THE UNIVERSITY OF ARIZONA
KEYS
Research Internship

2022 KEYS

LED BY THE BIO5 INSTITUTE

16TH ANNUAL RESEARCH SHOWCASE

Dear Interns, Family , and Friends,

We are excited to celebrate another successful summer of KEYS, and to honor the accomplishments of our 2022 KEYS class!

We are so proud of the tenacity of the 55 individuals who shared their summer with us! Their research experiences spanned a wide variety of scientific emphases and included hands-on projects, as well as data analysis and computational modeling. Interns got to actively participate in ongoing research in areas like cancer biology, neurodegenerative and cardiac diseases, biomedical engineering, environmental impact, toxicology, and virology.

Thank you to our University of Arizona research faculty and their staff. They welcome high school interns into their labs and provide opportunities for the students to explore and experience the excitement of scientific research and discovery.

Additionally, our interns learn from the exceptional post docs, graduate, and undergraduate students in their respective labs, as well as the KEYS crew and staff who mentor them throughout their internship and beyond. Over 150 people work together to make KEYS a success each year.

We sincerely appreciate the ongoing support of our generous program sponsors and donors. Without you, there would be no KEYS, and therefore, few opportunities for high schoolers to participate in world-class University of Arizona research before their college experience even begins.

With our commitment to advancing next generation science and scientists, we are gratified to now count 631 students as KEYS alumni with the addition of this year's interns.

Congratulations KEYS class of 2022, and best wishes for what we know will be a bright future!

Sincerely,

Lisa Romero
Executive Director, Public Affairs,
Communications, and Engagement,
BIO5 Institute

Kelle Hyland
Program Manager,
Public Affairs, BIO5 Institute

Polarization-dependent Efficiency of a Diffraction Grating

PI - Dr. Arvinder Sandhu

In the context of optical science, polarization refers to the direction of the propagating electric field. The polarization dependence of diffraction gratings is nontrivial and can have a significant impact in spectroscopy experiments. In this project, we explore polarization-dependent diffraction effects of a reflective grating using a linear-polarization 633 nm helium-neon laser. The polarization of the beam is controlled by a half-wave plate and monitored by a high-contrast polarizer. Our results show that different diffraction orders can be used to optimize different polarizations, which may guide future attosecond photoabsorption investigations.

Literature Review: Can Oxytocin Help Women Postpartum with Opioid Use Disorder?

PI - Dr. Alicia Allen

Opioid use disorders (OUD) are a public health problem with women in the postpartum period being most vulnerable to relapse. Oxytocin, a hormone that stimulates contraction of uterine muscle and the secretion of milk (Schmid et al. 1998), has been recently researched in treating addiction. My role has been conducting an expanded literature review looking at existing articles on the relationship between oxytocin and any substance use disorder. We did find that intranasal oxytocin was found effective in helping lower alcohol cravings which raises the question, does oxytocin affect alcohol the same way as OUD and how does that specifically affect women postpartum? However, there is still not enough research about the ability of external oxytocin to combat OUD in women postpartum.

Assessing Frailty Through Heart Rate Complexity

PI - Dr. Nima Toosizadeh

Frailty is a clinical syndrome in which three or more of the following criteria are present: unintentional weight loss, exhaustion, weakness, slowness, and low physical activity. The physiological indicators for frailty are still being studied. Our hypothesis is that patients with congestive heart failure (CHF) have a less complex heart rate than the healthy control subjects. CHF, closely associated with frailty, is an aging-associated condition that reduces the heart's pumping power. The complexity of an individual's heart rate was calculated from electrocardiogram data, the measured electrical activity of the heart, using MATLAB. We found that the patients had a lower heart rate complexity than the control subjects, supporting our hypothesis, and that heart rate complexity can possibly be used as a physiological indicator for frailty.

Estimating Hippocampal Subfield Volume in Typical and Atypical Youth

PI - Dr. Jamie Edgin

Down syndrome (DS) is the most common cause of intellectual disability. This project aims to see how hippocampal subfield volumes vary throughout age for typically developing (TD) vs Down syndrome youth. MRIs were taken of participants aged 11-20, both typically developing and with Down Syndrome to measure brain structure and activity. In addition, we gathered sleep data and performed cognitive tests. Using the software ITK-Snap and Dr.Arne Ekstrom's segmentation protocol, we were able to estimate and compare subfield volumes with the MRIs,followed by an Inter-rater reliability test. We found differences in subfield volume or variance differences between the groups. Pairing this data with our sleep data,cognitive testing, and fMRIs, we will be able to understand and apply information about youth hippocampal development.

Determining Cell Proliferation and the Impact of YAP Following Irradiation

PI - Dr. Kirsten Limesand

Previous research suggests repression of YAP, a protein that activates transcription of genes are necessary for restoration of irradiated salivary glands. We studied the harmful effects of radiation on salivary glands of mice. We compared proliferation of salivary gland cells after radiation in the presence and absence of YAP. By injecting some mice with tamoxifen, an estrogen receptor that activates CRE, an enzyme that removes YAP from the genes, we were able to compare them with untreated mice and conclude there is no significant difference between cells' regeneration with or without YAP. Although the results are not significant, by studying various treatments, we pave the path for future studies in the area and direct researchers to find the most effective ways to regenerate salivary function.

Water Harvesting and Soil Resilience

PI - Dr. Laura Meredith

Water harvesting is generally seen as environmentally friendly. However, effects of harvesting treatments on soil moisture are less known. This project analyzed moisture resilience, how soil returns to stable levels after water events like rain. Three treatments were tested: the control was natural land, the passive treatment collected rainwater, and the last treatment was irrigated by greywater. Belowground sensors recorded hourly moisture for a year, providing high-resolution data. Resilience efficiency, a metric compiling time, rate, and destination of return to equilibrium, was calculated for each treatment (Todman et al, 2016). The greywater treatment was most efficient, an important moisture dynamic finding. However, additional research is required to understand how all tested treatments affect biological, chemical, and physical soil factors, allowing for optimized water harvesting practices.

Effects of Saline Flush on Plicae Displacement in Fallopian Tubes

PI - Dr. Jennifer Barton

Falloposcopes can achieve early detection of some ovarian cancers at their origin in the fallopian tubes, improving patient outcomes. However, they may be obstructed by plicae (fingerlike projections inside the tubes). Saline flush has been proposed but not tested as a method of plicae displacement. To test this method, we built a flow chamber and ran saline of varying flow rates over porcine fallopian tissue, observing the plicae under an optical coherence tomography system. We found that saline flush alone is unlikely to produce adequate displacement for falloposcopy, but it does produce certain types of motion which could be useful for revealing the epithelium to the falloposcope. We hope that future research will test other methods of plicae displacement, like an everting balloon.

Interactions between Alpha-Synuclein Mutants Proteins and the Lipid Bilayer, and how GCG can affect this Interaction

PI - Dr. Michael Marty

Alpha-synuclein is a protein with implications in Parkinson's disease. When it interacts with the lipid bilayer, alpha-synuclein aggregates and becomes toxic. We looked at how alpha-synuclein mutated proteins interact with the lipid bilayer and how EGCG affects this interaction. We grew cells containing the mutant protein, A53T, and lysed them to free the protein. Next, we purified our sample and exposed them to nanodiscs, which are synthetic models used to mimic the structure of the lipid bilayer. Our next step will be to visualize the protein-nanodisc complex using mass spectrometry and see how EGCG affects the complex. We are still working towards results; however, we expect that the A53T proteins will bind to the nanodiscs and EGCG will inhibit A53T from binding to the bilayer.

Observing the Relationship between Sphagnum Gas Exchange and Moisture Dynamics

PI - Dr. Laura Meredith

Moss substantially contributes to Arctic regions' biomass, but is not incorporated into land surface models of gas exchange. The exclusion makes it impossible to accurately quantify ecosystem carbon balance or improve understanding of climate change impacts. To include moss in models, moisture dynamics must be understood as a moss gas exchange control. Our study quantifies moss drying rate and observes the relationship between carbonyl sulfide (OCS) gas exchange and the moss moisture content. OCS acts as a tracer gas for photosynthesis alongside CO2 measurements; otherwise, it is difficult to distinguish photosynthesis uptake from cellular respiration production. Experiments were conducted on dried and living Sphagnum moss. Results provide insight into drivers of moss gas exchange that will help grow our understanding of ecosystems.

Scanning Ion Conductance Microscopy and Human Platelets

PI - Dr. Craig Aspinwall

Platelets are cells in blood that attach to themselves, creating blood clots. Scanning ion conductance microscopy (SICM) can be used to create highly accurate 3D models of live platelets. SICM uses a pipette with a current that cuts off when it gets close to the sample. Graphing current versus time then creates a 3D image with topographical data attached. We used SICM to image platelets, then used the software Gwyddion to analyze the data and find the area and volume of each platelet. Those measurements can then be used to research the physical processes of platelets over time. SICM gives us information needed to perform further research involving platelets and how to treat strokes and other blood clots.

Normal Cognitive Aging: Demographics and Predictors

PI - Dr. Bonnie LaFleur

Currently, cognitive health lags behind our physical lifespan. In this study, I compared two of the largest cognitive aging datasets using R to generate visual summarizations of patient demographics to understand the cognitive aging process. Dropout rates between the datasets were uneven, while cognitive progression rates were relatively similar across both datasets. In both datasets there was a higher proportion of female patients out of those with normal cognition. I also evaluated the trend in concentrations of three cognitive aging biomarkers and found that the biomarkers started with statistically different curves but ended up at similar concentrations by five years. This study may help adjust a patient's cognitive treatment to be more targeted which can improve cognitive health for people at risk of cognitive decline.

A Review on the Impact of Caregiving Mechanisms on Postpartum-Induced Hormones Influencing Opioid use Disorder

PI - Dr. Alicia Allen

Opioid Use Disorder (OUD) is a growing issue for women in postpartum who are influenced by ovarian hormones to engage in substance misuse. The goal of the ORCHID study is to analyze how caregiving mechanisms can influence these hormones to lead to cessation from opioid use. My role in this project was to conduct the review of literature by analyzing the relevance of 150 articles related to caregiving and hormones. I narrowed the study down to 35 articles that demonstrated a relationship between breastfeeding and prolactin, a hormone that was imperative to our study. Using 5 rounds of paper elimination through narrowing each round by generic categories until the specific prolactin-breastfeeding relationship was demonstrated helped include only relevant papers to the study.

Machine Learning Detection of Abnormal Brunner's Glands in Duodenal Gastrinoma

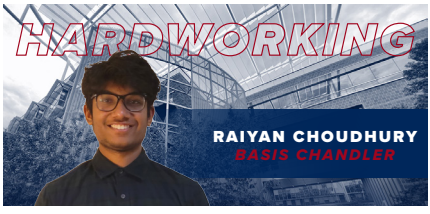
PI - Dr. Travis Sawyer

Duodenal Gastrinomas are a rare type of neuroendocrine tumor in the small intestine duodenum tissue. Multiphoton microscopy (MPM), being able to create label-free images with textural features without reactive contrast agents and invasive procedures, is a promising method to discover abnormal Brunner's Glands, which are thought to lead to duodenal gastrinomas. This project aimed to find if machine learning (ML) models were applicable to identify abnormal Brunner's Glands in MPM tissue images with the goal of automating and improving clinical duodenal gastrinoma diagnosis. Pre-collected MPM tissue images were quantified using ImageJ (an image processing software) and were analyzed to spot significant data trends. The processed MPM images were trained to ML models and an image classifier to achieve high accuracy in abnormal Brunner's Gland detection.

Warfarin Pharmacogenomics in Hispanic & Latino Populations: A Candidate SNP Study

PI - Dr. Jason Karnes

Warfarin is a common anticoagulant drug for treating blood-clotting disorders. Due to its narrow therapeutic index or beneficial range, proper dosing is difficult (Steiner et. al). Genotype-guided algorithms consider both clinical and genetic factors to calculate accurate warfarin dosing, but it's still not used clinically. We genotyped previously identified influential genetic warfarin variants from Tucson populations, which confirmed previous genotyping results. Additionally, CYP2C9 (cytochrome P450 family 2 subfamily C member 9) genotypes were compared with the square root of their weekly warfarin dose to determine the variant effects, showing a statistically significant association between having the CYP2C9*3 allele and requiring less warfarin. This strengthens the evidence for clinical implementation of genotype-guided dosing. However, future studies are needed to identify novel warfarin-impacting variants using non-Europeans.



Developing an Ontology to Model Post-Acute Sequelae of SARS-CoV2-2 Infection

PI - Dr. Vignesh Subbian

Post-Acute Sequelae of SARS-CoV-2 infection (PASC), commonly known as Long Covid, is the persistence of symptoms 4 weeks after an acute COVID-19 infection. PASC affects nearly 30% of surviving COVID-19 patients making PASC a critical healthcare concern. Unfortunately, there are currently almost no frameworks that can holistically categorize all aspects of PASC. Thus, this project developed an ontology (a formal model of organizing data) using Protégé (a Web Ontology Language development environment) to systematically classify relationships between PASC symptoms and its underlying causes and develop a comprehensive understanding of PASC. The ontology successfully processes patient data to model relationships between symptoms and underlying causes of PASC. Moving forward, ontologies such as this one can help guide researchers in discovering prevalent trends in PASC data.

Effect of Low Glycemic Index Potatoes on Blood Glucose and Weight Gain in Rats

PI - Dr. Jennifer Teske

Obesity and type II diabetes are co-occurring epidemics in the U.S. that are influenced by diet1. A rodent model was used to evaluate if diets varying in fat and supplemented with a low glycemic index potato would affect blood glucose and weight gain. It is expected that the rats fed the diet containing the low glycemic index potato will gain less weight and have lower blood glucose and insulin levels regardless of sex or dietary fat level. Results from this research may inform future studies designed to improve blood glucose levels by incorporating low glycemic foods into the diet, which may lower rates of type II diabetes and obesity. 1.) Khan MAB et al., 2020. J Epidemiol Glob Health. 10(1):107-111.

Creation of Tethered Dual Photocatalysts

PI - Dr. Thomas Gianetti

Photocatalysts increase the speed or improve the feasibility of light-based reactions, making them attractive for use in synthetic chemistry. However, many common photocatalysts are toxic and expensive. Tethered dual photocatalysts are an eco-friendly and cost-effective alternative to those photocatalysts. We hypothesized that by attaching ligands to organic catalysts, metal catalysts would bond with the attached ligands, creating a tethered dual photocatalyst. An NMR checked for impurities and made sure the reaction was successful. We confirmed that it was possible to attach ligands to organic catalysts, as well as attaching metal catalysts to organic catalysts. However, further testing is needed before confirming a successful tethered dual catalyst.

Use of the National Alzheimer's Coordinating Center Data to Examine Normative Cognitive Aging

PI - Dr. Bonnie LaFleur

Cognitive function varies amongst the aging population, creating a gap between cognitive health and chronological age. In support of the Precision Aging Network (PAN), whose goal is to close this gap, we performed a harmonization of two existing large cognitive aging datasets and examined the association between certain health conditions and cognitive decline. Using RStudio, we visually represented data and performed logistic regression analyses. We found that the cognitively normal, mild-cognitive impairment, and dementia diagnoses were similar, however, dropout rates and percentage of male participants differed between the datasets. We also found that hypertension and stroke are associated with the worsening of cognitive diagnoses. PAN benefits from these findings, as the comparison and comorbidity association will improve the understanding of cognitive aging during data collection.

Search Tortuosity in *Temnothorax rugatulus* Ants When in Marked and Unmarked Territory

PI - Dr. Anna Dornhaus

Social insects live in large colonies, and each individual provides value, yet how these insects interact is largely undetermined. However, we know most ant species will expedite searching in known territory, due to the presence of pheromone trails. In order to isolate this influence in *Temnothorax rugatulus*, ants were placed in a blank arena. This creates an environment where they can only rely on pre-existing pheromone tracks. These ants were tracked, the resulting tracks created graphs using MATLAB. Many errors were caused. Trackers often overlapped or lost ants. We compared data from two time periods, one marked arena and one fresh arena. Given that other ant species rely on old pheromones to expedite searching, we hypothesize that ants on marked territory will search less tortuously.

Molecular Modeling Drug Design

PI - Dr. Robin Polt

Opioids are leading contributors of drug overdose deaths. The Polt Lab has been interested in glycopeptide drugs because they can be synthesized to be more receptor selective, and instead of metabolizing into harmful substances, they break down into amino acids, which are already found naturally occurring in the body. The Polt Lab synthesized glycopeptide drugs inspired by oxytocin because of its pain-killing properties. SSOxy-6 is the lab's current leading compound. My job was to find different forms of SSOxy-6 molecules with energetically favorable structures when bound to the receptor using MOE. We found that structures that increased intramolecular hydrogen bonding had the lowest energies. However, this trend was not observed for the system. Many lower energy ligands did not interact with receptors with energy favorability.

Modeling Rhodopsin Activation Utilizing Molecular Dynamics and Electronic Structure Methods

PI - Dr. Michael Brown

Rhodopsin is the G-protein coupled receptor responsible for vision in dim light environments. Rhodopsin activates when light contacts the protein, triggering conformational changes. Molecular dynamics simulations and electronic structure calculations were used to investigate two aspects of rhodopsin activation. Experimental data suggests that an influx of water is important in driving conformational changes. However, an analysis of completed molecular dynamics simulations unexpectedly showed no significant increase in internal water between the inactive and active states. Additionally, experimental data has shown that more light than theoretically predicted is required to start activation. Model systems of light activation were simulated using the Gaussian computer program. Calculations showed an expected orbital structure of the active site. The results of these simulations will allow for more accurate rhodopsin modeling.

Genetically Proving Tailocin-Based Killings in E. Coli O157:H7

PI - Dr. David Baltrus

Antibiotic resistance, a growing problem in recent years, causes antibiotics to become ineffective, especially against gram-negative bacteria. Thus, the development of new antibiotics becomes critical to treat certain infections. Dr. Baltrus' lab studies a unique type of antibiotic called a tailocin. My project focuses on trying to genetically mutate tailocin-producing bacteria to then test whether or not the bacteria maintained its killing capacity against E. Coli O157:H7. To accomplish this, we used conjugation to mutate the bacteria along with overlays to help visualize the killing zones. We also tested for various factors such as induction, mutation method, and amounts of antibiotics. These tests helped to determine the necessity of induction, efficiency of conjugation, and level of antibiotic resistance in conjugated DBL 1084 and 330.

Genetic Relatedness of Threatened Northern Crested Caracaras *(Caracara plancus)*

PI - Dr. Melanie Culver

Although northern crested caracaras are threatened, investigating relatedness can reveal relationships and guide conservation efforts. I used RELATED to uncover patterns of relatedness by region, sex, and year (Wang et al., 2002). I found no relatedness between each population which indicates that caracaras are not mating across states. However, the Arizona and Texas samples are particularly small, so a larger sample size could reveal better resolution. I also performed pedigree reconstruction to further analyze the relationships between crested caracaras (Huisman, 2017; Borgatti et al., 2002). Every mated pair found was monogamous which aligns with established observations. Nevertheless, further research on the relatedness of mated pairs is necessary to determine if there is inbreeding and to plan for population management.

Structural and Functional Analysis of CPS1: A Virulence Factor in Valley Fever

PI - Dr. Thomas Tomasiak

Valley fever is an endemic fungal disease in arid zones of America. It was discovered that the protein **CPS1** is crucial for valley fever virulence and knockouts have been used in vaccine candidates. We hypothesized that CPS1 uses ATP and coenzyme-A (CoA) to create lipids as cell wall building blocks. By using thermal shift assays on purified CPS1, we demonstrated that ATP binds CPS1 by a 2°C change in thermostability. We measured ATP consumption in the presence of palmitic acid and CoA, which are suspected to interact with CPS1. Our results show a higher activity when CPS1 correlates with palmitic acid, CoA, and ATP, possibly indicating the formation of acyl CoA, a building block of the cell wall.

Detecting Autofluorescence in Staphylococcus Bacteria Using a Smartphone-Based Device

PI - Jeong-Yeol Yoon

Autofluorescence in bacteria, another word for bacteria showing colors after being “excited” by light, has a history of use in medical devices. However, current portable devices only use it to detect the amount of bacteria present rather than the type. My research focused on refining a smartphone-based device that can actually classify bacteria in a sample using autofluorescence. Its significance lies in the potential for detections before symptoms occur. In our experiments, we prepared samples of skin bacteria representing both sick and healthy individuals and, using the device to image them under combinations of filters and LEDs, compared their hues. Our discoveries showed some difference in color between healthy and unhealthy samples under certain filters, giving insight into potential early diagnosis of skin disease.

Determining Polymeric Hydrogel Microstructure Through Characterization of Polymer Thermoresponsiveness

PI - Dr. Minkyu Kim

Elastin-like polypeptides (ELPs) are artificially engineered polymers that mimic the properties of natural elastin. Under a certain temperature, its LCST, they are soluble, while above are insoluble. ELPs can be crosslinked to form a hydrogel, where along with other additives, are suspended in water to form a solid. We aimed to discover the mathematical relationship between the concentration of polymers to their LCST. We tested our samples through UV-VIS spectrometry which beams light into our mixtures to quantitatively find its LCST. Polymer concentration and LCST were found to have a linear relationship in which we were able to predict a polymer’s LCST given its concentration. This research informs future polymeric hydrogel designs so artificially engineered tissues possess mechanical properties that match that of natural tissues.

De-mouse-tifying Valley Fever with CRISPR/Cas9

PI - Dr. Teodora Georgieva

Disseminated coccidioidomycosis is a more serious form of Valley Fever, a disease endemic to Arizona and California. Since changing a glutamic acid to a glycine in the STAT4 protein correlates with an increased predisposition to disseminated coccidioidomycosis in humans, we hypothesized that an edit of the mouse STAT4 gene in a similar way would result in an effective model for Valley Fever research. Using CRISPR/Cas9, we introduced the desired nucleotide edit into the mouse genome. PCR, restriction analysis, gel electrophoresis and sequencing were used for genotyping and identifying mice with the mutation.This mouse model is useful for further Valley Fever research or vaccine/treatment trials

Analyzing Immediate Head Impact Response in MMA

PI - Dr. Kaveh Laksari

In MMA, the incidence of match-ending head trauma is 31.9% and there is evidence of long-term neurodegenerative disorders. Despite this, there is limited research regarding the immediate response to brain trauma. For my project, I am analyzing kinematic data from impacts in MMA, calculating brain strain, and correlating the kinematic data to the changes in blood flow velocity. I used angular velocities to calculate brain strain in the participants. We found that there is an inverse correlation between blood flow velocity and linear acceleration and we did not see any correlation between blood flow velocity and angular velocity. Among participants, there was a large range in the kinematic data. Understanding brain responses will allow us to better predict and prevent concussions.

Rescuing a Minicircle Producing E. coli Bacterial Stock

PI - Dr. Koenraad Van Doorslaer

HPV is the most common sexually transmitted pathogen, causing 5% of all cancers. We worked with a special strain of E. coli that is able to produce minicircles. However, this strain contains plasmids with HPV that are resistant to the antibiotic kanamycin. Our objective was to cure the plasmids using ethidium bromide, and we hypothesized if the bacteria is no longer resistant to kanamycin, then the plasmids have successfully been cured. We found a majority of the plasmids were cured, and by patch plating selected individual colonies, we identified the cured colonies. Now, with a replenished stock of the cured E. coli, the lab can use the bacteria to make different types of HPV to test in human cells and see how it causes cancer.

Regulation of Glycolytic Enzymes Through Filamentation

PI - Dr. Nancy Horton

Glycolysis is a metabolic process seen in nearly all organisms involving the breakdown of glucose to produce energy in cells. Many glycolytic enzymes form chain-like filament structures. We are investigating the role of filamentation in regulating enzymatic activity. Enzymes were produced in cell culture and purification was performed using resin and chromatography, for example, fast protein liquid chromatography. Successful purification of important filament-forming enzymes was detected via western blots and enzymatic activity assays. Future research will determine the conditions which induce filament formation, and the resulting effect of filamentation on enzyme activity. As glycolysis is a fundamental metabolic process, knowledge gained from these studies could inform new avenues for treatment of metabolic and other diseases.

Analysis of Gender Bias in Autism Diagnosis Through DSM-4 Criteria and Natural Language Processing

PI - Dr. Gondy Leroy

Autism spectrum disorder (ASD) affects 1 in 44 children. Current autism diagnosis rates show boys are diagnosed four times more often than girls. This project seeks explanations for potential gender bias within clinicians' language through electronic health records (EHRs). We analyzed a dataset of 200 8-year-olds' EHR with and without ASD diagnosis. The total and average occurrences of DSM-4 diagnostic criteria per participant, by gender, and diagnosis status were calculated. Within undiagnosed children, females met the criteria A2a and A2b significantly more than males. These criteria signify stunted speech development and conversational impairment. Undiagnosed females were also described as "able," "appropriate," "expressive," and "social" more than boys. The results may indicate that positive social behaviors may lead clinicians to overlook girls' symptoms.

An Improved Prostate-on-a-Chip Model for Prostate Cancer Research

PI - Dr. Yitshak Zohar

Organ-on-a-chip devices are plastic devices that cells are inserted into and grown, creating a cellular model that mimics a true organ. This idea has been useful for prostate cancer research; however, current prostate-on-a-chip models only contain two main prostate cells. To improve these models, I researched whether a better prostate-on-a-chip model with three key cells could be developed. To research this, created a three cell prostate-on-a-chip model and used microscopy to determine whether the cell stacking and layering mirrored a true prostate. My lab and I have shown a three cell prostate-on-a-chip is possible, and these improved human cell based models, rather than traditional animal or culture models, can be used to better research prostate cancer, a common, fast-progressing, deadly, and severely under-researched disease.

How Does the Size and Amount of Wasp Eggs Affect How Wasps Reproduce

PI - Dr. Todd Schlenke

My project can be summed up in one question: How Does the Number and Size of Wasp Eggs Affect How They Reproduce? Dr. Schlenke previously looked at nine different wasp species to measure the length and number of eggs for each species, and found that bigger eggs meant less eggs. I did eight more species and dissected wasps under a microscope using forceps to view a single ovary to look at it under a microscope connected to a computer with a program that allowed me to view the eggs. The next part will be to see the eggs laid and competing for resources. My data generally followed what Dr. Schlenke previously found, which means that wasps with smaller eggs will hatch faster.

Improving Usability of Community Datasets in Google Earth Engine

PI - Dr. Tyson Swetnam

Many geospatial datasets are difficult to access, navigate, and require preprocessing; This creates a problem for data scientists performing planetary scale analyses. Data standardization creates a uniform structure, improving usability. The Spatio-Temporal Asset Catalog (STAC) specification designates the metadata for geospatial datasets. Using the principles of the STAC specification, we began standardizing Dr. Samapriya Roy's Awesome-Gee-Community-Datasets, a 104.05TB GitHub repository of datasets for use with Google Earth Engine (GEE), a platform for planetary geospatial analysis. Our results determined that the standardized metadata provides data scientists further knowledge on how to use, cite, and understand the Awesome-Gee-Community-Datasets for GEE analysis. Standardization promotes discovery and open science, ensuring equity within computing and helping scientists work to understand Earth's processes, building a more aware and conscientious society.

Studying the Interaction Between GPCR & G-Protein Subunits in Pico Level Using BRET2 Technology

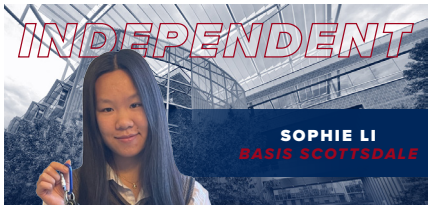
PI - Dr. Pascale Charest

Directed cell migration, known as chemotaxis, is critical to many bodily processes such as wound healing. However, chemotaxis is also responsible for metastasis-the migration of cancer cells. Understanding chemotaxis is critical to halting the spread of cancer cells and reducing the mortality rate. This led my lab to pose this question- do multiple phosphorylation sites in the C-terminal of G-coupled protein receptors affect the dissociation of protein alpha and beta within the cell? Finding the answer involved using site-directed mutagenesis and molecular cloning to alter specific serine sites into alanine, effectively neutralizing them. Using BRET analysis, we produced results showing that mutated cAR1 significantly reduced G-protein dissociation, meaning that the neutralized serine sites are necessary for the proper functioning of the signaling cascade.

Modeling Rhodopsin Activation using Molecular Dynamics and Electronic Structure Methods

PI - Dr. Michael Brown

G-protein coupled receptors (GPCRs) are proteins often targeted by pharmaceuticals, making them an important research topic. Studying rhodopsin, a GPCR involved in light perception, can greatly aid in understanding GPCR mechanics. We used two methods of computational simulations to model two aspects of rhodopsin activation. We first found that, contrary to previous experimental results, new analysis of molecular dynamics simulations detected no difference between hydration in the rhodopsin inactivated and light-activated states. We also characterized the orbital structure of rhodopsin using model systems of the rhodopsin active site,obtaining a partially optimized model with the expected qualitative orbital arrangement. Understanding these aspects of rhodopsin activation will allow for more accurate rhodopsin simulations.



Characterization of Sulfenyl Chloride Polymer

PI - Dr. Jeffrey Pyun

The Pyun group works in polymer chemistry, motivated by creating polymers with elemental sulfur that is a waste product from oil-refining processes. Polymers are long chains of monomers that are used in materials such as plastics. I created sulfenyl chloride model compounds to characterize through Nuclear Magnetic Resonance (NMR) Spectroscopy to study molecular structure. This study of model compounds will be applied to large scale polymerizations to better understand the properties of the polymer, poly(S2-AMB-Cl2), for novel imaging technologies. The Pyun group is striving to make better alternatives for industrial use that are both cheaper and environmentally friendlier.

Efficacy of ARV-771 in Treating Senescent Cancer

PI - Dr. Wei Wang

When a cancer patient receives chemotherapy, in some cases not all the cancerous cells are killed off. Some that survive can be induced into senescence. Senescent cancers activate new tumor growth and are difficult to kill with chemotherapy, therefore a threat to the human body. This project aims to determine whether the compound, ARV-771, is effective in killing senescent cancer. Using western blot and cell viability data, we were able to conclude that the molecule is effective. In future research, the molecular drug-cancer interactions can be manipulated in the development of a specialized pro-drug to kill senescent cancer. This treatment used after chemotherapy has the potential to eliminate all cancerous cells, resulting in a longer life expectancy for cancer patients.

The correlational study of cell density and optical density of two mutants and a wild type of *Streptococcus pneumoniae*

PI - Dr. Michael Johnson

Streptococcus pneumoniae is a bacteria found mainly in children and immunocompromised individuals, causing diseases like pneumonia and meningitis. Antibiotic treatments must be effective against several mutants of *Streptococcus pneumoniae* because differences within the mutants, like shape or size may decrease the treatments' effectiveness. To determine the existence of dissimilarities, the optical density and cell density of two mutants and their wild type were collected. By growing each strain in glucose or lactose, then using a spectrophotometer to measure light absorption, the optical density was obtained. For the cell density, the solution was diluted, grown on blood agar plates and visible individual colonies were counted. The results show the mutants tend to reach a higher cell density at a lower optical density than the wild type.

Retinal Microglia Morphology and Distribution in Mice Fed a High-Fat Diet for 18 Weeks

PI - Dr. Erika Eggers

Microglia are essential within a healthy retina, but when problems arise they can turn from helpful to harmful. Under normal conditions these cells maintain and support tissue in the retina and central nervous system. However, when blood glucose levels are elevated, microglia directly contribute to chronic inflammation which encourages the development of diabetic retinopathy (retinal disease in diabetic individuals). Our research analyzes how the structure and distribution of microglia change throughout the retina in mice fed a high-fat diet (elevating blood glucose) compared to a control group. We did this by examining the size, percent coverage and quantity of microglia in the retina. Through understanding how these cells change we can assist the development of more effective treatment and early detection systems for retinal diseases.

Arsenic Hormesis in *Caenorhabditis Elegans*

PI - Dr. George Sutphin

The Sutphin lab focuses on healthy aging to extend lifespan in C. elegans, or worm. We observed how different stains react to doses of the heavy metal Arsenic. By inhibiting reactive oxidative species in the pathways, C. elegans have been found to live longer and have healthier aging. Eggs were allowed to grow to the L4 stage, young adult stage, and moved to NGM agar plates containing Arsenic. We hypothesize that Arsenic will elicit a hormetic response and increase the worm's lifespan. There are currently inconclusive results due to incomplete trials, however, we expect the results to support the hypothesis.

Fabrication of an hBN/CrI3/InSe/hBN Device

PI - Dr. John Schaibley

Dr. Schaibley's lab examines the properties of atomically thin materials in optical, electronic, and magnetic fields. My research included the creation of a Chromium Triiodide (CrI3), hexagonal Boron Nitride (hBN), and Indium Selenide (InSe) device. CrI3 is a ferromagnet and InSe is a semiconductor that has a similar lattice constant to CrI3, making them pair well; although both degrade when exposed to light and oxygen. We exfoliated the materials to collect few atom thick samples and then stacked up all the materials to create the final device in which the hBN encapsulates both the InSe and CrI3 and prevents degradation. In the future, we hope to measure the optical properties of this device at low temperatures as this research can contribute to more versatile superconductors.

Studying ACM Through the Lense of Mouse Models and IPSCs

PI - Dr. Jared Churko

Arrhythmogenic Cardiomyopathy (ACM) is a cardiac disorder known for causing sudden death, especially in young, athletic individuals. (Corado et al. 2017) ACM is characterized by **fibrofatty infiltration, cardiomyocyte death, and irregular heartbeats** (Zhang et al. 2012). Currently, the Churko Lab is using genetically-edited mouse models and induced pluripotent stem cells (IPSCs), which are stem cells derived from patient blood samples, to study this disorder. My research focused on observing and implementing these tools to learn more about ACM. I differentiated IPSCs into cardiomyocytes and performed contraction analysis on the cells, and using the mouse models, I sectioned, stained, and imaged their heart tissue samples. A prediction can be made that both the tissue and cell cultures will be structurally damaged as a result of ACM.

Analysis of Electronic Health Records to Explain the Gender Discrepancy in Autism Diagnosis

PI - Dr. Gondy Leroy

According to the CDC, boys are four times more likely to be diagnosed with autism than girls. Autism can sometimes be difficult to manually detect. However, the existence of electronic health records (EHR) and natural language processing can help speed up the process. I analyzed the EHR of 200 children using natural language processing in Python. I collected data on the most frequent words used to describe children and observed if there were any differences between genders in the frequency with which these words were used. I found that the frequencies were quite similar, which suggests that there is no gender bias in EHR in the case of autism diagnosis.

Qualitative coding to find alternative treatments and medications for symptom management of EDS and hEDS

PI - Dr. Jennifer Andrews

Hypermobile Ehlers Danlos Syndrome (hEDS) is an inherited disorder affecting connective tissues which is present in multiple body systems. This project conducted interviews of individual's experience with hEDS symptoms and management strategies. Using the question "what alternative methods and treatments are hEDS patients using to assist with symptom management" we performed qualitative coding in a subset of interviews (N=8) to identify non-prescribed treatment methods used in symptom management. Overall symptom severity scores are not associated with the number of treatments tried so the decision to treat is likely due to interference with quality of life as on average at least 70% of participants reporting symptoms sought treatment. This data will provide patients alternative treatments for their symptoms based on peer reports.

Isolation and Identification of the Semi-Arid Ecosystem Soil Bacteria of the Saguaro National Park during Pre-Monsoon Season

PI - Dr. Malak Tfaily

In the semi-arid desert ecosystem of the American Southwest, the soil bacteria community is understudied and varied. Soil acts as a carbon sink: plants fixate carbon, and bacteria release it back into the atmosphere. In order to accurately predict how climate change will impact carbon sequestration, it is necessary to understand the different identities of soil bacteria. We hypothesized that the bacteria population (pre-monsoon season) in the Saguaro National Park was composed of 20-25 species. To test this hypothesis, we conducted a genomic analysis by extracting bacterial DNA and amplifying the 16S rDNA region of various isolated colonies by colony PCR. Collectively, we demonstrated that the soil microbial community in the Saguaro National Park is ecologically rich and diverse with 20 unique bacteria.

Differential Expression of SCN8A in Human iPSC-Derived Neurons During Stages of Differentiation

PI - Dr. Michael Hammer

SCN8A encephalopathy, a rare form of early-onset epilepsy, is caused by a single base mutation in the SCN8A gene. In this study, we measured SCN8A expression in 6 human induced pluripotent stem cells (iPSCs) over multiple stages of differentiation. 3 of these cells had the healthy control SCN8A genotype while the other 3 cells had the pathogenic SCN8A variant. Extracted RNA was first converted into DNA and then amplified via quantitative polymerase chain reaction. Using the Livak method for data analysis, our results revealed that SCN8A expression increases as differentiation progresses. Additionally, towards later stages of differentiation, the control samples expressed slightly more SCN8A than variant samples. Overall, these results provide insight into the mechanisms behind epileptogenesis and could aid in the development of therapeutics.

Determining the Structure of the DNA-binding Domain of NRF2

PI - Dr. Donna Zhang

NRF2, a transcription factor that was thought to control your cells protective pathways, has been shown to have a link to cancer and diabetes. In my project, I worked to find the structure of NRF2 when it binds to your genes. We used bacterial cells to make the protein, and separated it from contaminants using two different purification methods. Finally, we set up crystal trays and periodically checked them using a microscope. So far, we have had success in forming microcrystals and crystal clusters. Once we have grown a large enough crystal, we plan to use x-ray crystallography to determine its structure. A better understanding will help scientists target NRF2 with biological drugs, having major applications for prevention and treatment of cancer and diabetes.

Developing an HSP70 Inhibitor to Treat Cancer

PI - Dr. Eli Chapman

Heat shock proteins (HSPs) are molecular chaperones that refold misfolded proteins. HSP70 is a specific HSP family. Stress factors lead to HSP70 overexpression, interrupting protein function and causing inhibition of p53 which regulates cell growth. The Chapman lab is developing a selective HSP70 inhibitor that will help treat cancer. The research involves making molecules and testing them with various HSP70s. My focus was on molecular synthesis which consisted of preparing a reaction, analyzing the structure of the molecule, and isolating the reaction product through multiple purification processes. One of the molecules we created was compound ZXY-0032 which effectively binded to two out of six tested proteins. Our results indicate a specific molecular component was effective and can be paired with other compounds in future reactions.

Slugbot

PI - Dr. Jekan Thanga

Space is a harsh environment causing terrestrial robots to frequently break down. Recently, naturally inspired robots have been developed to traverse similar environments. I inquired, “How could a naturally inspired robot be applied to space exploration?” Slugbot was modeled off of a slug to use median paired fin locomotion in a sinusoidal pattern. Slugbot’s durability will be measured by measuring velocity on sand and in water. Currently, Slugbot can move in predetermined paths by manipulating its fins. Sensors have been individually tested for image quality. I expect that Slugbot will need greater fin oscillation in water and a restricted degree of movement on sand. In the future, Slugbot’s shell must be segmented to reduce cracking during fin movement while being water resistant.

Characterizing Lifespan of Conformal Encapsulation for Implantable Devices

PI - Dr. Philipp Gutruf

The new generation of flexible, thin biomedical devices requires an encapsulation layer that provides elastic properties and protects the device from the body’s chemistry. These encapsulations have traditionally been tested in static heated phosphate-buffered saline (PBS) solutions. To account for the mechanical strain devices face in the body however, the Gutruf lab developed ESTIRA, a stretching stage designed to test both a coating’s resistance to PBS and repeated mechanical strain.One of the huge benefits of ESTIRA is that it provides researchers with continuous data while the device is being tested. Using devices coated in dimethicone, I found that in cases of encapsulation failure, the reported electrical resistance value across the device would spike, informing the researcher exactly when and how the protective coating failed.

The Efficacy of a Stainless Steel Probe with Teflon Adhesive at Detecting Dust Particles in a Hypersonic Wind Tunnel

PI - Dr. Stuart A. Craig

In hypersonic wind tunnels, clean air flow is extremely important for achieving more repeatable data. My project, in the Boundary Layer Stability & Transition lab, was to design and build a probe to detect dust particles in the LT5 tunnel. The probe was designed using Solidworks 3D design software, and built with stainless steel piping. Teflon adhesive was attached to the probe to catch particles and images of the Teflon were taken under a microscope before and after running the tunnel with the probe installed. A numerical reflection of the amount of particles that the probe caught was obtained with ImageJ software. The probe can be used & modified whenever desired, so this project will enable researchers to see when particles may be affecting data.

N Terminus of Pepino mosaic virus Capsid Protein Affect Host Range, Symptoms, and Infection Dynamics

PI - Dr. Zhongguo Xiong

As adjuvant-free, optimized vaccines, viral nanoparticles (VNPs) provide a systemic trigger to the immune system. This project investigates the functionality of a specific VNP, Pepino mosaic virus (PepMV) capsid protein. Functionality is defined by a virus's control of host range, symptoms, and infection dynamics. Two PepMV mutants, d12 and d25, were generated by trimming 12 and 25 amino acids, respectively, from the N-terminal of PepMV capsid protein and were then tested on 5 tobacco species and 4 tomato varieties. PCR and mechanical inoculation were used to detect and analyze the viruses. Our results showed d12 didn't lose significant functionality, whereas d25 could only infect one tobacco species, N.benthamiana, at a much slower rate.

Cornea Movement Assessment

PI - Dr. Dongkyun Kang

In vivo confocal microscopy is used for improving eye diagnosis. It's a non-invasive, rapid imaging tool that provides cellular information on various tissue layers (Latifi, 2022, p.1). However, current technology can be faster and cheaper. My goal is to improve image quality by understanding how eye movement affects the cornea's optical axis. We videoed a moving eye, then tracked changes in radius and movement of the cornea's center. The changes found in the cornea's radius could be caused by head movement. Additionally, due to the unmatched radius of the cornea with the eyeball, slight eye movement could misalign the optical axis, affecting how light travels through the eye, leading to errors in imaging.

Latifi, & Hau, S. (2022). In Vivo Confocal Microscopy in Eye Disease

POSTER ABSTRACTS

Impact of Various Plant-Derived Fibers on Inflammation and Metabolic Homeostasis

PI - Dr. Frank Duca

Over ⅔ of the US population is affected by obesity, which is associated with western diets that are high in fat and low in fiber. High-fat diets (HFD) increase bacterial lipopolysaccharide (LPS) and lead to metabolic endotoxemia, or 'leaky gut' syndrome, inducing inflammation. However, specific dietary fibers, when supplemented into HFD, can reduce body weight and adiposity. I aimed to determine a potential mechanism by which dietary fibers improve metabolic homeostasis, specifically through a reduction in inflammation. I isolated RNA from mouse small intestine and liver and performed RT-qPCR on two main inflammatory markers–TNF-alpha and IL-6. I observed no significant changes in inflammation upon dietary fiber supplementation into HFD. The lab will continue to analyze inflammation in the adipose tissue and measure circulating inflammatory cytokines.

2022 ACKNOWLEDGEMENTS

KEYS PERSONNEL


Lisa Romero


Dr. Lisa Elfring


Dr. Nadja Anderson


Dr. Uwe Hilgert

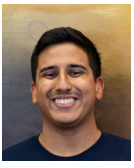

Kelle Hyland


Jordan Pilch


Robyn Pratt


Alexis Cruickshank-Taylor

KEYS CREW


Suraj Bharaj


Ryan Conant


Juan Pablo Dabdoub


Yaritza Durazo


Moses Foiryolo


Marina Hu


Nathan Kuo


Carolina Noriega


Vara Vungutur

2022 PRINCIPAL INVESTIGATORS

Dr. Alicia Allen
Dr. Jennifer Andrews
Dr. Craig Aspinwall
Dr. David Baltrus
Dr. Jennifer Barton
Dr. Michael Brown
Dr. Eli Chapman
Dr. Pascale Charest
Dr. Jared Churko
Dr. Stuart (Alex) Craig
Dr. Melanie Culver
Dr. Anna Dornhaus
Dr. Frank Duca
Dr. Jamie Edgin
Dr. Erika Eggers
Dr. Teodora Georgieva
Dr. Thomas Gianetti
Dr. Philipp Gutruf
Dr. Michael Hammer
Dr. Nancy Horton
Dr. Michael Johnson
Dr. Dongkyun Kang
Dr. Jason Karnes
Dr. Minkyu Kim
Dr. Bonnie LaFleur
Dr. Kaveh Laksari
Dr. Gondy Leroy
Dr. Kirsten Limesand
Dr. Michael Marty
Dr. Laura Meredith
Dr. Robin Polt
Dr. Jeff Pyun
Dr. Arvinder Sandhu
Dr. Travis Sawyer
Dr. John Schaibley
Dr. Todd Schlenke
Dr. Vignesh Subbian
Dr. George Sutphin
Dr. Tyson Swetnam
Dr. Jennifer Teske
Dr. Malak Tfaily
Dr. Jekan Thanga
Dr. Thomas Tomasiak
Dr. Nima Toosizadeh
Dr. Koenraad Van Doorslaer
Dr. Wei Wang
Dr. Zhongguo Xiong
Dr. Jeong-Yeol Yoon
Dr. Donna Zhang
Dr. Yitshak Zohar

2022 MENTORS

Arif Ahmed
Patricio Arrue
Meagan Ash
Christian Ayala
Kasturi Banerjee
Argelia Benavides
Justina Marie Bonaventura
Vanessa Buzzard
Chris Camp
Mengyang Chang
Mandi Corenblum
Hope Dang
Noura Darwish
Seka Devin
Matthew Dodson
Fathima T. Doole
Andrew M. Erly
Viviana Freire Zapata
Dominique Brianna Galvez
Hannah Goodman
Carissa Grijalva
Miriam Heras
Elizabeth Howard
Jason Hsieh
AFM Tariqul Islam
Rob Jackson
Thomas Knapp
Taehyung Kwon
Felicidad Lebario
Linnea Linde-Krieger
Annalysa Lovos
Dr. Lalitha Madhavan
Stephanie Mallahan
Sarah Ann Mathena
David Mills
Allison Newton
Dmitrii M. Nikolaev
Chisom Olikagu
Natalie Payne
Roberto Peralta
Stefan Popp
Athip Raj
Kayla Raymond
Photinin Rice
Mikhail N. Ryazantsev
Yamil Sanchez
Henry Sanders
Devin John Seka
Kailie Szewczyk
Aryatara Shakya
James T. Shira
Adam Skora
Katie Sosnowski
Trevor Stanfill
Ben Stansfield
Savannah Stull
Momoka Sugimura
Yisha Tang
Dash Tapasyatanu
Dr. Karla Vargas
Andrea Wellington
Sergio Yanes-Pagans
Xiaoyi Zhu

2022 SUPPORT TEAM

Dr. Nadja Anderson
Sean Cadin
Dr. Elliott Cheu
Melanie De Sa
Dr. Lisa Elfring
Dr. Uwe Hilgert
Tom Keating
Dr. Julie Ledford
Dr. Kirsten Limesand
Dr. Marti Lindsey
Brooke Moreno
Regina Ozaeta
Robyn Pratt
Sarah Smallhouse
Brenda Steeber
Helen Wertheim
Patricia Wheeler

BIO5 Deans Advisory Board:

Dr. Michael Abecassis
Dr. Shane Burgess
Dr. Carmala Garzione
Dr. David Hahn
Dr. Guy Reed
Dr. Rick Schnellmann

SPECIAL THANKS TO 2022 DONORS

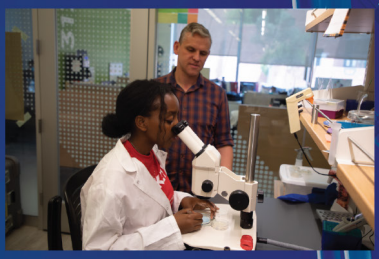
AFEA
Anonymous Foundation
Jennifer K. Barton
Carlton and Elzbieta Benson
Thomas R. Brown Foundation
Jane Craig
Brianna Doyle
Brian M. Ellerman
Teodora Georgieva
Vijay Gokhale
Scott Hamstra
Connie Hillman Family Foundation
Reenie Keating
Thomas W. Keating
Jae S. Lim Foundation
Matthew Masters
Jimmy and Glennis Nokes
Susan Petrus
Jeffrey Pilch
Robyn Pratt
Quidel Corporation
Lisa Rezende
Angela Roberts
Kristen and Gary Swingle
University of Arizona Cancer Center CRTEC
University of Arizona College of Agriculture and Life Sciences
University of Arizona College of Engineering
University of Arizona College of Medicine-Tucson
University of Arizona College of Science
University of Arizona College of Pharmacy
University of Arizona Hispanic Serving Institute
University of Arizona W.A. Franke Honors College
Marcel Villalobos
Anthony M. Webber
Helen Wertheim

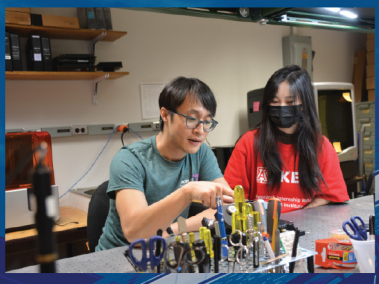
2022 SPONSORS

BIO5 Institute
THE UNIVERSITY OF ARIZONA College of Pharmacy
Hispanic Serving Institution Initiatives

If you are interested in supporting the KEYS Research Internship Program, contact keys@bio5.org or 520-626-8124.

KEYS.ARIZONA.EDU






Yaritza!


BIOS
ENGAGE! TRAINING TO DEVELOP THE WORKFORCE OF TOMORROW


THE UNIVERSITY OF ARIZONA
KEYS
Research Internship