoietic stem and progenitor cell populations. We anticipate Coccidioides dissemination into the bone marrow environment due to intravenous delivery and will assess skewing of progenitors towards CMP or CLP differentiation. Determining whether disseminated Coccidioides alters HSC lineage commitment will provide insight into early immune responses and how fungal burden shapes the hematopoietic microenvironment, informing improved diagnostics and therapies.

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Julian Reyes

Characterizing Homing Dynamics of Bone Marrow Progenitors into Thymus

Faculty Research Mentor: Joel Spencer

ABSTRACT

The thymus is responsible for the production and maturation of T-cells and depends on the continuous recruitment of hematopoietic progenitor cells from the bone marrow.While it is established that bone marrow derived progenitors enter the thymus through the corticomedullary junction the precise homing dynamics and spatial distribution is not understood.The purpose of this study is to characterize the homing dynamics and spatial distribution of bone marrow progenitors following transplantation.To examine bone marrow homing dynamics, green fluorescent protein expressing whole bone marrow was transplanted into wild type host. We then extracted the thymus, performed whole organ tissue clearing, and imaged the sample using a custom two photon microscope., The subsequent whole organ image datasets were then processed in a custom imagej analysis pipeline to identify donor bone marrow cells. WIth this work we established a workflow that allows for the localization of the individual donor bone marrow cells in the thymus and subsequent spatial analysis.These findings will improve the understanding of the mechanisms of bone marrow progenitor homing and provide guidance to future therapies to enhance thymus recovery following irradiation.

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Gabriel Rodriguez

Driving Intent Across Abstraction Levels: Instruction Composition and Decomposition for Long-Horizon Autonomous Driving

Faculty Research Mentor: Ross Greer

ABSTRACT

Recent advances in Vision Language Action (VLA) models have enabled autonomous systems to interpret natural language instructions and translate them into vehicle actions. The doScenes dataset established a foundation for instruction-based autonomous driving by pairing real-world driving scenarios with short-horizon directives grounded in immediate vehicle behaviors [1]. However, it also highlights a critical gap between short-horizon instruction following and long-horizon planning, which remains an open challenge [1]. As natural language becomes a primary interface for human-vehicle interaction, real users are unlikely to provide the precise, atomic commands on which current systems are trained. Instead, humans naturally express loosely structured, multi-step intentions within a single instruction (e.g., "Turn right, drive to the library, and pull up to the nearest curb"). To execute such commands, autonomous systems must decompose high-level goals into temporally grounded sub-instructions while maintaining consistency with the original intent. Current approaches primarily focus on short-horizon directives lasting several seconds, while long-horizon instructions require planning over extended sequences of actions. To bridge this gap, we propose a unified intermediate representation that enables long-horizon instructions to be decomposed into short-horizon commands and recomposed while preserving driving intent. We define driving intent as the intended vehicle trajectory, represented as a sequence of N (x, y) positional offsets from the vehicle's starting position over time. This motivates our research question: Can long-horizon driving instructions be accurately decomposed into temporally grounded sub-instructions and recomposed without loss of driving intent?

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Pablo Zurita Cruz

Optimization of a Flow Cytometry Protocol for Assessing Mitochondrial Function in Murine Thymocytes

Faculty Research Mentor: Jennifer O. Manilay

ABSTRACT

Pesticides such as glyphosate and pyraclostrobin are widely used throughout California's Central Valley, yet there is limited research investigating their potential effects on mammalian immune cell development. The thymus is a primary immune organ responsible for producing and maturing T-lymphocytes, which are an important component of the adaptive immune system. Mitochondria are best known for providing energy to the cell, but they also regulate biosynthetic and metabolic pathways that support cellular proliferation, differentiation, and survival. These functions are especially important during the double-negative 3 (DN3) stage of thymocyte development, when cells undergo β-selection and rapid proliferation before transitioning to the DN4 stage. Because alterations at this checkpoint may have downstream effects on later stages of T-cell development, establishing a method to assess mitochondrial function is an essential first step before investigating pesticide exposure. This study focused on optimizing a flow cytometry protocol using MitoTracker™ Green FM to measure mitochondrial mass and MitoTracker™ Red CMXRos to measure mitochondrial membrane potential. Experiments compared incubation time, wash conditions, staining order, and incorporating Zombie UV viability dye. Optimization data indicate that incubating cells with the MitoTracker dyes at 37°C for 30 minutes, followed by a wash before antibody staining, produced higher fluorescence and consistent staining. In addition, incorporating Zombie UV as the first staining step maintained compatibility with prior staining steps. This protocol provides a foundation for future studies investigating how pesticide exposure alters mitochondrial function during thymocyte development.

UC LEADS

Rhea Acholkar

AI-Enhanced LiDAR System for Object Identification

Faculty Research Mentor: Brandon Stark

ABSTRACT

While modern autonomous drones require intelligent object detection, current LIDAR-only systems often cannot distinguish what type of obstacle they detect. This experiment explores how data from a LiDAR A3 sensor can be used by a Convolutional Neural Network (CNN) to identify nearby objects. The NVIDIA Jetson Orin Nano Developer Kit is used as an onboard computing platform, collecting LiDAR data and mapping it over time into an image, processing it through the CNN for classification. This temporal accumulation also captures the drone's motion relative to nearby objects, offering additional shape cues beyond a single static scan. The system classifies objects like a wall, tree, or a window that enables the drone to make well-informed navigation decisions and safely maneuver around these obstacles. This approach offers a solution for autonomous systems that can help improve their intelligence while reducing reliance on backup systems and avoiding collisions.

UC LEADS

W. David Amaya

Comparative Accuracy and Precision of Cyanobacteria Cell Counting Methods

Faculty Research Mentor: Ruben M. Ceballos

ABSTRACT

Accurate quantification of cyanobacteria cell density is essential for: monitoring growth; assessing physiological responses; and, supporting ecological, molecular, and biotechnological studies. Selection of an appropriate cell counting method influences the accuracy, reproducibility, and interpretation of experimental results. In this study, we evaluated three approaches for cell enumeration: (1) manual hemocytometry counting; (2) optical density measurements at 750 nm (OD750); and, (3) flow cytometry. Two model cyanobacteria: Synechocystis sp. PCC 6803 and Synechococcus sp. PCC 7002 - were used to compare the performance of each method across a range of cell concentrations. An automated cell counter was also assessed; however, its performance was limited by the small cell size, pigmentation, and the intrinsic autofluorescence of cyanobacteria, resulting in inconsistent cell detection and unreliable quantification. The three primary methods were compared based on trend consistency, reproducibility, sensitivity, and practical applicability. Flow cytometry provided the highest sensitivity and enabled rapid, high-resolution quantification with excellent reproducibility. Manual hemocytometry also served as a reliable method by allowing direct visualization of individual cells; however, this method is labor-intensive, subject to operator variability, and not practical for rapid quantification. Optical density (OD750nm) measures offer a rapid, inexpensive, and non-destructive approach for routine monitoring of cyanobacterial growth; however, this method is less accurate at low and very high cell densities. Optical density measures are also susceptible to variability caused by changes in cell morphology and pigmentation. Overall, this comparative study highlights the importance of method selection and optimization based on experimental objectives.

UC LEADS

Avneet Brar

Nesprin-1 is Required for Kupffer’s Vesicle Establishment of Left-Right Asymmetry in Zebrafish

Faculty Research Mentor: Stefan Materna

ABSTRACT

After they are specified during gastrulation, the Dorsal Forerunner Cells (DFCs) remain tightly compact as they migrate along the dorsal edge of the embryo. The DFCs eventually form a fluid-filled, ciliated organ known as Kupffer’s vesicle (KV). KV acts as the left-right organizer in zebrafish and is responsible for the breaking of bilateral symmetry. The syne1b gene is highly and specifically expressed in the DFCs/KV during this period of development. The syne1b gene is very large (328.5kb) and encodes the giant KASH protein Nesprin-1. Nesprins are thought to be involved in processes as diverse as mechanosensation, scaffolding, signaling, and nuclear positioning, but their exact function depends on their domain composition. We found that Nesprin-1 expressed in KV includes a KASH domain at the C-terminus, which anchors this protein in the outer nuclear membrane of the nuclear envelope. Nesprins anchored in the nuclear envelope interact with SUN proteins in the inner nuclear membrane to form the LINC (Linker of Nucleoskeleton and Cytoskeleton) complex. We found that Nesprin-1 is required for proper KV formation and that loss-of-function results in defective left-right patterning.

UC LEADS

Bobby Escobar

Synthesis and Characterization of Faceted Iron Oxide Nanoparticles

Faculty Research Mentor: Jennifer D. Lee

ABSTRACT

Catalysts serve as key materials that facilitate chemical reactions and improve efficiency. Previous studies have shown that nanoparticle shape influences reduction behavior and properties, which can affect catalytic performance (1,3). However, it is still not fully understood how certain shapes affect catalytic performance. This project focuses on the synthesis of faceted iron oxide nanoparticles (FeOx NPs) and investigating how their morphology influences catalytic performance. Octopod-shaped FeOx NPs were synthesized using the colloidal method (2). Transmission electron microscopy (TEM) confirmed the morphology with an average size of 21.0 ± 3.2 nm. XRD results of carbon-supported FeOx NPs reflected patterns of iron oxide with spinel structures (e.g. Fe_3O_4 and Fe_2O_3).

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Rufus Hernandez

Mapping Variable Lymphocyte Receptor C in Lamprey using Immunohistochemistry

Faculty Research Mentor: Chris Amemiya

ABSTRACT

Within the jawless vertebrates lies an adaptive immune system composed of variable lymphocyte receptors (VLRs): proteins that function similarly to immunoglobulins and are derived from leucine-rich repeat cassettes assembled in lymphocyte-like cells. These cassettes are used in a gene conversion mechanism to generate diverse antigen receptors capable of highly specific antigen binding. There are currently 6 VLR genes identified in the lamprey: VLRA, VLRB, VLRC, VLRD, VLRE, and VLRF. The lymphocytes in which VLRs are expressed are analogous in function to T cells and B cells. While VLRB is expressed on B-cell-like lymphocytes, the remaining (VLRA, C, D, E, and F) are expressed on T-cell-like lymphocytes. VLRC has been shown to be endogenously produced in the skin of lamprey; however, prior to this project, its spatial distribution within the skin had not been mapped. Using immunohistochemistry with antibodies against VLRC, this project aims to map and visualize the distribution in larval lamprey. Initial staining occurred with whole tissue sections, but the primary focus has shifted to the epidermal tissue. Characterizing the spatial localization of VLRC in the skin will help elaborate the intricate systems of the jawless vertebrates' immune system and provide broader insight into the evolution of adaptive immunity.

UC LEADS

Pat Huang

Identification of Functionally Relevant Target Genes in the Candida albicans Mini-Biofilm Regulatory Network

Faculty Research Mentor: Clarissa J. Nobile

ABSTRACT

Candida albicans forms unique free-floating, biofilm-like structures known as mini-biofilms in response to interactions with strict anaerobic bacteria such as Clostridium perfringens. These structures are adapted to polymicrobial environments and are distinct from conventional surface-associated biofilms. To identify the transcriptional network governing mini-biofilm formation, we performed genome-wide RNA-seq and CUT&RUN analyses under mini-biofilm conditions, focusing on key transcription factors (TFs) identified through a genetic screen whose deletion completely abolished mini-biofilm formation. Integration of the RNA-seq and CUT&RUN datasets identified a comprehensive mini-biofilm regulatory network consisting of core TFs and their directly bound downstream target genes. To determine the functional importance of these target genes in mini-biofilm formation, we prioritized downstream targets regulated by the core TFs based on their potential roles in processes such as hyphal development, stress response, metabolic adaptation, and interspecies interactions. Using a CRISPR-Cas9 genome editing system, we deleted a subset of high-priority target genes, assessed their roles in mini-biofilm formation, and identified several functionally relevant genes required for mini-biofilm formation.

UC LEADS

Javier Miramontes

Mapping California Wildfires and Their Impacts on Solar PV Electricity Generation Efficiency.

Faculty Research Mentor: Samuel Markolf

ABSTRACT

The growing demand for clean energy, driven by environmental concerns, has brought renewable energy technologies, particularly photovoltaic (PV) systems, to the forefront of sustainable energy generation. PV technology harnesses solar energy to meet global electricity needs. Yet, relative to traditional energy sources, solar PV is more susceptible to dust accumulation, which can impact the performance of PV systems. The research question my PI and I are investing is: "What is the relationship between solar energy efficiency and wildfires in the performance of generating electricity?" Using ArcGIS and Excel, I created maps that highlight historical data taken from credible databases such as the EIA, CAL FIRE, the California Office of Emergency Services, and California Open Data to see which counties have been impacted the most by wildfires. I have also used data visualizations software such as Excel and Tableau to highlight the data that was found in order to showcase how wildfires impacted communities. Using the datasets, I am developing maps of specific counties in California using ArcGIS and Excel to showcase historical structures and acres that were destroyed by wildfires in the 20th century, as well as to highlight counties that are at higher risk of wildfires. I also developed bar charts in Tableau and Excel, using datasets from EIA and California government sources to illustrate PV generate throughout the year. Anticipated results from this work will set the foundation of exploring how wildfires can impact future solar photovoltaic projects in certain counties and develop stronger PV technologies.

UC LEADS

Andrea Palafox

Type I IFN Signaling Contributes to the Regulation of Neutrophil Extracellular Traps and ROS in Aspergillus Fumigatus Infection

Faculty Research Mentor: Kelly Shepardson

ABSTRACT

Aspergillus fumigatus (A.f) is a ubiquitous fungus known to cause invasive disease in individuals with weakened immune systems. However, in recent years, we've seen an increase in secondary A.f infections that has become a major concern in in influenza infected individuals. The immune response plays a significant role in determining the outcome and control of these fungal infections. Specifically, Type l IFN Signaling contributes to the regulation of reactive oxygen species (ROS) and Neutrophil Extracellular Traps (NETs), important defense mechanisms used to kill and trap fungal hyphae and potentially contribute to tissue damage. To dissect the role NETs, play in invasive growth, we measure their production with our different knockout mice. To examine this, neutrophils are isolated from the bone marrow of mice and stimulated with A. f hyphae. Following incubation, NETs are stained and imaged with a fluorescent microscope for analysis. Similarly, for ROS, cells are stained and run on a microplate reader. Currently, results suggest that IFN-β potentially regulates NET production. Specifically, in ifnar2$^{-/-}$ mice, NET levels are increased, and when IFN-β is removed, NET production returns to WT levels, indicating that IFN-β and ROS inhibition plays a role in controlling NET formation during infection. Understanding how Type I IFN signaling and ROS-dependent mechanisms influence neutrophil-mediated antifungal responses may provide insight into fungal infection progression in the lung microenvironment.

UC LEADS

Brenda Perez Navarro

Efficient and Adaptive Embedded Intelligence on the Batteryless Edge using LDC

Faculty Research Mentor: Xiaofan Yu

ABSTRACT

Most batteryless embedded systems require maintenance that does not allow for long-term deployment in remote environments. Developing this technology continues to be a challenge due to the energy availability constraints for reliable computation. This work proposes a solar energy-harvesting system that powers an MSP430 microcontroller with a Low-Dimensional Computing program. Aiming to develop an efficient and adaptable LDC program to adjust its computing complexity with available energy. Fast-Inf and MicroVSA are the baseline for comparing inference latency, energy efficiency, and accuracy. Energy-Trace technology will be used to measure energy consumption of the interaction between the energy-harvesting system and embedded software. This work aims to demonstrate the first steps in adaptable and efficient energy-harvesting embedded intelligence capable of long-term rural deployments.

UC LEADS

Luis Salvador Valdivia

Optimizing migration efficiency of biological micro swimmers in confined environments

Faculty Research Mentor: Joel Spencer

ABSTRACT

Biological micro swimmers are a type of active matter, transforming chemical energy into mechanical motion. Sperm cells or bacteria, for example, consume energy to beat their flagella, propelling themselves forward. To describe the motion of micro swimmers, the dynamics governing biological filaments driven by follower forces can be used. Prior studies have looked at filaments that are either pinned at one end or freely moving in an open space. Typically, however, these micro swimmers experience confined environments like cervical mucus or soil. In this work, we apply the discrete model of a filament to describe micro swimmers moving in confinement represented by a two-dimensional channel. We vary the width of the channel as well as the propulsion force and bending rigidity of the filament to measure the migration efficiency of the swimmer. We have identified combinations of bending rigidities and propulsion forces that optimize the migration efficiency of a swimmer under different amounts of confinement. Our results provide insights into the swimming efficiency of natural microorganisms and suggest design principles for artificial micro swimmers.