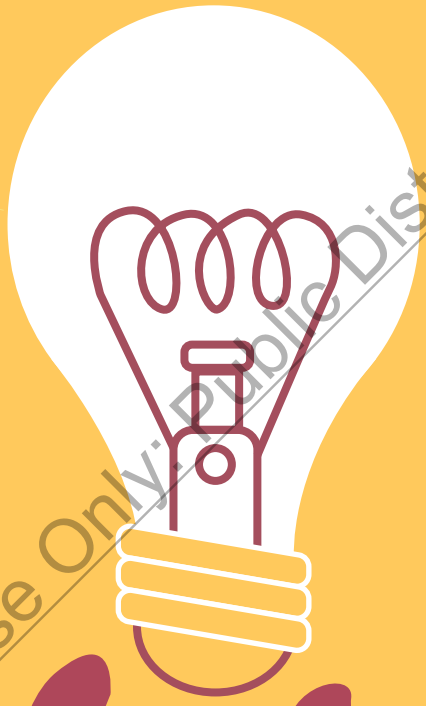
2021

# The 24th Annual Boston University Undergraduate Research (UROP) Abstracts

The 24th Annual

# UROP

## Undergraduate Research Symposium



Poster Presentations
11am to 1pm

October 22nd, 2021
GSU Metcalf Ballroom



BU Undergraduate Research Opportunities Program

*The Twenty Fourth Annual*

# *Undergraduate Research Symposium*



**Friday, October 22, 2021**

Metcalf Ballroom
George Sherman Union
775 Commonwealth Ave.
Boston, MA 02215

**The Undergraduate Research Opportunities Program (UROP)**
**Boston University**
www.bu.edu/urop

**Cover design by Gayatri Sundar Rajan**
**Booklet compiled by Diána Hughes**

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# Welcome to UROP

**The Undergraduate Research Opportunities Program (UROP)'s** mission is to nurture curiosity, capture imagination, and cultivate relationships between faculty and students beyond the classroom to shape independent, innovative and collaborative research leaders. UROP funds faculty-sponsored research to help students hone critical skills while learning the language of their chosen discipline.

*Note – If you are looking to volunteer or conduct research for credit, you do not need to apply for UROP funding. To find out more about receiving academic credit for your research, please reach out to your academic advisor.*

# Types of Funding UROP Offers

**Student Research Award (SRA)** SRAs are stipend awards that are fully funded by UROP. SRAs are typically reserved for highly competitive students whose faculty mentors are not able to provide financial support to the student.

**Faculty Matching Grant (FMG)** FMGs are stipend awards where half of the funds are provided by UROP and the other half is provided by the faculty mentor.

**Humanities Scholars Awards (HSA)** The Humanities Scholars Award provides students with a stipend, supplies/travel support, and research funding to their faculty mentors during the summer.

**Supplies Awards** Supplies Awards fund the purchase of supplies for the student's research project (e.g., enzymes, pipette tips, archive or zoo memberships, prints from microfilm).

**Travel Awards.** Travel Awards support travel expenditures for students presenting at professional conferences and/or conducting off-site research.

**Housing Supplements.** (Summer only) Housing supplements provide up to $1000 toward summer housing in the Boston area for students with the greatest financial need.

# Special Awards

The **Arts Research Award** is sponsored by the BU Arts Initiative in the Office of the Provost to support a student pursuing the arts as a primary area of inquiry. The summer 2021 awardees are Danielle Chang (CFA Graphic Design '23), Janya Mikolaitis (CFA Painting '22), and Gisela Rodriguez (CFA Theater Arts '23).

The **Clare Boothe Luce Scholar Award** supports undergraduate summer research projects undertaken by females in select STEM fields. The summer 2021 awardees are Hayden Bronson (CAS Physics '23), Sophie Caplan (ENG Mechanical Engineering '23), Kiran Gomatam (ENG Mechanical Engineering '23), Taylor Janke (ENG Mechanical Engineering '22), Iris Simone (CAS Chemistry), and Bhargavi Thakar (CAS Chemistry '22).

The **Loren E. Wold Research Award** supports undergraduates working in research labs of faculty in the Department of Biology and other departments in the College of Arts and Sciences, the School of Medicine, or the School of Public Health. The summer 2021 awardees are Niharika Desai (CAS Biology '23), Helen Feng (CAS Biology '22), James Lu (CAS Biology '22), Kelley McCutcheon (CAS Biology '22), Katherine Sotiropoulou (CAS Biochemistry and Molecular Biology '23), and Kimberly Tran (CAS Biochemistry and Molecular Biology '22).

The **New England BioLabs Scholar Award** is supported by New England BioLabs and is part of UROP's corporate sponsorship program. The summer 2021 awardee is Christopher Olsen (CAS Biochemistry and Molecular Biology '22).

The **Mary Erksine Undergraduate Research Award** was established in memory of former UROP Director and CAS Biology Professor, Dr. Mary Erskine. The summer 2021 awardee is Riley McDonald (CAS Neuroscience '22).

The **Mark W. Riemen Summer Research Prize** was established by family, classmates, and colleagues in memory of Mark W. Riemen (CAS '75), a distinguished research scientist. The summer 2021 awardee was Amelia Pfaff (CAS Biochemistry and Molecular Biology '22).

# How to Apply for UROP Funding

Step 1: **Find a Research Mentor.** Any Boston University faculty member is eligible to serve as a UROP mentor. We recommend that you check out the opportunities page on our website and contact faculty members whose research interests align with yours.

- *Tip: Department websites typically have faculty webpages that provide the research interests and contact information for faculty in that department.*
- *Tip: The UROP office offers General Research Inquiry appointments where you can meet one-on-one with a UROP staff member. In these meetings, we will look at how to find and engage with potential research mentors. To book an appointment, please see our Calendly page here.*

Step 2: **Decide on a Project.** What are you looking to research? Depending on your relationship with your faculty mentor and your knowledge of your discipline, you may be applying for UROP funding to work on an existing project that your mentor is working on, or you may be designing your own project. Note that it is important to discuss with your mentor how many hours per week you would like to work on this project and what each out you are expecting out of your research time.

Step 3: **Complete the UROP Application.** Now that you know what you are applying for, and what project you intend to work on, you are ready to start working on your UROP application. The application consists of a wide variety of questions including project title, project description and goals, project significance/importance, methodology/process, timeline, background experience, and bibliography. Once your application is complete, send a copy to you mentor for feedback.

- *Tip: UROP does application review meetings, where we offer generalized feedback on the application. Meeting with the UROP staff does not increase the likelihood of receiving funding*

*but can provide you with tips to strengthen your overall application. To book an appointment, please see our Calendly page here.*

Step 4: **Make Sure Your Mentor Submits a Letter of Recommendation.** Part of your UROP application is a letter of recommendation written by the faculty mentor with whom you are working. In the letter of recommendation form, faculty will be asked about the number of hours per week you will be working, so it is important that you discuss your proposed schedule with your mentor. The faculty recommendation form (accessible to BU faculty only) can be found here.

Step 5: **Receive funds to do research!** If your application is funded, you will be able to use your stipend, supplies funding, or travel funding to conduct research.

# Acknowledgments

UROP is supported primarily by Boston University's Office of the Provost. We are particularly indebted to Associate Provost for Undergraduate Affairs, Amie Grills, for her encouragement and enthusiasm. We also thank our faculty advisory committee for their efforts in reviewing applications and guiding UROP to achieve its mission. Most importantly, we thank our faculty mentors for providing learning environments for our undergraduates and thus making UROP possible.

In addition, we thank the following financial sponsors for their generosity:

*Funds from faculty research grants*
*Boston University Arts Initiative*
*National Science Foundation*
*Clare Boothe Luce Program of the Henry Luce Foundation*
*New England Biolabs*
*Friends & Family of Dr. Mark Riemen*
*Friends & Family of Dr. Mary Erskine*
*Dr. Loren E. Wold*

If you are interested in contributing to support undergraduate research at Boston University, please contact UROP at (617) 353-2020 or urop@bu.edu. Donations may also be made through the UROP website here. All donations will go directly to support undergraduate research activities.

# *Biological Sciences*

### An Investigation of Genetic Mechanisms Underlying Strategic Growth in the Clown Anemonefish Amphiprion percula

**Student Presenter:** Douglas Alvarado
**Faculty Mentor:** Peter Buston (CAS Biology)
National Science Foundation - Research Experience for Undergraduates (SURF)

Strategic growth, whereby individuals modify their growth and size in response to their social environment, has been documented in a few remarkable social vertebrates such as Kalahari meerkats, naked mole-rats, and clown anemonefish. Clownfish (Amphiprion percula) have been shown to exhibit competitive growth, growing faster in response to the presence of a size-matched rival, however the mechanism by which they do this is unknown. Over the next two years, we plan to investigate these genetic mechanisms. The first step to doing this is to improve the experimental design used to elicit competitive growth in the lab, from a highly artificial one to one that better simulates their natural environment. There are two main components for this experimental setup. First, to mimic a more natural environment, cages have been set up that contain reef rock with live sea anemones in large volume (30 gallon) tanks. Second, larvae will be reared and juveniles from different clutches will be housed as pairs in half of the anemones and housed solitarily in the other half. Juveniles will be measured at the beginning and end of the experiment to estimate growth. The predicted results are that the larvae in pairs will show more growth than the solitary larvae due to competitive growth. Successfully showing that larvae can exhibit competitive growth in this more natural setting will allow for future experiments with large sample sizes to be built off this one, enabling us to investigate the genetic mechanisms underlying competitive growth in clownfish.

### Improving Camelina Sativa's Anti-Herbivory Chemical Defense Repertoire by Introduction of the Arabidopsis Genes Known to Increase Glucosinolate Production

**Student Presenter:** Madelyn Battcock-Emerson
**Faculty Mentor:** John Celenza (CAS Biology)
UROP Award

Plants use a variety of specialized metabolites in order to protect themselves from herbivory. One large class, glucosinolates, are frequently found in the mustard family that contains Arabidopsis thaliana and Camelina sativa. Camelina is an emerging sustainable oilseed crop adapted to northern climates. Enhancing Camelina's chemical defenses has the potential to increase its value in the face of the changing environment. Most mustards produce two subclasses of glucosinolates, indolic glucosinolates (derived from the amino acid tryptophan) and aliphatic glucosinolates (derived from the amino acid methionine). However, while Camelina has the genes needed to produce both subclasses, indolic glucosinolates are absent. This is likely due to the absence of the transcription factor MYB34, which is necessary for indolic glucosinolate production in related species. In addition, the CYP83B1 gene, which encodes a key enzyme necessary for glucosinolate production, is poorly expressed in Camelina. These two factors are possible reasons for the species' indolic glucosinolate deficiency. Previous work in the Celenza lab has shown that adding the MYB34 transcription factor allows for some glucosinolate production, but it is significantly below the level of production seen in Arabidopsis. Therefore, my work is focused on creating a stable transgenic Camelina genotype that overexpresses Arabidopsis CYP83B1, a key indolic glucosinolate biosynthetic gene that is weakly expressed in Camelina. To that end, I have subcloned Arabidopsis CYP83B1 into a vector that will express CYP83B1 under the control of an inducible promoter and am in the process of creating transgenic Camelina using this vector.

## Exploring the Interplay Between Alternative Nearby Promoters

**Student Presenter:** Kaveri Bhargava
**Faculty Mentor:** Ana Fiszbein (CAS Biology)
UROP Award

Promoters are the minimum sequences capable of activating transcription and are vital to gene expression. Alternative promoters enable the production of multiple transcript isoforms from the same genes. Promoter usage can provide insight into gene regulation and are important in cancer genomics. Our goal is to study the interplay between alternative promoters and the effect of these interactions on the dynamic regulation of gene expression. We will generate a series of mutants where we can manipulate alternative first exons and in turn, their upstream promoters. Genes with several isoforms and at least three unique alternative first exons (AFEs) were selected using the UCSC Genome Browser and GTEx portal. Primers were designed for each first exon with a reverse primer for the subsequent exon. We determined which exons were amplified using PCR and qPCR (quantitative polymerase chain reaction). GMEB2 and MGAT4A successfully expressed all three AFE's in our HEK A293 and HeLa cell lines. We will activate the second AFE of these genes using CRISPR activation (CRISPRa) and evaluate the effect on the alternative nearby promoters. We will then use Gibson Assembly to generate a series of mutants where we can block, flip or switch the order of promoters, to explore the influence of one promoter on other nearby promoters. We hypothesize that expression of one promoter may either decrease or increase expression of other promoters by affecting transcription machinery. Ultimately, this will help us in understanding the dependence of promoters on one another and how their interplay affects gene expression.

## Effect of Nutritional Status on Transcriptional Factor NF-κB and Immunity in Sea Anemone Models: Implications for Effects of Environmental Change on Marine Organisms

**Student Presenter:** Niharika Desai
**Faculty Mentor:** Thomas Gilmore (CAS Biology)
Loren E. Wold Research Award

Nuclear factor κB (NF-κB) is a transcription factor linked to immunity in animals from protists to humans. In one project, the Gilmore lab has been exploring the effect of nutritional status on NF-κB and immunity in sea anemone models. In the non-symbiotic and generally thermoresistant sea anemone Nematostella vectensis, there is a decrease in protein levels and activity of NF-κB under nutrient-poor conditions. To further investigate this finding we have been investigating NF-κB and nutritional status in Exaiptasia pallida (Aiptasia), which participates in facultative symbiosis with algae of the family Symbiodiniaceae and lives in a narrow range of temperatures. Aiptasia can be used as a proxy to study the effects of bleaching in corals, which also host intracellular Symbiodiniaceae and lose their symbionts as a result of increasing water temperatures and other stressful conditions. In the present experiment, clonal pairs of Aiptasia were either fed Artemia or starved for two weeks. We then conducted anti-NF-κB Western blots and DNA-binding assays with whole animal lysates on replicate pairs of symbiotic and aposymbiotic Aiptasia. In contrast to N. vectensis, there was more NF-kB protein and activity in starved Aiptasia than fed ones, both in symbiotic and aposymbiotic clonal pairs. We are conducting further experiments to understand this phenomenon on a molecular level, including RNA sequencing, to identify genes and pathways that act differently in facultatively symbiotic Aiptasia and the non-symbiotic Nematostella. The outcome of these experiments will contribute to our understanding of how environmental changes can affect marine organisms.

**Northern Diamondback Terrapin Nesting Response to Climate Change in Buzzards Bay**

**Student Presenter:** Raphael Edwards
**Faculty Mentor:** Peter Buston (CAS Marine Science)
UROP Award

The northern diamondback terrapin is threatened in Massachusetts and endangered in Rhode Island. This brackish water species of turtle is often found in marshes of Massachusetts South Shore. The rise in sea levels have caused their nesting habitats to be submerged, forcing terrapins to find new spots for their eggs. During the summer, I have been working with the non-profit organization NECWA to conduct field research on the northern diamondback terrapin in Buzzards Bay, to protect the terrapins and to collect data about them to learn about their response to climate change. Some locations have seen an increase in predation while others have seen a decrease, sometimes even a lack of predation. The number of terrapins observed nesting on land has increased from the previous years also. We hope that this information can help us understand more about the future of the species.

**Dissecting Protein Interactions with Multi-Domain Human Cofactors**

**Student Presenter:** Thierry Edwards
**Faculty Mentor:** Trevor Siggers (CAS Biology)
UROP Award

Gene expression and, ultimately, cellular and organismal function, is regulated by a complex set of interactions between proteins within the cell. A subset of these interacting proteins are cofactors, that each bind to numerous transcription factor (TF) proteins, which then bind to DNA. This study aims to dissect the TF interactions with the orthologous cofactors P300 and CBP. Our approach is to break down the large P300 and CBP proteins into several molecular subdomains, and individually study the TF interactions with each subdomain. TF interactions will then be measured using a nuclear extract protein-binding microarray experiment (NextPBM), a technology developed in the lab to study TF-cofactor interactions using cell extracts. Towards this goal, we are cloning, expressing and purifying five well-annotated domains for CBP and P300 (i.e., NRID, KIX, CH1, CH3 and IBiD). We are also examining three disordered linker regions from P300 which have not been well studied. These protein subdomains will be used in a NextPBM experiments to identify the interacting TFs, and our results will be compared to the results from the intact native proteins. This work will help to understand how large, multidomain cofactors interact with TFs. Furthermore, we anticipate that this work will help to identify competing or synergistic interactions between TF and cofactors when interactions are mediated by the same or different subdomains, shedding new light onto the biophysical rules of gene regulation.

## Interrogate the Interaction Between Transcription from Alternative Promoters

**Student Presenter:** Helen Feng
**Faculty Mentor:** Ana Fiszbein (CAS Biology)
Loren E. Wold Research Award

Alternative promoters, each associated with a specific first exon, often occur near annotated internal exons, creating hybrid exons (exons used as first or internal exons). My previous research found that downstream first exons and hybrid exons are more active than upstream and first exons only (FEO, exons only used as first exons), respectively, leading to an investigation on how and why molecular mechanisms contribute to this trend, which is largely unexplored. Computational methods like bedtools, STAR, cufflinks, hybrid-internal-terminal index, MaxEntScan, and iProEP were used to analyze genomic and Encyclopedia of RNA Elements data. Through genomic composition analysis, downstream and hybrid exons were found to have less promoters. Furthermore, downstream and hybrid exons both have stronger 3' splice sites, but only hybrids have stronger 5' splice sites strength in comparison to upstream and FEO. Both findings suggest that features besides genomic composition are crucial in defining exon activation. This led to an exploration of the role of RNA binding proteins in this trend where one-third of them, including ~50% of spliceosome components, were found to favor downstream over upstream exon usage. In addition, most U1 and U2 small nuclear ribonucleoprotein components were found to be associated with higher levels of hybrid usage as first exons and with an increased number of hybrid exons. From these results, further analysis on alternative first promoters will be done to gain a better understanding of their impact on the increased usage of downstream and hybrid exons and how they are associated with diseases.

## Genotyping and Investigating Immune Response of Aldolase B Deficient Mice

**Student Presenter:** Christine Foran
**Faculty Mentor:** Dean Tolan (CAS Biology)
UROP Award

Hereditary fructose intolerance (HFI) is the inability to process fructose efficiently caused by mutations in the ALDOB gene resulting in the buildup of the toxic metabolite fructose1-phosphate (Fru 1-P). This can cause failure to thrive, nausea, kidney dysfunction, and death, but can be effectively treated by avoiding fructose, although this is often difficult. This makes HFI incredibly difficult to study on humans so a mouse model was designed and is used to study HFI. The mouse model is the ALDO2 knockout mouse. These mice are either homozygous wild type (WT), heterozygous (Het), or homozygous knockout (KO). In breeding mice for experiments on HFI, mice need to be genotyped. To do so, polymerase chain reaction (PCR) is used to amplify the DNA and gel electrophoresis is used to image the results. Previously, a three-primer method was inefficient with many artefacts making results unclear. It was hypothesized that a four-primer method would be more efficient. The primers were then optimized and the effectiveness was tested on a large sample size of DNA samples. The four-primer method was more efficient and effective, and has allowed for the genotypes of ALDO2 knockout mice to be determined quickly and accurately. In a subsequent study of KO mice, the full transcriptome of liver samples will be determined and compared to het and WT littermates. Total RNA is isolated and characterized for quality before use in reverse-transcription and next-generation sequencing. The changes induced by the loss of aldolase B expression will be determined.

## The Role of Algal Symbiont Long Mon-coding RNAs (LncRNAs) in the Coral Bleaching Response

**Student Presenter:** Yaoyuan Gan
**Faculty Mentor:** Sarah Davies (CAS Biology)
UROP Award

Long non-coding RNAs (or lncRNAs) are loosely defined as > 200 nucleotide long RNAs with no apparent coding capacity. Because of their relatively recent discovery, lncRNAs have yet to be described in many organisms, placing them in the wild west of transcriptional exploration. LncRNAs have recently been described in corals and are implicated in the bleaching process, but no one has investigated the role of lncRNAs in their Symbiodiniaceae algae to date. Relative to the coral host's mRNA expression in response to stressors, Symbiodiniaceae appear to have a more muted response in expression across treatment conditions. One theory for this is a reliance on post transcriptional processes and microRNA for transcription, making them an interesting organism to examine lncRNA functionality. RNAseq data were leveraged from a previous study by Levin et al (2016), which looked at two different natural populations of Symbiodiniaceae: one heat sensitive and heat tolerant. Each population had six samples with four replicates, which were isolated from the host and put in culture and then gene expression was measured across two temperatures (27 and 32°C) and three time-points (days 1, 9, and 13). We identified possible lncRNAs through filtering known protein coding sequencing from an assembled transcriptome and retaining transcripts longer than 200 nucleotides with an open reading frame of more than 100 amino acids. We provide functional analyses of lncRNAs differentially expressed across treatments and populations by examining gene ontology of co-expressed mRNAs. We also show evidence for conservation of lncRNAs between Symbiondiniaceae algae and corals.

## Site-directed Mutagenesis of Ketohexokinase-C towards Understanding the Catalytic Mechanism

**Student Presenter:** Kamila Gareeva
**Faculty Mentor:** Dean Tolan (CAS Biology)
UROP Award

Non-alcoholic fatty liver disease (NAFLD) is one of the most common liver disorders that present in approximately 25% of the world's population. NAFLD leads to conditions such as obesity, hypertension, diabetes, hypertriglyceridemia, and hyperlipidemia. The work on knockout mice for KHK shows the relationship between fructose metabolism pathway and NAFLD. Human ketohexokinase (aka, hKHK) is an enzyme that initiates a chain of pathways of fructose metabolizm. KHK inhibition can be used for NAFLD treatment. hKHK has a specific site that binds fructose and ATP in order to perform the metabolism through phosphoryl transfer from ATP to fructose. Acid-base catalysis is thought to be important in the catalytic mechanism. Acidic amino acid, Asp 258, is likely to be involved in acid-base catalysis at the active site of hKHK. Thus, Asp-258 is replaced with another acidic amino acid, Glu, by site-directed mutagenesis that would hopefully lead to changes in the properties of the acid-base catalysis. At the moment, multiple transformants were selected and sent out for DNA sequence analysis at Eurofins. Once a successful expression of mutant gene is confirmed a further protein analysis will take place. The analysis includes protein-affinity purification, determining protein's purity and yield with SDS-PAGE, and analyzing activity of the protein via activity assays and steady-state kinetics procedures. The successful mutagenesis of hKHK can be later used by pharmaceutical companies in developing a drug that would gently impair hKHK function as a way of treating patients suffering from NAFLD.

## The Effect of 4-Aminopyridine on Synaptic Activity in the Crayfish Ventral Superficial Flexor

**Student Presenter:** Nichole Goldfeder
**Faculty Mentor:** Jen-Wei Lin (CAS Biology)
UROP Award

4-Aminopyridine (4-AP) is a drug used to treat patients with multiple sclerosis (MS) and Lambert-Eaton myasthenic syndrome (LEMS). 4-AP remedies the loss of electrical conduction caused by MS or LEMS by blocking voltage-gated potassium channels (Kv) and prolonging action potential (AP) duration. A preparation of the crayfish ventral superficial flexor was used to determine the effects of 4-AP on APs and postsynaptic potentials (PSPs) at concentrations used to treat MS and LEMS. Suction electrodes were utilized to monitor the activity of the APs, focusing on change of AP amplitude and changes in after-hyperpolarization (ahp). Sharp electrodes were inserted into the muscles to monitor changes in PSP amplitude. During the 2-4 hour experimental period, control data was recorded first, and then 4-AP (40 µM) was administered to obtain experimental recordings. Analysis of recordings from 8 crayfish preparations demonstrated effects on the peripheral nervous system including ahp delay in 6 axons and equal instances of PSP amplitude increasing, decreasing, and remaining the same. AP amplitude was unaffected by 4-AP treatment. Effects on the central nervous system (CNS) included increase in AP frequency in half of the crayfish preparations. The results of this study suggest that there are diverse channel types among the motor axons recorded and in CNS of the crayfish. Implications of this study could influence the future treatment of diseases like MS and LEMS by developing more specific drugs for the subtypes of Kv channels and could provide a better understanding of the management for side effects of 4-AP.

## Regulation of Cell Death During Drosophila Oogenesis

**Student Presenter:** Kristen Harder
**Faculty Mentor:** Kimberly McCall (CAS Biology)
National Science Foundation - Research Experience for Undergraduates (SURF)

Regulated cell death is a necessary process in development and disease pathways. Regulated cell death occurs during Drosophila oogenesis, where nurse cells are murdered and cleared away by follicle cells. We investigated involvement of Drosophila caspases using nurse cell specific RNAi to knockdown caspases in the nurse cells. Most of the caspase knockdowns did not have any obvious effect on developmental nurse cell death. Surprisingly, knockdowns of decay lacked nurse cells and oocytes, indicating decay is involved in germline survival. We also investigated oncogenes Src42A and Src64B by knocking them down in follicle cells. Src42A knockdowns expressed strong defects in nurse cell engulfment, indicating that Src42A is required for developmental death. However, about half of the nurse cells were still degraded, indicating other pathways are involved. Single knockdowns of Src64B did not have a phenotype. We created a double knockdown of Src42A and Src64B and found more egg chambers with high numbers of persisting nurse cell nuclei, but much more variability among egg chambers. We also characterized nurse cell plasma membrane destruction using myristoylated-GFP staining. Throughout nurse cell development and death, the nurse cell plasma membrane goes from structured and organized to condensed in one area, which is a different pattern of destruction than seen for nurse cell nuclei. Using FYVE to stain lipid vesicles, we visualized formation of early follicle cell phagosomes coinciding with nurse cell destruction. Investigating genes involved in regulating cell death and mechanisms of destruction can improve understanding of cell death involved in disease and development.

## The Effects of Diel Thermal Variability on Coral Symbiont Physiology and Overall Thermal Stress Resistance

**Student Presenter:** Jourdan Harold
**Faculty Mentor:** Sarah Davies (CAS Biology)
National Science Foundation - Research Experience for Undergraduates (SURF)

Many coral species are extremely susceptible to warming ocean temperatures as it leads to a breakdown of the coral symbiont relationship, killing the coral in the process. High diel thermal variability (DTV; the range of temperatures a coral experiences per day on the reef) has been shown to be an important factor in thermal bleaching resistance and could prove integral to preserving reefs worldwide. For this experiment two species of coral, Orbicella faveolata and Orbicella franksi were taken from the wild and fragmented into 120 samples, 60 per species. Half of each species were placed into a control or DTV treatment for 90 days. The control treatment was stagnant at 26˚ C and the DTV treatment had a variable temperature ranging from 23.6-28.4˚C per day. Samples were then placed into 14-day (32˚C) heat stress. After the heat stress, all samples were flash frozen until processing. Samples were defrosted, a tissue sample was taken for later RNA/DNA analysis and then the rest of the tissue was airbrushed. We then measured symbiont density, chlorophyll concentration and used surface area to normalize symbiont and chlorophyll concentration pre-heat stress. After heat stress O. faveolata from the DTV treatment displayed a trend of high symbiont and chlorophyll concentrations when compared to the controls. These results were not statistically significant, they indicate that each coral species had its own response to the thermal stress. In the future, other species with wider temperature ranges could be focused on to see how DTV affects their bleaching resistance.

## Characterizing Responses of Bacterial Communities to Rapid Environmental Changes

**Student Presenter:** Alyssa Haynes
**Faculty Mentor:** Joe Larkin (CAS Biology, Physics)
UROP Award

Bacterial communities are found in extremely complex environments in nature, yet a vast majority of laboratory research is conducted within highly-controlled, two-dimensional environments lacking the complexity required to truly understand their behaviors. Specifically, in the human gastrointestinal tract, bacterial communities experience transient changes in environmental geometry, temperature, nutrient and oxygen concentrations, and pH. Our goal is to work toward a more comprehensive understanding of the microbiome by adding layers of environmental complexity to our studies. Although work has been done to characterize general community and individual reactions to different pH environments, our project aims to better understand the dynamic changes in B. subtilis community structure in response to transitions between multiple different-pH environments within defined timescales. In order to do so, we first needed to create and test an appropriate medium to support colony growth and buffer the extracellular environment within precise, biologically relevant pH ranges. Our initial experiments using our 'MM9 media' revealed a novel 'microcolony' phenotype when bacteria are cultured on agar pads at an acidic pH. These microcolonies appear to have negligible matrix gene expression -- a property essential to nutrient acquisition and collective behaviors in biofilms. After thoroughly characterizing these 'microcolonies,' experiments involving multiple separate culture steps have pointed toward an influence of the previous environment's pH on the colony's response to the following environment's pH. This finding has renewed our interest in conducting microfluidics experiments in which media of distinct pHs can be smoothly transitioned at a time scale relevant to the human gut.

**Exploring Viral Mechanisms of Immune Evasion through Inhibiting Interferon Signaling**

**Student Presenter:** Isabella Ho
**Faculty Mentor:** Juan Fuxman Bass (CAS Biology)
UROP Award

Viral infections give rise to some of the deadliest illnesses known to mankind. A central part of this pathogenicity is related to immune evasion mechanisms that prevent viral clearance such as interfering with the interferon production. The goal of this project is to better understand how viral peptides modulate the activity of the interferon signaling pathway. To this end, we designed an oligonucleotide library encoding approximately 70,000 peptides corresponding to 33 viruses pathogenic to humans. This library will be transduced into a stable A549 cell line containing a GFP reporter under the control of an interferon-beta (IFNB) promoter. Peptides which downregulate the interferon pathway will cause a reduction in GFP fluorescence in stimulated cells. Such cells will be separated via fluorescence-activated cell sorting (FACS), and the peptides will be identified using Illumina sequencing. This summer, I assisted in ongoing preliminary experiments, including FACS protocol optimization, and positive control experiments with peptide ORF3B. Having adjusted/re-performed four iterations of this positive control without satisfactory results, the experimental cell line was treated with the viral peptide library to ensure it was indeed capable of withstanding transduction. We will now move forward with the full-scale infection of the A549:IFNB:GFP cell line with the library. In sum, such a project will provide insight into a central viral immune evasion mechanism, and will pave the way for future anti-viral therapies.

**Evaluation of Differential Expression between Endogenous Scabrous and the Scabrous 5-120 Mutant**

**Student Presenter:** Otto Holbrook
**Faculty Mentor:** Kyle Gobrogge (CAS Biology)
UROP Award

Alcohol use disorder (AUD) is one of the most common use disorders and is characterized by the cycle of binge drinking, withdrawal, and anticipation. This study investigated the anticipation step of this cycle by studying the formation of ethanol reward memory, specifically studying the protein scabrous (sca) and its mutant which have been identified as contributing to the formation of this reward memory in Drosophila melanogaster. This study specifically sought to observe the differences in expression and behavior between flies that expressed endogenous sca and flies that expressed the mutant of sca. To test the behavioral difference between endogenous sca and the mutant sca, a behavioral assay conditioned flies to associate an odor with ethanol. Flies were then put into a chamber and had the option to go between two odors, indicating if they had developed a preference to ethanol. To test the difference in expression, flies were dissected, and their brains were mounted onto a slide and analyzed under a fluorescent microscope. It was found that the flies with the mutant of sca showed a preference for ethanol after being conditioned, even though the mutant has been shown to create an aversive response in flies to ethanol. It was also found that there was a reduction in sca expression in mutant sca flies after ethanol conditioning. These findings show that the expression of the sca mutant decreases when the flies are exposed to ethanol, which may lead to a better understanding on how ethanol reward memory is established.

**The Effect of Distorted Visual Cues on the Adaptive Size Modification of Clown Anemonefish (Amphiprion percula)**

**Student Presenter:** Diane Hwangpo
**Faculty Mentor:** Pete Buston (CAS Biology)
UROP Award

Clownfish are social animals that can, remarkably, adjust their size in response to the dimension of other members of their group. They are capable of both outgrowing their size-matched reproductive rivals and decreasing their growth to remain smaller than higher-ranking group members to avoid conflict. The purpose of this experiment was to study how juveniles would adjust their size in response to distorted visual cues, and thereby expand our understanding of the mechanisms underlying strategic growth in social vertebrates. Juveniles were reared and placed in individual four-liter tanks: one side contained an artificial anemone and the juvenile, while the other side contained a mirror producing an image perceived as a competitor. Dividers containing one of three magnification treatments (0.75x, 1.0x, and 1.25x) were placed in the middle of the tank, distorting the size of the competitor image via the lens' interaction with the mirror when perceived by the juvenile. Juvenile standard length was measured at the beginning and end of the experiment to estimate growth. Growth under each treatment was to be compared using an ANOVA. A pilot experiment, carried out over the summer, prompted a redesign in experimental set-up, as juveniles did not properly home to their anemones, preventing them from consistently viewing their reflection. Low hatch rates from breeding pairs prevented additional experiments. The diets of the breeders have been adjusted with the aim of producing higher yields. If all goes well, more experimental trials will take place during the fall semester – stay tuned.

**Investigating the Temporal Specificity of Sequence Learning through Predictive Coding**

**Student Presenter:** Anthony Khoudary
**Faculty Mentor:** Jeffrey Gavornik (CAS Biology)
UROP Award

The primary visual cortex (V1) has been classically viewed as an immutable feature detector, with robust responses to low-level characteristics of objects in the visual field. Recent studies have shown the capacity of this cortical area to perform more complex computations. Nominally, the phenomenon of sequence learning relies on the ability of V1 to encode the serial order and temporal frequency of a spatiotemporal visual sequence. Investigating the mechanism of this phenomenon through the lens of predictive coding will further the understanding of how V1 operates locally to encode time and learns to predict the future based on minimal sensory information. Through multi-unit recordings from awake mice, this project sought to isolate neural evidence for predictive processing within the paradigm of sequence learning. Specifically, the capacity of V1 to encode the temporal frequency of a visual stimulus was probed by training mice on the same stimulus presented with alternating temporal frequencies. Following the training period, mice were tested by presenting the stimulus under familiar and novel timing. The neural responses were investigated for evidence indicative of predictive processing. Approximately thirty-two units were isolated from thirteen mice. Initial analysis of spiking activity is inconclusive making it difficult to draw novel conclusions from this data set.

## Comprehensive Yeast Based Screen of Heterodimer DNA Binding

**Student Presenter:** Ryan Lane
**Faculty Mentor:** Juan Fuxman Bass (CAS Biology)
UROP Award

During infection in humans, the immune system is triggered, causing the activation of immune response genes. The regulation of these genes involves interactions between regulatory proteins called transcription factors and DNA. Many human transcription factors often bind DNA as pairs known as heterodimers. Using a novel yeast-based technique called heterodimer yeast one-hybrid (HetY1H) assays, we can detect binding between human transcription factor heterodimers and DNA sequences of interest. This screen approach can comprehensively evaluate all known human transcription factor heterodimers and their ability to bind immune transcriptional control regions. This summer, I assisted in preparing for the screen by generating yeast strains that express heterodimer pairs. I cloned hundreds of transcription factor pairs, and transformed them into yeast. These yeast strains will express the chosen heterodimers that will be used in the comprehensive screen. I also cloned various transcription factor isoforms, alternative versions of transcription factors, that will be used in the assay. In the future, these heterodimer yeast strains will be combined with the yeast containing the target DNA sequences to quantify the binding ability to immune related DNA regions. This study will provide novel insight into the role of transcription factor heterodimers in the immune responses.



## Temperature Regulation of Anti-herbivory Defense Compounds in Arabidopsis thaliana

**Student Presenter:** Man Li
**Faculty Mentor:** John Celenza (CAS Biology)
National Science Foundation - Research Experience for Undergraduates (SURF)

When subjected to biotic or abiotic stress, plants produce secondary metabolites as a defense response. In the well-studied mustard plant Arabidopsis thaliana, glucosinolates are defense compounds produced in response to herbivory. Recent studies have suggested that glucosinolates are also produced in response to abiotic stress such as elevated temperature. While regulatory mechanisms for the response to herbivory are well-defined, mechanisms for a response to abiotic stress are less clear. In this study, we aimed to characterize the temperature induction of tryptophan-derived indole glucosinolates (IGs) in Arabidopsis thaliana. We incubated 14-day old Arabidopsis thaliana wildtype at 29˚C for 48 hours to observe the effects of temperature induction on IG production. IGs were then quantified by high performance liquid chromatography and found to be induced approximately two-fold. This induction was found to depend on the IG-regulating MYB51 transcription factor. Based on previous studies, the transcription factor PIF4 was also found to be required for the expressionof many temperature-regulated genes, including the IG biosynthesis gene CYP79B2. However, this was not found for our growth conditions. We also found that camalexin, an antifungal compound derived from an indolic intermediate in common with the IG pathway, was greatly decreased in plants exposed to 29˚C heat stress. As climate change presents major challenges for crop production in the context of a growing human population, it is advantageous to understand the mechanisms by which plants respond and adapt their defense pathways to temperature.

**Studying Mouse Monocular Visual Cortex Potentiation with C-fos Immediate Early Gene Expression in Response to Monocular Visual Sequence Stimulation**

**Student Presenter:** Mable Lin
**Faculty Mentor:** Jeff Gavornik (CAS Biology)
UROP Award

Understanding the mechanisms of low-level visual sequence learning in mice can serve as a model for understanding higher cognitive functions, including recognizing patterns and learning to predict temporal sequences based on limited information. Our lab's previous research has demonstrated that repeated exposure to visual spatiotemporal sequence stimuli successfully encoded predictive representations in mouse binocular visual cortex (v1) layer four. However, little is known regarding the mechanisms underlying monocular v1 activation in this context. Therefore, this project aims to study the neuronal activation of monocular visual cortex in response to visual sequence stimuli. We observed the expression c-fos, an immediate early gene that is expressed rapidly and transiently after synaptic activation and depolarization, as a proxy for monocular neural activity. We compared the expression of c-fos immunofluorescence across hemispheres, where the monocular v1 contralateral to the monocular visual stimulus was hypothesized to have higher c-fos expression than the ipsilateral monocular v1 that was deprived of stimulus. Extracellular electrodes measuring visually evoked potentials (VEPs) were also implanted in both monocular v1 regions to further compare responses between hemispheres; NeuN and GFAP staining that visualized neural and glial cell populations verified correct electrode positioning and relative location to c-fos expression. If there is a quantifiable difference across hemispheres, c-fos would also allow us to localize and specify activated neurons and their regions in monocular v1, studying co-expression with interneurons parvalbumin (PV) and somatostatin (SST)—cells involved in visual sequence potentiation.

**Voltage-Gated Calcium and Potassium Channel Activity are Required for Normal Skeletal Patterning in Lytechinus variegatus**

**Student Presenter:** Simone Marrujo
**Faculty Mentor:** Cynthia Bradham (CAS Biology)
National Science Foundation - Research Experience for Undergraduates (SURF)

Voltage-gated ion channels are involved in a variety of cellular functions, including division and differentiation of cells. In general, the role of ion channels in developing embryos remains largely unexplored; the existing studies, however, indicate that ion channels play important roles, often in early developmental stages. To identify the roles of voltage-gated ion channels during embryonic patterning, we treated Lytechinus variegatus embryos with either nitrendipine or 4-aminopyridine, inhibitors of voltage-gated calcium (VGCC) and potassium channels (VGKC) respectively, and we found that this inhibition results in abnormal skeletal patterning of the pluteus larva skeleton. The pluteus skeleton is secreted by a migratory group of cells called the primary mesenchyme cells (PMCs), which receive instructive cues from the ectoderm that direct their migration. We show that inhibition of both VGCCs and VGKCs results in abnormal positioning of the PMCs at late gastrula. Experiments with timed inhibitor treatments indicate that VGKCs operate earlier in development than VGCCs, which has interesting implications for their respective roles in skeletal patterning. We also show that in the early embryo, inhibition of VGCCs and VGKCs results in depressed intracellular sodium ion concentration in the ectoderm relative to controls; however, membrane voltage is unaffected. Taken together, our data demonstrates that VGCC and VGKC activity is required for normal PMC positioning and subsequent patterning of the sea urchin larval skeleton. The next steps to further investigate calcium and potassium ion concentrations as consequence of inhibiting either the VGCC or the VGKC.

**Localizing Muscarinic Receptors Involved in Sequence Learning in Mouse V1**

**Student Presenter:** Catalina Martinez
**Faculty Mentor:** Jeffrey Gavornik (CAS Biology)
UROP Award

From the simple task of knowing that the red light of a crosswalk is followed by a green light, to the complex challenge of driving a car, recognizing and predicting visual sequences is the basis of most cognitive functions. The M2 muscarinic acetylcholine receptors are involved in visual sequence learning in mouse V1, yet little is known about the neural mechanisms that link these receptors to sequence learning. By staining the mouse visual cortex using primary and secondary antibodies targeting the muscarinic receptor M2, we determined the distribution and localization of this receptor in V1. M2 was found to be unevenly distributed among different layers of the cortex, being most abundant in layer 4. Although further research is still necessary, these findings point to the possibility that visual sequence learning could occur early in the processing hierarchy as visual input enters the cortex from the thalamus in layer 4 of V1. All in all, characterizing one of the underlying mechanisms of sequence learning brings us one step closer to understanding the wildly complex processes of perception, learning, memory, and cognition.



**PFAS Compounds are Teratogenic in Sea Urchin Embryos**

**Student Presenter:** Kelley McCutcheon
**Faculty Mentor:** Cynthia Bradham (CAS Biology)
Loren E. Wold Research Award

Kelley McCutcheon, Alexandra Lion, Joyce Wong, Jennifer Schlezinger, and Cynthia A. Bradham Per-and polyfluorinated substances (PFAS) are synthetic chemicals used to make fluoropolymer coatings that are found in many products, such as non-stick pans, clothing, and food packaging. These chemicals are known as “forever chemicals,” as they are highly persistent and do not easily break down in the environment. They easily contaminate water sources, and as a result bioaccumulate in many kinds of wildlife. The purpose of this study was to characterize the effect of two PFAS, perfluorooctanoic acid (PFOA) and hexafluoropropylene oxide dimer acid (Gen X) in in Lytechinus variegatus embryos. We examined the overall effect of PFOA and Gen X on development and patterning using primarily immunostaining and HCR-FISH. We found that both PFOA and Gen X are sufficient to perturb skeletal patterning and primary mesenchyme cell (PMC) migration in L. varigatus embryos. Additionally, both chemicals perturb dorsal-ventral (DV) specification, as shown by ciliary band expansion and change in spatial domains of genes that determine DV boundaries. Though Gen X is thought to be a “safer” alternative to other PFAS such as PFOA, our findings suggest that Gen X may have an earlier and more specific effect on DV specification. Because these chemicals are so persistent in the environment, they would continue to be a problem even if their production were to cease, which is why characterizing their effects on biological systems and seeking methods of their removal is crucial.

**The Effect of 4-AP on Action Potential and Synaptic Potential in the Crayfish Neuromuscular Junction**

**Student Presenter:** Riley McDonald
**Faculty Mentor:** Jen Wei Lin (CAS Biology)
UROP Award - Mary Erskine Undergradaute Research Award

Potassium channels are the most diverse of the voltage-gated ion channels. They play a major role in shaping action potentials (AP) firing rhythm, timing and duration. Our research serves to examine the effects of a potassium channel blocker, 4-aminopyridine (4-AP), on APs recorded intracellularly from motor axons of the crayfish opener preparation. 4-AP has been used clinically to treat multiple sclerosis (MS) and Lambert-Eaton myasthenic syndrome (LEMS) in humans. In this study, we test the effects of 4-AP on crayfish motor axons at concentrations comparable to those used in humans. We observed that 4-AP at 10-30 μM could prolong AP duration but had no impact on AP amplitude. An increase in AP amplitude requires a concentration above 50 μM. Our results suggest that 4-AP at low concentration could distinguish at least two types of potassium channels in the crayfish axon. The first, likely to belong to the Kv1 family, has extremely high 4-AP affinity and has a relatively slow activation kinetics such that this channel does not influence the rising phase of AP, nor AP amplitude, but can shape the repolarization. At a slightly higher concentration, 4-AP could block a second family of potassium channels, likely to be Kv3, that has fast channel opening rate and controls AP amplitude. These Kv1 and Kv3 channels are also found in Mammalian CNS neurons. The results could be understood as the mechanisms underlying the treatment of MS and LEMS as well as the reasons for side effects associated with 4-AP.

**The Role of Nrp1 on Osteocyte Function**

**Student Presenter:** Carly Newell
**Faculty Mentor:** Paola Divieti Pajevic (SDM Biology)
UROP Award

Bones are made up of three types of cells, osteoblasts, osteoclasts, and osteocytes. Osteocytes are bone cells immersed in the mineral matrix of the bone. Osteoporosis, a condition associated with reduced bone mass, increases the risk of fractures and is often related to aging. Osteocytes are important regulators of bone; they control both osteoblasts and osteoclasts activities through the secretion of proteins and factors. Neuropilin-1 (Nrp1) is a protein involved in the regulation of the nervous system. Previous research conducted in the lab identified Nrp1 as a protein secreted by osteocytes. The aim of this study was to evaluate the role of Nrp1 on osteocyte function. For this experiment I used an osteocytic cell line generated in the lab, Ocy454-12H, and a gene editing technique (CRISPR-Cas9) to generate cells in which the gene encoding for Nrp1 was ablated (12H-Nrp1KO). Successful knock-out (KO) of Nrp1 was examined by real time PCR. Ocy454-12H control and 12H-Nrp1KO cells were characterized by analyzing gene expression for sclerostin (SOST) and Rank ligand (RANKL), osteocytic genes that regulate bone metabolism. Real time PCR of 12H-Nrp1KO and 12H-control cells showed significant upregulation of SOST in KO cells compared to controls, whereas RANKL was unchanged. Next I analyzed the matrix mineralization using Von Kossa staining, which showed that control cells had a greater area of mineralization than 12H-Nrp1KO cells. Taken together, this data suggests that Nrp1 in osteocytes plays a role in SOST expression and mineralization.

## KHK Inhibition as a Potential Therapeutic Target for Type 2 Diabetes Mellitus

**Student Presenter:** Christopher Olsen
**Faculty Mentor:** Dean Tolan (CAS Biology)
UROP Award - New England BioLabs Scholar

Current medications utilized in treating Type 2 Diabetes (T2D) tend to focus on lowering the amount of glucose circulating in the blood stream, or increasing insulin secretion from the pancreas. Recent evidence however has been mounting towards fructose, not glucose, as the main source of metabolic dysfunction leading to T2D and other metabolic disorders. Previous work found that ketohexokinase (KHK) knockout mice (KHK-/-) remained protected from developing diet induced metabolic disorders compared to wild type mice. In the present study mice are put on a diet high in fats and fructose over a long period meant to induce T2D. They are then given ketohexokinase (KHK) inhibitors designed to prevent the processing of fructose through the fructolysis pathway. To test for the effects of this treatment, several assays for markers for T2D are utilized, including serum glucose, liver and serum triglycerides, and liver collagen as a marker for fibrosis. In conjunction with this project, the same markers were tested in ALDO2-/- mice, which is a model for hereditary fructose intolerance (HFI), and cannot metabolize fructose. This research will aim to further elucidate novel treatments for T2D and metabolic syndrome.



## The Effect of Tryptophan Metabolism Mutants on Gene Expression in Arabidopsis thaliana

**Student Presenter:** Sarah Osman
**Faculty Mentor:** John Celenza (CAS Biology)
UROP Award

Rapid fluctuations in the environment caused by climate change have created new challenges for agriculture as many crop species will be more frequently exposed to abiotic stresses they are not adapted for. Because plants typically respond to stress by producing defense compounds, climate change will likely alter plant metabolism. Therefore understanding the molecular mechanisms regulating plant defense in relation to metabolism can inform methods for engineering more stress-tolerant plants. In the Celenza lab, past experiments have focused on studying defense compounds derived from the tryptophan pathway in Arabidopsis thaliana, a convenient model plant species. This project builds on these past experiments by quantifying gene expression in mutants with significantly altered tryptophan metabolism as a way to determine the systems level effects of altering one metabolic pathway. I have focused on eight different Arabidopsis mutant strains that have single or combined mutations that alter tryptophan synthesis and/or catabolism. Each mutant changes levels of tryptophan and/or tryptophan-derived defense compounds and in many cases affects overall plant health. I hypothesize that these metabolic changes will alter gene expression both in tryptophan metabolism and likely more globally. Using mRNA extraction followed by quantitative reverse transcription PCR, I have found that tryptophan-derived defense compound biosynthetic genes such as CYP79B2 have significantly elevated gene expression in all of the mutants tested when compared to wild type suggesting that both increased and decreased tryptophan metabolism trigger a defense response. These results support our hypothesis and will be followed up using RNA-seq to assess global transcriptional changes.

**Analysis of Gene Activation by a Protist Nuclear Factor κB (NF-κB) Transcription Factor**

**Student Presenter:** Jada Peart
**Faculty Mentor:** Tom Gilmore (CAS Biology)
National Science Foundation - Research Experience for Undergraduates (SURF)

Transcription factor Nuclear Factor κB (NF-κB) is a protein that plays an integral role in regulating the transcription of genes involved in immunity and development. Interestingly, NF-κB homologs are found in many evolutionarily distant organisms, including Capsaspora owczarzaki (Co), a unicellular protist believed to be a close relative to multicellular animals. Previous RNA-sequencing (RNA-seq) and Gene Ontology analyses identified over 300 potential gene targets of Co-NF-κB, including homologs of SRC and SYK, genes known to be involved in immunity and development in higher organisms. Human cell luciferase assays were performed in order to determine if Capsaspora NF-κB regulates transcription of the SRC and SYK genes. These assays showed that Co-NF-κB does not activate the transcription of either gene. In an effort to better understand the role of the C-terminus of the Co-NF-κB protein, yeast cell β-gal reporter assays were performed using the full-length Co-NF-κB. The Capsaspora NF-κB C-terminal sequences were shown to be capable of inhibiting transcriptional activation in this β-gal assay. In addition, we used co-immunoprecipitation assays to demonstrate that the N-terminal and C-terminal sequences of Co-NF-κB can interact directly in cells. Future analysis of other potential gene targets identified from RNA-seq data of Co-NF-κB might give insight into the evolution and function of this important transcription factor in an evolutionarily important organism.

**Purification of Fructose 1,6-Bisphosphate Aldolase from Saccharomyces Cerevisiae for Use in an Assay to Measure Fructose 1-phosphate Levels In Vitro**

**Student Presenter:** Sahrah Rajeh
**Faculty Mentor:** Dean Tolan (CAS Biology)
UROP Award

High Fructose Corn Syrup is pervasive in the American Diet. Consequently, there has been a rise in fructose metabolism diseases, including Hereditary Fructose Intolerance- HFI, which is the inability to process fructose due to the absence of aldolase B. An aldolase B deficiency results in the rapid accumulation of the toxic metabolite fructose 1-phosphate (Fru1P), a potential marker for Non-Alcoholic Fatty Liver Disease (NAFLD). Roughly 30% of the American population suffers from NAFLD, which, if left untreated, can lead to insulin resistance, triglyceride accumulation, and ultimately death. FruIP is not easily measured in a clinical setting, therefore my investigation aims at developing a coupled enzyme assay to achieve this. This assay utilizes a non-commercially available class II aldolase from Saccharomyces cerevisiae, previously determined to be specific for fructose 1, 6-bisphosphate. To accomplish this, a new protocol has been developed inspired by conditions seen in similar class II aldolase purifications done in other species. Preliminary data has been collected, and will be used to further optimize the purification of aldolase, and to confirm its substrate specificity. Once purified, the enzyme will be incorporated to measure Fru1P levels, first with purified intermediates, then for use in vitro with tissue extracts from an animal model to characterize the development of NAFLD. In the future, this will be used to determine at what point in the metabolic process the liver becomes fatty, and prevent further damage and morbidity.

**Using Amplification-Refractory Mutation System-PCR to Discern Rising Frequency of Hereditary Fructose Intolerant Mutations**

**Student Presenter:** Afua Sarpong
**Faculty Mentor:** Dean Tolan (CAS Biology)
National Science Foundation - Research Experience for Undergraduates (SURF)

Hereditary Fructose Intolerance (HFI) is a condition in which individuals are unable to metabolize fructose. This research investigates one of the frequent mutations of HFI, R59Op, and also seeks to understand if R59Op is prevalent enough in the community and if a screening assay can be developed to help diagnose the mutation more efficiently. Through the technique of Amplification Refractory Mutation Systems-PCR (ARMS-PCR), an efficient way of amplification can be achieved in comparison to whole exome sequencing or allele-specific oligonucleotide hybridization. This technique identifies specific point mutations by helping to better analyze the differences in allele sequences. Mismatches were incorporated into the designed primers: one at the 3' end to mismatch with the wild-type or mutant allele sequence, and another mismatch at the 3' end near the -2 position of the primer. At this -2 position, strong mismatch nucleotides are incorporated, either G/A, T/T, or C/T pairs. Six different PCR reactions are conducted using the different primer pairs. Afterwards, agarose gel electrophoresis is performed to determine the success of the amplification, or lack of success, of the desired DNA segments. The forward and reverse primers successfully amplified the 280 bp region containing the mutation once the proper magnesium concentration was determined. This result is significant in that the mutation can be detected using these primers in a shorter period of time simply using the PCR. In the future, this technique can be utilized to screen for A337V and L256P mutations, which are also difficult to diagnose and similar to R59Op.

**Probing the Effects of Habitat Geometry on Bacillus Subtilis Swarming Morphology**

**Student Presenter:** Angelina Serafini
**Faculty Mentor:** Joe Larkin (CAS Biology)
UROP Award

Bacterial colonies can take on a number of forms in order to maximize survival opportunities in given conditions. One notable pattern of association includes swarms. For my summer project, I studied to what extent the spreading behavior of a growing swarm can be attributed to growth (via cell replication) versus swimming (via flagellar motility). This helps us better understand what factors affect swarm behavior the most. I conducted a series of simple experiments with varying nutrient conditions and agar percentages. I was able to measure how the spreading of the swarm responds to these perturbations, allowing us to ultimately decide to what degree the 1) speed of the swarm and 2) the pattern that is formed is influenced by each factor. I found that growth rate will be primarily affected by the quality and quantity of the nutrients in the agar, while swimming will be affected by the physical properties of the substrates, confirming our original hypothesis. More experiments must be done in order to refine the findings and determine to what degree these factors contribute.

## Uncovering Inhibitory Viral Mechanisms of Interferon Signaling

**Student Presenter:** Vivian Shen
**Faculty Mentor:** Juan Fuxman Bass (CAS Biology)
UROP Award

Viruses pose a major threat to human health. In response, the human immune system has evolved various methods to combat viral infections. During viral infection, activation of the interferon (IFN) signaling pathway promotes transcription of hundreds of interferon-stimulated genes (ISGs), responsible for inhibiting viral replication and infection. ISGs are activated through an upstream IFN-stimulated response element (ISRE) promoter sequence. Viruses have thus adapted multiple mechanisms to evade immune detection, encoding proteins and peptides that inhibit the activation of ISGs. However, knowledge of viral peptides interfering with the interferon signaling pathway is limited to a few anecdotal examples. Here, we will use a stable cell line carrying the GFP reporter under control of the ISRE promoter and a viral peptide library comprising ~70,000 peptides from more than 20 viruses that infect humans to perform a pooled screen. This will allow the identification of viral peptides that interfere with activation of the ISRE promoter and subsequently inhibit ISG expression. To prepare for transduction of the peptide library into the reporter cell line, we have optimized the concentration and incubation time of IFNA2A, a stimulant that promotes activation of the ISRE promoter. We will thus use and optimize protocols for fluorescence-activated cell sorting (FACS) to distinguish stimulated cells and ensure proper system functioning. Overall, the identification and characterization of inhibitory viral peptides of the interferon signaling pathway will advance the understanding of viral strategies of immune evasion and offer insight into potential therapeutic avenues for combating viral diseases.

## Effects of Pine Encroachment into Hardwood Forests on Fungal Communities and Soil Biogeochemistry

**Student Presenter:** Katherine Sotiropoulou
**Faculty Mentor:** Jennifer Bhatnagar (CAS Biology)
Loren E. Wold Research Award

Pine trees encroach into hardwood forests through their association with ectomycorrhizal fungi (EMF); root symbionts that provide plants with nutrients in exchange for carbon (C). I hypothesize that EMF communities in forests experiencing pine encroachment differ from those in other forests in terms of species composition and activity, and that these differences correlate with plant and soil biogeochemistry. I also hypothesize that a subset of EMF are shared between native hardwoods and pines with varying activity based on their host species and forest type. I tested these hypotheses by sampling roots and soils from oak and pine trees across four types of forest stands in MA: mature hardwood, mature pine, mature mixed, and hardwood stands experiencing pine encroachment. Additionally, I characterized the soil biogeochemistry of these stands by taking pH, moisture content, nitrogen (N) mineralization, C content, and soil temperature measurements. I am also measuring EMF activity via metatranscriptomics on pine and hardwood roots across these stands. Preliminary biogeochemical findings show that stands with a pine presence (mature pine, mixed, and encroachment) have a lower pH compared to pure hardwood stands, while mature pine stands have the least soil moisture. This fall, I plan to optimize the root RNA extraction procedure, prepare cDNA libraries for sequencing, and complete soil biogeochemical analysis. These findings will shed light on the relationship between fungal communities and plant and soil biogeochemistry as well as the below ground mechanisms of shifting forest plant community composition.

## Expression of a Library of Proteins Encoded by the Sars-Cov-2 Coronavirus

**Student Presenter:** Anusha Thaniana
**Faculty Mentor:** Tom Gilmore (CAS Biology)
National Science Foundation - Research Experience for Undergraduates (SURF)

SARS-CoV-2 is a novel beta coronavirus that has approximately 80% sequence homology with the known SARS-CoV virus. As the SARS-CoV virus was found to have originated from bats, it is believed that bats are also a likely source for SARS-CoV-2. Bats are not affected by either SARS-CoV virus, but humans are experiencing a severe reaction. Thus, we are interested in learning how the proteins from SARS-CoV-2 affect different cell types: namely, human kidney cells (293T), chicken fibroblast cells (DF1) and bat kidney cells. SARS-CoV-2 encodes 29 different proteins: nsp1 to nsp16, ORF3a, ORF3b, ORF4 to ORF10, Spike (S), Envelope (E), Membrane (M) and Nucleocapsid (N). In these experiments we transfect DF1 cells with expresson plasmids for individual FLAG-tagged SARS-CoV-2 proteins and then performed immunofluorescence to determine expression and localization of the proteins in cells. We found that the subcellular expression of proteins, whether it was only in the nucleus, only in the cytoplasm or throughout the cell, differed among proteins. For example, the nsp2 protein was expressed only in the nucleus whereas ORF3b and ORF 9b were expressed only in the cytoplasm. Future studies will compare the expression of all proteins across different species in order to determine whether certain proteins vary across species in localization or effects on cell physiology or phenotype, which may explain the different effects of SARS-CoV-2 on different species of organisms.

## Investigating the Effects of Zaire Ebola Virus Transcription Factors on Host Chromatin Structure

**Student Presenter:** Kimberly Tran
**Faculty Mentor:** Juan Fuxman Bass (CAS Biology)
Loren E. Wold Research Award

The Zaire Ebola virus (EBOV) is an infectious disease at the forefront of international health organizations' attention, especially since the West African outbreak in 2014. To observe how EBOV's viral proteins affect host transcription, we focused our study on host chromatin structure changes in the presence of EBOV encoded proteins that are crucial for viral transcription: NP, VP30, and VP35. To do this, each viral protein was individually overexpressed in A549 cell line using a stable lentiviral system. These cells were then evaluated using ATAC-seq, to determine regions of open chromatin, and RNA-seq to determine changes in host gene expression. We compared the sequencing data of cell lines overexpressing the viral proteins to the same cell line without viral protein expression. Analysis of differentially expressed genes shows that viral protein change gene expression of the host cells. All three proteins were able to suppress host immune response. An example of immune response regulation includes the upregulation of LFNG, a protein that inhibits NOTCH signaling, by NP. NP and V30 also upregulate genes related to GPCR activity, which have historically been known to facilitate viral infection through cell signaling interference. While all three proteins also showed regulation of cell secretion, a process that helps spread viral particles throughout the host, NP had the highest variety of differentially expressed genes in this category like SYT13 and RAB37. The functional redundancy of the genes regulated by these three proteins suggest coregulation of these host pathways are crucial to EBOV infection.

# *Physical Sciences*

**A Relation Between Local Forcing, Climate, and Biological Components of Carbon Uptake in an Urban Environment: A Case Study of Boston, Massachusetts**

**Student Presenter:** Violette Ballecer
**Faculty Mentor:** Robert Kaufmann (CAS Earth & Environment)
UROP Award

Expanding a data set used to test for a local relation between temperature and atmospheric concentrations of CO2 in Boston that was compiled during the Spring 2021 semester, we include the biological components of these interactions, respiration and photosynthesis, to estimate the effects of temperature, rainfall, precipitation, and solar insolation on atmospheric net carbon fluxes. Investigating these relations at a local scale focuses previous efforts to estimate global relations. Understanding these relations is increasingly important as climate change continues. Consistent with the importance of photosynthesis during the growing season, preliminary results indicate that temperature, rainfall, precipitation, and solar insolation, have statistically measurable effects on atmospheric concentrations of carbon dioxide. At other times, coefficients associated with temperature, rainfall, precipitation, and solar insolation indicate that soil respiration dominates the atmospheric exchange of carbon dioxide. These results are preliminary and will require further statistical analysis and experimentation in order to generate robust results that may merit publication.

**Amine Functionalized Poly-Amidosaccharide-RNA Nanoparticle for RNA Interference Therapeutic Delivery**

**Student Presenter:** Paige Beaudry
**Faculty Mentor:** Mark Grinstaff (CAS Chemistry)
UROP Award

RNA interference (RNAi) is a powerful and emerging class of nucleic acid therapeutics that targets specific genes by downregulating their messenger RNA (mRNA) expression by using small interfering RNA (siRNA) molecules. RNAi can be applied to genetically-linked diseases and disorders as well as viral injections, such as SARS-CoV-2. Once RNAi reaches the intracellular space, it is highly effective at gene knockdown. However, the delivery of the nucleic acids has proven to be a complex clinical challenge. Amine-functionalized poly-amidosaccharides (AmPAS) are a class of cationic and mucoadhesive polymers synthesized by the Grinstaff Lab. Through charge-charge interactions, AmPAS complexes with the siRNA to form RNAi nanoparticles. Due to AmPAS's inherent biocompatibility coupled with its cationic nature, I hypothesize AmPAS-RNAi nanoparticles will have better transfection efficiency and lower cytotoxicity than other RNAi delivery methods. This project aims to optimize formulations of AmPAS-RNAi nanoparticles through different N:P ratios (N: amino group of the AmPAS, P: phosphate group of the siRNA) and formulation conditions. Physical characterization of these novel nanoparticles includes: Dynamic Light Scattering, Scanning Electron Microscopy, and zeta potential to determine the shape, size, charge, and stability. The characterization results suggest there is an optimal formulation between siRNA subtypes that form consistent and stable nanoparticles. These formulations can be used to assess the transfection efficiency of the AmPAS-RNAi nanoparticles in a custom in vitro model of SARS-CoV-2. Demonstration of high transfection efficiency and low cytotoxicity of AmPAS will provide proof-of-concept for its use as a broadly applicable transfection reagent for nucleic acid therapeutics.

## RET-Mediated Signaling Dynamics and Cross-Talk in Differentiating NB41A3-GFRα3 Cells

**Student Presenter:** Brennon Berard
**Faculty Mentor:** Adrian Whitty (CAS Chemistry)
UROP Award

Neuritogenesis involves the coordinated activation of various signaling pathways and cellular processes for proper neurite outgrowth in differentiating cells. These signaling pathways ultimately promote cell survival and differentiation, and drive the rearrangement of the cytoarchitecture. Activation of the RET (REarranged during Transfection) receptor activates the Ras/Raf/MEK/ERK, PI3K/Akt, JNK/c-Jun, and p38 MAPK signaling pathways in stimulated cells. Using an engineered cell line expressing the GFRα3 co-receptor, activation of the RET receptor with the ligand artemin (ART) promotes neurite outgrowth in NB41A3-GFRα3 cells. Although RET signaling is involved in neuritogenesis, the molecular crosstalk among the downstream signaling pathways that regulate this process is still not fully understood. Previous unpublished work in our lab has shown that inhibition of the JNK/c-Jun pathway enhances neurite outgrowth in differentiating neuroblastoma. Using JNK-specific inhibitors, crosstalk between the JNK/c-Jun pathway and other pathways was probed using an enzyme-linked immunosorbent assay (ELISA) and Western blotting to begin characterizing the molecular signaling dynamics in ART-stimulated NB41A3-GFRα3 cells. Current results show that inhibition of JNK increases both ERK and Akt activation levels in Ras/Raf/MEK/ERK and PI3K/Akt pathways, respectively. These results suggest that signaling crosstalk is involved for proper neurite formation in differentiating neuroblastoma downstream of RET activation. A better understanding of the molecular crosstalk involved in neuritogenesis downstream of RET signaling will provide further insight into proper neurite formation, as well as allow for the development of potential therapies for progressive neurological disorders.

## Search for Top-W Scattering in CMS

**Student Presenter:** Hayden Bronson
**Faculty Mentor:** Indara Suarez (CAS Physics)
UROP Award - Clare Boothe Luce Summer Undergraduate Scholar

While the Standard Model (SM) is the most accurate model we have to describe elementary particles, it is still unable to describe some phenomena such as Dark Matter and gravity. There are proposed solutions to this issue that predict the existence of additional particles that could cause a reassessment of the SM. The Large Hadron Collider (LHC) aims to resolve these discrepancies in the SM through observation of proton-proton collisions, which help to demonstrate the physical laws at work on the quantum scale. In particular, collisions at the LHC that produce top quarks along with a boson could potentially help to find physics beyond the standard model. This study focuses specifically on collisions that produce a top and anti-top pair, a W boson, and an additional quark (top-W scattering). We will measure the production rate of this process using data collected from Run 2 (2016-2018) of the Compact Muon Solenoid (CMS) detector and compare this observed production rate to the rate theoretically predicted by the SM. A deviation from the SM predicted value would indicate the existence of physics beyond the SM. Since the final state of the top-W scattering process looks very similar to other SM processes, we have to find ways to distinguish between the two. For example, for top-W scattering events that have two leptons in its final state, we can look only at those events that have leptons with the same charge and, by doing so, can eliminate a lot of our background.

## Trigger Development on DarkQuest Experiment

**Student Presenter:** Caspian Chaharom
**Faculty Mentor:** David Sperka (CAS Physics)
UROP Award

Based on observations and calculations of the rotation of galaxies and from gravitational lensing, there is strong evidence that there is more mass in the universe than what can be directly seen. Dark matter is a hypothesized form of matter believed to make up the missing 85% of the total mass density of the universe. The Standard Model of particle physics does not describe any particles that could explain, or interact with dark matter, but Beyond the Standard Model theories hypothesize particles that could account for dark matter and interact with it. The dark photon is one such hypothetical particle, similar to the regular photon but not massless, that can interact with dark matter. The DarkQuest experiment attempts to detect the existence of dark photons by searing new areas in the phase space of possible masses and coupling strengths using a proton beam dump experiment at FermiLab. The SeaQuest experiment's detector will be used in addition to the PHENIX experiment's electromagnetic calorimeter. Dark photons could be produced through different production modes, primarily through bremsstrahlung, and it's decay tracked through the detector to calculate its properties. The proton beam dump creates 53 million events/second, therefore a trigger system has to be implemented to identify and only save events useful for further analysis. Code was written to use path of muons through the hodoscopes to calculate the vertex where the decay would have occurred and will be integrated in the FPGA trigger.

## Screening Compound Collections for Inhibitors of the KEAP1-Nrf2 Protein-Protein Interaction

**Student Presenter:** Angela Chen
**Faculty Mentor:** Adrian Whitty (CAS Chemistry)
UROP Award

Cellular response to oxidative stress is mediated in part by proteins KEAP1 (Kelch-like ECH-associated protein 1) and Nrf2 (nuclear factor erythroid 2-related factor 2). Disruption of the KEAP1-Nrf2 complex upregulates antioxidant genes, improving cell survivability. Consequently, the interface between KEAP1 and Nrf2 has been increasingly recognized as a potential drug target. Many reported noncovalent inhibitors of the KEAP1-Nrf2 complex contain one or more carboxylate groups to mimic interactions made by two glutamate residues on Nrf2 central to binding with KEAP1. As charged groups, carboxylates decrease the drug-likeness of a compound, and an uncharged group capable of mimicking the interactions of a carboxylate group may be beneficial for increasing drug-likeness without decreasing affinity of the inhibitor for KEAP1. A competition fluorescence polarization (FP) assay was used to screen a small glutamate mimic library and the larger BU-CMD compound collection to identify carboxylate mimics and to identify new functional groups that bind to KEAP1, respectively. In the FP assay, compounds compete with a fluorescently labelled Nrf2-derived peptide for binding to KEAP1. Eight hits were identified from the glutamate mimic library screen and a dose-response was confirmed for each hit by FP assays with varying concentrations of inhibitor. We hope to obtain X-ray crystal structures of hits complexed with KEAP1 to determine whether the inhibitors utilize new modes of binding to KEAP1 and whether the glutamate mimics recapitulate the interactions of Nrf2 carboxylates. We will then attempt to incorporate functional groups capable of exploiting these interactions into a macrocycle or cyclic peptide scaffold.

## Non-Fullerene Acceptor Syntheses for Application in Organic Solar Cells

**Student Presenter:** Ryan de Kock
**Faculty Mentor:** Malika Jeffries-EL (CAS Chemistry)
UROP Award

Organic solar cells (OSCs) have been well-researched for their cost-efficiency, clean syntheses, and modifiability relative to historically popular inorganic solar cells. The major drawbacks of OSCs are their lower energy efficiencies and stability compared to their inorganic counterparts. To optimize the performance of OSCs, push-pull systems consisting of alternating electron donating units and electron accepting units have been developed. In previous work, mesh-like carbon-based molecules known as fullerenes have been used as the electron accepting unit in solar cells. However, fullerenes have been shown to limit the efficiency of devices and other device types due to their weak absorption profiles and thermal and photo instability. Recent research has utilized non fullerene acceptors (NFAs) for their greater absorbance in the visible region of light and tunability relative to previously used fullerenes. This project focuses on the development and execution of multi-step synthetic pathways for ten different NFAs. The 10 compounds were selected as moieties due to known improvements of NFA-based properties including reduced bandgap energies and greater absorbance profiles. Upon successful synthesis, the ten NFAs as the accepting unit will be coupled to a benzobisoxazole cruciform as the donating unit and fabricated into OSCs for testing and characterization of their optical and electronic properties. Ideal OSCs will present high absorbance in the visible region of light and have power conversion efficiencies comparable to that of current inorganic solar cells.

## Pedagogy in Practice: Exploring the Use of Pedagogy Course Knowledge by Learning Assistants

**Student Presenter:** Vera Degtiareva
**Faculty Mentor:** Manher Jariwala (CAS Physics)
UROP Award

Learning Assistants (LAs) are increasingly used in classrooms all over the globe, where LAs help teach in a variety of student-centered, active-learning environments. The LA Model consists of three pillars: the LA pedagogy course, weekly prep meetings with the instructional team, and the LA practice of working with small groups of students. In this paper, we utilize an existing framework of essential pedagogy principles identified by Top et al. to develop a methodology for comparing what LAs learn in the pedagogy course to what they do in their LA practice. In particular, we looked for evidence that LAs use the concepts of acknowledging student ideas, constructing knowledge, and formative assessment. We apply the methodology to audio recordings of ten different LAs facilitating student discussion in five separate sections of an approximately 400 person, introductory studio physics course. We found that our methodology can be used to demonstrate the LA use of the essential pedagogy principles. We propose that our methodology could be employed as a part of the LA pedagogy class to facilitate peer observations as well as a diagnostic tool that the pedagogy course instructors could use to evaluate and improve the course.

## Expanding the Lantern Complex Library: Homobimetallic Lantern Complexes and Related Mononuclear Species

**Student Presenter:** Alice Fan
**Faculty Mentor:** Linda Doerrer (CAS Chemistry)
UROP Award

Hetero- and homobimetallic lantern complexes are promising candidates for single molecule electronics and molecular wires due to their interesting electronic properties. Synthetic control of individual components of the lanterns (backbone ligand, axial ligand, and 3d metal center) renders the lantern framework highly tunable and allows for studies of structure-property relationships. In collaboration with the Kamenetska group, electronic properties of these complexes can be probed using single molecule conductance measurements. Previous measurements of lantern complexes have shown competition from the gold (Au) electrodes for binding to the ligands of the lanterns. The incorporation of anionic ligands, with linker groups to bind to the Au electrodes, has been proposed to increase the strength of the intramolecular metal-ligand bonding of the lantern. Attempts to synthesize modified versions of previously existing lanterns were undertaken by altering one or more of the aforementioned lantern components. Some notable alterations included: installation of 2-methylimidazole (MeIm) or thiocyanate (SCN-) as axial ligands, incorporation of 4-aminobenzoic acid (PABA) as a backbone ligand, and substitution of copper (Cu) or cobalt (Co) as metal centers. X-ray crystallography revealed that mononuclear complexes with Cu or Co cores were formed instead of lanterns. Efforts are still on-going to understand how to control reaction stoichiometry to prevent lanterns from breaking up into mononuclear complexes. While bimetallic lantern complexes were not formed, this series of complexes is useful for determining if the additional electrostatic effect in the metal-ligand bonding will keep the coordination complex intact during single molecule break-junction measurements.

## Designing an Aerogel RICH Detector for EMPHATIC Experiment

**Student Presenter:** Samuel Fulton
**Faculty Mentor:** Edward Kearns (CAS Physics)
Symposium Volunteer

This research is part of the software analysis for EMPHATIC, an experiment to measure particle scattering and production cross-sections. The basic experimental setup consists of a proton beam directed at a carbon target and numerous downstream detectors for momentum analysis and particle identification. In this study, we analyze the sensitivity of an aerogel Cherenkov detector (ARICH) for track reconstruction and particle identification.Similar to a sonic boom, charged particles traveling faster than the speed of light in a medium emit a cone of light called Cherenkov radiation.In ARICH, the particles traveling through a low-density transparent material, called aerogel, emit a cone of Cherenkov radiation that is projected as an ellipse onto the image plane. Using momentum, possible track candidates, and computer software we simulate the expected Cherenkov rings to create an expected photon distribution. With our expected photon distribution and reconstruction algorithm, we can identify the most likely combination of particle identification and track information for simulated and real data.The results of this study demonstrate the expected sensitivity of EMPHATIC. Furthermore, the algorithms that we develop will be used for the analysis of real data that will be generated at Fermi lab in the spring of 2022.

## The Development of Nanoparticles to treat SARS-CoV-2

**Student Presenter:** Melissa Gillis
**Faculty Mentor:** Mark Grinstaff (CAS Chemistry)
UROP Award

This project aims to develop nanoparticles (NPs) that can be delivered intranasally to treat SARS-CoV-2. Medical research and drug development for SARS-CoV-2 has primarily focused on developing vaccines, and thus alternative treatments are understudied. Remdesivir is currently the only FDA approved drug used to treat SARS-CoV-2 and can only be administered to patients with severe symptoms under the surveillance of health care professionals. Intranasally delivered NPs are a less invasive and more accessible treatment option for SARS-CoV-2. The NPs affect viral capsid fusion with the membranes. By inhibiting viral capsid fusion, SARS-CoV-2 virus is unable to release viral nucleic acids which are responsible for the resulting infection. The NPs will be made from biocompatible materials therefore, I anticipate minimum side effects. Intranasal delivery will allow for maximum uptake in the respiratory system, the primary site of infection. To develop NPs, I performed various fabrication techniques, and varied the temperature, mixing conditions, and surfactant to form ideal NP formulations. I optimized these approaches to create stable NPs and found that several variations produced stable NP candidates. These NPs will now be further tested in cell and animal studies.

## Terpene Remodeling of Raman Active Derivatives: Cholesterol

**Student Presenter:** Ricardo Hernandez
**Faculty Mentor:** John Snyder (CAS Chemistry)
UROP Award

Cholesterol and its derivatives can be categorized under this definition due to its ubiquity in the body and its abundance in cell membranes. Cholesterol also stabilizes lipid bilayers surrounding gold and silver nanoparticles, and prior work in our group has shown that cholesterol can be replaced with other triterpene analogs in this role. In this earlier work, in a collaboration with the Bjoern Reinhard group, we have shown that cholesterol derivatized with an alkyne tag allows for the tracking and determination of the orientation of the molecule by Raman spectroscopy. Novel methods to generate such derivatives with the alkyne anchored on the lipid bilayer surface have been examined and developed to maximize the synthetic yields. The key steps in this approach have been the ozonolysis of cholesterol, followed by a reductive aminocyclization. Thus far, successful synthesis of such derivatives has been effective at low yields. Development of better methods is still in process to generate a better yielding aminocyclized product.

## Optimized Synthesis of an Air-Stable Fe(III) Fluorinated Hydroxide Alkoxide

**Student Presenter:** Ana Herning
**Faculty Mentor:** Linda Doerrer (CAS Chemistry)
UROP Award

The large bond dissociation energy of sp3-hybridized C-H bonds and the closed-shell electronic structure of compounds such as methane result in a high activation energy, which makes the selective oxidation of C-H bonds challenging. The use of fluorinated alkoxides as ligands has made it possible to synthesize complexes that perform selective C-H bond oxidation. One example of a reactive oxygen species is the terminal Fe(IV)-oxo motif, active in numerous enzymes, such as TauD, an αkG-dioxygenase which catalyzes taurine hydroxylation. Fe(III) hydroxide complexes have been proposed as products of the reactive Fe(IV)-oxo intermediate, after an H atom has been abstracted from the substrate. Prior work in our lab has shown C-H bond oxidations from [Fe(II)(pinF)]2 / O2 reaction mixtures that may contain a transient Fe(IV)-oxo. Therefore, the goal of this project was to synthesize the novel [FeIII(OH)(pinF)2]2-. In optimizing its synthesis, the amount and nature of the base was considered, as well as reaction and recrystallization conditions. Characterization of the peach-colored [FeIII(OH)(pinF)2]2- was achieved using 1H NMR, 19F NMR, and X-ray crystallography. Future work will include further characterization by elemental analysis, UV-Vis spectroscopy, and solution magnetic susceptibility. This purified Fe(III)-OH complex may also be an Fe(IV)-oxo precursor, and additional studies of the reactivity of Fe(II) and Fe(III) alkoxide complexes with O2 will be enriched by the identification of this product.

## How Students Learn and Prepare Effectively for Classroom Work in Chemistry: Assessing the Utility of Question-Embedded Videos

**Student Presenter:** Nadja Jacimovic
**Faculty Mentor:** Binyomin Abrams (CAS Chemistry)
UROP Award

Pre-lecture videos have increasingly been implemented into coursework by instructors as a way to introduce content before it is discussed in lecture, reducing students' cognitive load and allowing for deeper learning during class time. While the students who engage fully with this content benefit from their preparation, previous studies have shown that most students passively consume video content or skip them altogether. The result is that this out-of-class work can increase heterogeneity in student preparation. In this study we investigate learning behaviors of students related to pre-lecture videos to develop the most effective approach in supporting students in their preparation for class. Specifically, the utility of question-embedded videos (QEVs) in a course-wide implementation will be assessed, the aim of which is to combat passive learning by utilizing accountability measures in the video assignments to promote active learning. We seek to learn how QEVs can affect student self-efficacy and metacognitive abilities, and, thus, improve student learning.Preliminary results from surveys on learning styles distributed to the summer general chemistry classes show that students are already utilizing numerous additional resources to aid in their studying -- changes to approaches and preferences, and, thus, changes in self-efficacy and metacognitive abilities, will be assessed. This project is the first that aims to identify the mechanisms by which QEVs improve student learning, and to assess course-wide implementation of QEVs in STEM education.

**Ultrafast Two-Dimensional Spectroscopy (2DIR) in Super Critical Fluids: Energy Relaxation and critical Slowing Effects**

**Student Presenter:** Arkash Jain
**Faculty Mentor:** Lawrence Ziegler (CAS Chemistry)
UROP Award

At the critical temperature and critical pressure, liquid and gaseous phase boundaries disappear, and the resulting fluid is described as a supercritical fluid (SCF). At the high densities that characterize a SCF, a lack of rotational spectral resolution due to factors like inelastic collisional effects makes quantitative analysis of linear absorption lineshapes challenging, but by using two-dimensional infrared(2DIR) spectroscopy, we can directly uncover dynamical effects giving rise to ambiguous SCF spectral lineshapes. 2DIR allows us to directly report on molecular energy fluctuation dynamics resulting from intermolecular interactions as a function of fluid density. We seek to study the rate of rotational and vibrational relaxation of nitrous oxide($N_2O$) as a small molecule solute probe of supercritical sulphur hexafluoride($SF_6$) experimentally and compare it to existing classical theories of energy flow and relaxation in dense fluids. The reason that we are interested in studying SCFs and the nature of intermolecular interactions in SCFs is because they have highly selective solvation properties which makes them potential green substitutes to pollutant organic solvents. Our preliminary results show that rotational equilibration in $SF_6$ is highly efficient requiring 1-1.5 solute-solvent collisions for rotational equilibria in molecules while vibrational equilibration takes more than 20 collisions. The significance of this study is that it enables descriptions of the relative gas and liquid-like populations of the molecular ensemble in each SCF solvent, helping describe special solvation effects of SCFs on a molecular-level, thereby providing extremely interesting insights into the relatively unknow field of supercritical fluids.

**Empirical Algorithm Development and Validation of CDOM Absorption in Coastal Waters Along the Terrebonne Bay**

**Student Presenter:** Dain Kim
**Faculty Mentor:** Cedric Fichot (CAS Earth & Environment)
UROP Award

Studying dissolved organic carbon (DOC) in aquatic ecosystems provides insights into predicting and understanding the global carbon cycle. One of the ways to facilitate the study of DOC across spatial and temporal scales is through the remote sensing of Chromophoric Dissolved Organic Matter (CDOM), an optical proxy for DOC in coastal waters. This study aims to assess the performance of empirical algorithms for retrieving CDOM absorption at 443 nm wavelength (ag(443)) in coastal Louisiana. A total of 123 in-situ water samples were collected around the Wax Lake Delta and Terrebonne Bay regions in Louisiana to formulate and validate the empirical algorithm. Band ratio and multiple linear regression (MLR) algorithms were developed and implemented on Landsat-8 satellite imagery of the study region. Out of the five algorithms we developed, the band ratio of remote sensing reflectance at 443 nm wavelength, Rrs(443), over remote sensing reflectance at 655 nm wavelength, Rrs (655), and the MLR model with Rrs (655) and Rrs (443)/ Rrs (865) resulted in better performance. However, the algorithms typically underestimated CDOM absorption values by >50%. This limited performance is very likely linked to the very limited spectral capabilities of the Landsat-8. Further work can be done to improve the model by utilizing hyperspectral imagery.

**Surveying Past Participants to Assess the Long-Term Impact of Project Accelerate**

**Student Presenter:** August Menchaca
**Faculty Mentor:** Andrew Duffy (CAS Physics)
UROP Award

Project Accelerate is an NSF-funded project aimed at helping students at underprivileged highschools prepare for the AP Physics 1 exam. It has been running since 2015. Participating high schools are located in Boston, Western Massachusetts, New Hampshire, West Virginia, and Texas. Our hypothesis was that getting a rigorous science experience in high school, through Project Accelerate, will make it more likely that the participating students go on to become STEM majors in college, and that they will be more likely to succeed in college when they get there. To test this hypothesis, I carried out eight interviews with and got an additional twelve survey responses from former Project Accelerate students. Analysing the interview transcripts along with the survey yielded the result that Project Accelerate students had a head start in their college physics and STEM courses. Another benefit from Project Accelerate is that it helped transition its students to online schooling from COVID. The hope is that these results might help Project Accelerate gain further funding in the future

**Seeing the Forest AND the Trees: Computer Vision and Machine Learning Applied to Unmanned Aerial Vehicle Imagery at Harvard Forest**

**Student Presenter:** Kira Milgrim
**Faculty Mentor:** Mark Friedl (CAS Earth & Environment)
UROP Award

Measurements and analysis of forest canopies can reveal critical information about important ecological functions, such as photosynthesis and net carbon exchange. They can also be used to identify ecological properties of an area, such as the species composition of a forest, the canopy height, and overall health of the vegetation. Typically, these measurements are taken manually on the ground, or by expensive sensors (such as LiDAR and satellite imagery). Recently, imagery from Unmanned Aerial Vehicles (UAV's) has shown to be a potential alternative to these technologies. Through this project, imagery of the Harvard Forest captured using a commercially available UAV (DJI Phantom) was processed to explore if and how UAV's might provide a feasible low-cost substitute for more expensive technologies in future applications. It was shown that software available online (in this case, commercial software called AgiSoft was used) can be applied to UAV imagery to create dense point clouds, orthomosaics, and a Digital Elevation Model (DEM) of the forest canopy. Further processing of the DEM using Python packages developed for geospatial data processing enabled creation of a hillshade model of the forest. This work has shown that UAV imagery has the potential to provide high-quality imagery that can be used to obtain ecological measurements in forested ecosystems, and could lead to further applications in making geospatial-related studies of ecosystems more accessible.

## Toward Controllable and Scalable Synthesis of 2D Ni(OH)_2 with Large Domains via the Hydrothermal Method

**Student Presenter:** Gillian Minarik
**Faculty Mentor:** Xi Ling (CAS Chemistry)
UROP Award

2D crystals composed of single- or few-layers of atoms display unique chemical, optical, and electronic properties compared with their bulk 3D counterparts due to the phenomenon of quantum confinement. This project initially sought to synthesize high-quality 2D Ni(OH)2 crystals as precursors for the conversion to 2D Ni-based Metal-Organic Frameworks (MOFs), a family of porous materials gaining recognition for their potential in environmental remediation and energy-efficient technologies. Synthesis of Ni(OH)2 crystals were performed via the hydrothermal method with variation of three key parameters: pH, reaction temperature, and cooling rate. The crystals were observed under optical microscopy and further characterized with bulk powder X-ray diffraction, atomic force microscopy, and Raman spectroscopy. The results show circular Ni(OH)2 nanosheets of unprecedented large domain size (20-50 μm) which were successfully synthesized reproducibly. Moreover, a detailed investigation on the influence of the synthetic conditions on the domain size, thickness, and morphology was performed, providing insight into a tunable and scalable synthetic pathway for single-crystalline Ni(OH)2 materials. Given that we have a well-rounded understanding of the synthesis mechanism, this synthetic pathway is promising to be generalized to 2D hydroxides of other 3d transition metals. Our future plan also includes the exploration of the synthesized 2D Ni(OH)2 flakes as channel materials for field-effect transistors (FETs) and as the color change materials for electrochromic devices, which will begin with UV-Vis and thermal stability measurements.

## Expression and Purification of Proteins to Interact with the CIA targeting complex

**Student Presenter:** Christopher Park
**Faculty Mentor:** Deborah Perlstein (CAS Chemistry)
UROP Award

Iron sulfur (FeS) cluster assembly proteins are essential for a multitude of proteins vital for our survival functions, including DNA replication, transcription, and translation. The Cytosolic Iron Sulfur Cluster Assembly (CIA) pathway builds and inserts FeS clusters into nuclear and cytosolic apo-proteins that are without FeS clusters. This system has a number of involved proteins involved in producing and targeting the location of the FeS cluster throughout the cell. The proteins CHL1, YTH1, ELP3, DNA2, GRX4, PRI1 and PRI2 have all yet to be expressed and purified in the Perlstein lab to coordinate the rest of the FeS cluster system. Each FeS protein requires unique optimized buffer conditions in order to remain soluble and interact with other proteins in vitro. To express and purify these proteins, Gateway cloning was necessary to add an affinity tag for purification and to allow for overexpression in E.Coli. Testing the binding of DNA2 to the targeting complex including Cia2, Cia1 and Met18 we are able to begin determining how this larger complex forms with DNA2. Continuing the optimization of growth and purification conditions of the expanded list of FeS cluster proteins will allow us to better understand how the system interacts together in order to build and insert FeS clusters.

## Understanding the Mechanism of NEMO Dimerization

**Student Presenter:** Amelia Pfaff
**Faculty Mentor:** Adrian Whitty (CAS Chemistry)
UROP Award - Mark W. Reimen Summer Research Prize

NF-kappa-B essential modulator (NEMO) is a dimeric protein that acts as a regulatory subunit in the IkB kinase (IKK) complex and is encoded by the IKBKG gene. Downstream effects of NEMO primarily include activation of genes controlling inflammation, immunity, and cell survival. Importantly, mutations in the IKBKG gene have been linked to several immune diseases; most notably incontinentia pigmenti (IP) and anhidrotic ectodermal dysplasia with immunodeficiency (EDA-ID). NEMO functions as a dimer. We hypothesize that certain disease-causing mutations in NEMO may function by destabilizing the dimer interface. This hypothesis can be tested by analyzing the effects of the mutations on the kinetics for subunit exchange between NEMO dimers. To do this, two NEMO constructs were expressed and purified: wild-type NEMO and NEMO with a genetically encoded yellow fluorescent protein (YFP) tag (YFP-NEMO). These dimers were then allowed to undergo dimer exchange in which YFP-NEMO homodimers exchanged subunits with NEMO homodimers to become YFP-NEMO/NEMO heterodimers. As the homodimers disassociated and heterodimerized, the homoquenching effect was lost, and as a result, an increase in fluorescence was observed. After determining the dimerization kinetics and reaction mechanism of NEMO, mutations known to cause IP and EDA-ID will then be introduced into NEMO. Dimerization experiments will then be repeated to determine how mutations in NEMO affect dimerization between subunits. This study will help elucidate the mechanism of dimerization in NEMO and determine if disease causing mutations correlate with a change in the dimerization of NEMO.

## Continued Development of System Tests for the CMS Endcap Timing Layer Detector

**Student Presenter:** Maxine Phillips
**Faculty Mentor:** Indara Suarez (CAS Physics)
UROP Award

The proton-proton collisions occuring at the Large Hadron Collider (LHC) at CERN provide information essential to deepening our knowledge of particle physics. In my research this summer, I have been designing and carrying out tests for readout boards and a sample disc section that will eventually reflect the Endcap Timing Layer (ETL) section of the new MIP (minimum-ionizing particle) Timing Detector (MTD). The MTD will improve the timing resolutions for MIPs and will help physicists to more accurately differentiate trajectories originating from noise from those coming from interesting processes, e.g. Higgs boson decays. This summer, I completed tests on the strength of the module mockups which ejected particles will hit on the detector. I also aided my team in constructing temperature sensors and a 'cold box' which emulates the equipment and environment of a section of the actual endcap, and tested the sensors and cold box for durability and performance. Both these projects will demonstrate how the actual modules and disc should be constructed and handled; the modules on a readout board that translates collision information into useful data, and the disc as a part of the larger endcap. Both projects will improve the particle reconstruction efficiency and will aid in the search for new elementary particles. The results of my work this summer will set me up for future work with the group to test and construct the new detector.

**Optimization of Expression and Purification of Human Adenosine Kinase in BL21 E. coli for X-ray Crystallographic and Inhibition Studies with Ketohexokinase Inhibitors**

**Student Presenter:** Benjamin Pollak
**Faculty Mentor:** Karen Allen (CAS Chemistry)
UROP Award

Ketohexokinase (KHK) catalyzes the conversion of fructose to fructose-1-phosphate and is a therapeutic target for inhibitor studies due to its involvement in diseases related to fructose metabolism. One of these diseases, hereditary fructose intolerance, leads to a deficiency in the enzyme that processes KHK-phosphorylated fructose, causing an accumulation of toxic products in liver cells. Other enzymes in the same protein superfamily as KHK may also bind KHK inhibitors due to structural similarity, which could lead to toxic side effects in vivo. Inhibition of family member adenosine kinase (ADK) can cause toxicity, and for this reason it is important, if binding is tested and does occur, to obtain structures of ADK with KHK inhibitors to help improve their specificity. Here, optimization of ADK production to reach the high concentrations of homogeneous protein needed for X-ray crystallography is described. Many different E. coli cell growth conditions were attempted to achieve pure and concentrated ADK, however, ADK had low solubility and activity when produced in any of these. Varying temperatures, growth conditions, broth compositions, purification parameters, and refolding experiments were shown to be insufficient with SDS-PAGE and activity assay analysis. Further alterations to the recombinant ADK gene inserted into E. coli were deemed necessary to improve solubility and active protein yield. The ADK gene was ligated into a SUMO tag plasmid, which added a large soluble protein fusion sequence to ADK. Optimization of SUMO-ADK expression and purification will be performed to create an efficient procedure for producing ADK for X-ray experiments.

**Structural Determination of Enzymes PglA and PglC from Campylobacter Concisus**

**Student Presenter:** Estelle Qi
**Faculty Mentor:** Karen Allen (CAS Chemistry)
UROP Award

Glycosyltransferases (GTs) and monotopic polyprenol phosphate phosphoglycosyl transferases (PGTs) are protein families that play a crucial role in the biosynthesis of sugars on the surface of bacterial cell membranes. Each species of bacteria has unique sugars on its surface, which play an essential role in the ability of bacteria to infect humans. Since GTs and PGTs are vital in the formation of glycoconjugates, therapies that target and disrupt the function of GTs and PGTs could assist in the design of new antibiotics to combat the rise in antibiotic resistance. Thus, a deeper understanding of the mechanism of catalysis of GTs and PGTs must be achieved through structural determination using X-ray crystallography.

To determine the conditions that would yield diffraction-quality crystals, several GTs, PGTs, and their variants were first expressed, isolated, and purified in E. coli cells. Crystal trays were then set up for each protein under conditions with varying concentrations of polyethylene glycol, salt, and buffer. Of the proteins that have been purified, the GT, PglA, as well as the PGT, PglC, from Campylobacter concisus were successfully crystallized. Next, X-ray diffraction data will be collected from optimized crystals sent to synchrotron beamlines and processed using MOSFLM, PHENIX, and Coot software to create models for each protein. The structure of GTs and PGTs could be utilized to better understand how GTs of similar function and predicted structures bind to different substrates and inform novel antibiotics that inhibit the activity of these enzymes.

**Sequence and Truncation Effects on the Population of Aggregation-Prone States on the Evolutionarily Conserved Lipid Scavenger Protein, Serum Amyloid A**

**Student Presenter:** Harrison Reiter
**Faculty Mentor:** John Straub (CAS Chemistry)
UROP Award

Amyloid formation is a hallmark of a variety of diseases such as Alzheimer's and Parkinson's disease, and the prion diseases. Amyloid fibrils are energetically stable proteinaceous deposits composed of polypeptides and various cofactors whose mechanism of assembly (from monomers to aggregate) has been extensively studied—experimentally and theoretically—but the key inter- and intra-molecular interactions leading to such fibrils remain ambiguous in many cases. One key step in understanding the mechanism of assembly is development of a clear picture of the monomer conformational ensemble (MCE) which gives insight into the intramolecular interactions leading to the stabilization or hindrance of aggregation-prone states in the absence of other monomers or cofactors. This work aims to elucidate the MCE of a highly evolutionarily conserved protein that functions as a lipid scavenger during immune response, serum amyloid A (SAA), that may also form fibrils in the liver, spleen, and kidneys of patients in systemic AA amyloidosis. The MCE of SAA was investigated using molecular simulation with the self-organizing polymer model for intrinsically disordered proteins (SOP-IDP). Simulation results were compared against experimental results, as well as theoretical predictions based on mean-field theories and precedent set by previous work with the SOP-IDP model. The role of sequence (native versus mutant) and truncation was investigated in the context of propensity for the monomer to adopt an aggregation-prone state. This work aims to understand the molecular underpinnings of aggregation-prone states in SAA, which may provide therapeutic targets in diseases in which SAA fibrillization plays a role.

**Molecular Simulation of Ionic Liquids: From Molecular Interactions to Transport Properties**

**Student Presenter:** Cedric Salame
**Faculty Mentor:** David Coker (CAS Chemistry)
UROP Award

Batteries that can operate at high temperature and pressure conditions are in increasing demand in the mining, consumer goods, and automotive industries. Current models use a solid electrolyte making them highly flammable and unsuitable for these applications. However, ionic liquids, which are highly conductive liquids at room temperature and non-flammable at high temperatures are a promising replacement for these electrolytes. Our work is developing a mechanistic understanding of the correlation between the interactions of these ionic liquids and their observed physical properties.To accomplish this goal, we have parametrized the ionic liquids' interactions using a polarizable force field model in order to compute its transport properties, including diffusivity, viscosity, and conductivity, from an ensemble of initial conditions that are sampled using replica exchange equilibrium molecular dynamics simulations. This enhanced sampling method allows us to overcome the issues brought about by the slow relaxation times of these liquids. The conductivity values resulting from the extensive work on the imidazolium-dicyanamide pair agrees strongly with experiment for the set of studied temperatures. Viscosity, on another hand, follows the same trend as experiment – viscosity values decrease with temperature – but all values are scaled down by a factor of seven. The reason behind this shift remains uncertain and will be further studied and analyzed with the work on the two remaining ionic liquid pairs considering that the methods and algorithms that we developed are highly transferable. This will allow us to improve our polarizable model and perhaps uncover some limitations to it.

**Functionalization of Betulin to Terpene-Separated Amino Acids**

**Student Presenter:** Iris Simone
**Faculty Mentor:** John Snyder (CAS Chemistry)
UROP Award - Clare Boothe Luce Summer Undergraduate Scholar

In this study, betulin (a natural product found in the bark of birch trees, *Betula papyrifera*) and its derivatives were explored as starting points for synthesizing terpene-separated amino acids, a novel drug chemotype with interesting applications in peptide drug development. Betulin is a triterpene with known medicinal activity against cancers, malaria, and infections, in addition to being widely abundant in nature and relatively inexpensive to work with. Manipulating the functionality of betulin at positions C-28 and C-29 was the main method employed to synthesize terpene derivatives. Through techniques such as reductive amination, oxidation, reduction, ozonation, and demethylation, synthetic routes from betulin to terpene-separated amino acids were explored. The novel betulin derivatives synthesized in this study have unique solubility properties, which is useful in pharmaceuticals for improving the oral bioavailability of terpene or protein-based drugs. In the future, more unique terpene-separated amino acids will be developed in order to evaluate the potential of this chemotype for activity against a variety of biological targets, perhaps even expanding into other terpenes for continued pharmaceutical investigation.

**Extreme Heat: Wet-bulb Temperature Hotspots in East Oklahoma & Implications for Heat Vulnerability & Policy**

**Student Presenter:** Claire Thomas
**Faculty Mentor:** Bruce Anderson (CAS Earth & Environment)
UROP Award

With each year comes more frequent and more intense extreme climate events due to unabated human-induced climate change. One of its most direct and deadliest impacts is extreme heat events, killing millions in places entirely unprepared to manage such events. Historically, temperature has been used to estimate the impacts of extreme heat events, but recently researchers are paying more attention to other factors such as humidity for a much more accurate estimation. The heat survivability threshold (HST) is the wet-bulb temperature, factoring temperature and humidity, past which humans cannot survive. In this study, my research partner found where in the US this threshold is being passed most immediately, and we created a heat vulnerability index (HVI) for that region to discover who is most vulnerable to such extreme heat. I then conducted a literature review of best practices and policy options for equitably mitigating extreme heat in a local context. We found that East Oklahoma is the greatest wet-bulb temperature hot spot in the US, and found no formal heat policy measures in existence for that region. I discovered that heat policy should be developed in local contexts, take into account the local human and environmental ecosystem, infrastructure and vulnerability patterns, and be a collaborative process led by the most vulnerable population sought to be protected. Equitable heat policy is needed everywhere now, and its necessity will only grow as extreme heat events continue and worsen in the coming years and decades.

**Improving Student Learning by Embedding Questions and Feedback in Video Resources**

**Student Presenter:** Daniela Torres
**Faculty Mentor:** Binyomin Abrams (CAS Chemistry)
UROP Award

Flipped classrooms have become increasingly popular in STEM courses because of their effectiveness on student gains and accessibility during the COVID19 pandemic. Previous work in the Abrams group established that studying from question-embedded videos (QEVs) significantly outperform students studying from comparable textbook excerpts. This study builds on those findings to investigate the role of the questions embedded in videos and their role in learning, by comparing identical QEVs to traditional (passive, non-question-embedded videos), with the goal of discriminating between passive lecture videos without QEVs and videos with QEVs. A random-control trial had students learning from one of the two resources, after which learning gains were assessed through post-tests. The group of students working from QEVs significantly outperformed the students who watched the identical passive videos. Moreover, the students studying from the passive videos showed no significant gains over the control group of students who were not given any study resource before completing the post-test. These results suggest that assigning passive videos is not sufficient to yield maximum learning gains for students; rather, assigning out-of-class work with QEVs leads to substantially greater learning gains. Moving forward, we intend to investigate the generalizability of these results by studying the efficacy of QEVs in other STEM disciplines, such as biochemistry and physics. In the end, we hope that these findings will help faculty to design future courses that make the best use of digital learning modalities, such as QEVs, and help instructors provide feedback to students in STEM classes to improve their learning.

**Using Computer Simulations To Model Viruses**

**Student Presenter:** Venika Vachani
**Faculty Mentor:** Erramilli Shyam (CAS Physics)
UROP Award

Given the current COVID-19 pandemic, understanding virus mechanics has never been more important. Atomic force microscopy (AFM)-based nanoindentation is a technique that involves the deformation of a biological entity using an indenter tip. This can measure viral properties such as stiffness and the Young's modulus, which can be used to estimate the internal pressure. This was simulated using the finite element analysis program COMSOL. Using similar simulation techniques, we can model more complex processes, such as virus inactivation through the use of femtosecond laser irradiation, which is the use of extremely fast pulses of lasers to render the viruses incapable of further spread/infection.

# *Social Sciences*

### Prosecuting White Power: How does White Identity Shape American Legal Institutions?

**Student Presenter:** Sophia Alvarado
**Faculty Mentor:** Jeremy Menchik (Frederick S. Pardee School of Global Studies)
UROP Award - Humanities Scholar

In the past twenty years, scholars have found that the white power movement and associated identity politics have become entrenched in American institutions. More specifically, following the Vietnam war, white nationalist groups in the United States became components of the broader white power movement and structured the movement to avoid wide-scale prosecution. Consequently, white supremacist violence has been ignored or ineffectively prosecuted by the American legal institution. This paper investigates why terrorists within this movement were or were not prosecuted, why they were acquitted, and how whiteness impacted the American judicial response. It draws comparisons between the prosecution of members of the white power movement, and the prosecution of members of the Black power movement in order to examine the role of race in the judicial response to political violence. Through a comparative historical analysis of 84 crimes and 133 white and black power movement members, I found that white power activists were not sentenced to life as often as black power activists, were killed extra-judicially by the police less often, and more frequently acquitted of their crimes. However, black power activists were more frequently convicted and sentenced with a later exoneration or dismissal of charges. White supremacy has continuously shaped US policy and national identity, as witnessed by the movement's resurgence during the Trump Administration. This study demonstrates the pervasiveness of whiteness, how countermeasures for white supremacy are under-resourced and under-prioritized in the US judicial system, and contributes to the body of literature regarding the institutionalization of white power.

### Student Perceptions of Safety on the Boston University Residential Campuses

**Student Presenter:** Eva Amato Bauer
**Faculty Mentor:** Erika Wells (CAS Psychological & Brain Sciences)
UROP Award

In the wake of an alarming string of break-ins on the Boston University campus last spring, I became interested in evaluating student perceptions of safety on campus. I wondered what areas of the residential campuses were perceived as the least and most safe. As I developed my research proposal, I broadened the scope of my research to analyze student demographics beyond campus location. I drafted and finalized a survey to collect data on student demographics, assessments of senses of safety, personal histories of crime and police interaction, the likelihood of reporting various crimes, attitudes towards police, and safety preferences. With the data, I hoped to conduct analyses and identify specific communities experiencing low senses of safety. Additionally, under the guidance of my advisor, Dr. Erika Wells, and with knowledge gained from the weekly workshops, I drafted the recruitment language, informed consent, and debrief forms that I would use upon IRB approval.

While I did not acquire approval in time to disseminate my survey, I found the UROP experience to be invaluable as a psychology student hoping to pursue further research opportunities. I gained knowledge and experience in research ethics and survey construction, as well as learning the proper protocol for applying for IRB approval. I remain interested in discovering which communities on campus are experiencing the lowest senses of safety, as I believe this information would be valuable to the BU administration and student body; I hope to implement the research this fall as soon as we gain IRB approval.

## The Costs of Extreme Weather Events on United States Military Instillations

**Student Presenter:** Meghan Ayre
**Faculty Mentor:** Rosella Cappella Zielinski (CAS Political Science)
UROP Award

Climate change is increasingly causing destruction to infrastructure, indeed extreme storms and sea level rise are making many areas around the globe uninhabitable. American military infrastructure is not exception. The US Deparment of Defense manages a global real property portfolio consisting of 568,383 facilities (valued at nearly $1,046 billion) on nearly 27.2 million acres of land located at over 4,793 sites worldwide. To begin to understand how and to what extent climate change is negatively affecting American military infrastructure, we account for all the military construction costs associated with named storms for Air Force bases in the continental United States from 2000-2020. Drawing from NOAA's named storm list, we have identified all Air Force bases that have been in the path of the named storm. Then, through a series of interviews, news reports, and Congressional appropriations we identify which storms caused a significant degree of damage such that the base's normal operating budget is not able to meet the repairs. We are currently in the process of FOIA-ing supplemental requests for repairs.

## Positivity For Which Bodies: Exploring Body Positivity and Fat Acceptance on TikTok

**Student Presenter:** Katie Barnes
**Faculty Mentor:** Cati Connell (CAS Sociology)
UROP Award

Content related to body image is a major trend on the popular video-sharing app, TikTok. Fat acceptance content, which is specifically geared towards increasing societal acceptance of fat people, often comes into conflict and conversation with body positivity content, which seeks to celebrate all bodies. TikTok creators that promote fat acceptance often criticize the body positivity movement on the app as lacking true diversity and abandoning the movement's original aim to analyze systems of oppression in order to focus on individual confidence. Furthermore, TikTok's algorithm has faced claims of bias. This research seeks to use the method of digital content analysis to investigate both movements to determine what discourses fat acceptance and body positivity creators engage in on TikTok, as well as which creators have the highest engagement on the platform. Digital content analysis considers both the content that creators post as well as the engagement metrics of the social media platform that hosts the content. Data was gathered for a sample of 10 body positivity and 10 fat acceptance creators, all of whom had more than 10,000 followers. The content analysis found that body positivity creators were more likely to frame the movement as being about individual insecurities and less likely to address systemic oppression, and that body positivity creators had higher levels of engagement overall. This research highlights the experiences of TikTok creators that speak up about injustice and can be used for further research into the platform and both movements.

**Throwing Out Tradition and Creating New Timelines: College Student Attitudes Towards Marriage and Family**

**Student Presenter:** Charlotte Beatty
**Faculty Mentor:** Nancy Smith-Hefner (CAS Anthropology)
UROP Award

Around the world, marriage and childbirth rates are on the decline. According to Inhorn and Smith-Hefner (2021), 61% of American adults under the age of 35 are currently childless and living without a spouse or partner. The structural forces behind this, such as increased education for women, rapid globalization, and widespread struggles for employment, coincide with massive cultural shifts in attitudes towards long-term partnership and family formation among Gen-Z young adults. Through interviews and qualitative data analysis, this research sought to identify some of the most common themes weighing on Gen-Z young adults when they envision their futures, and in turn understand why some of the U.S.'s brightest, most privileged, and most successful young professionals are significantly delaying marriage, delaying childbirth, or turning away from traditional scripts of marriage and nuclear family structure altogether. Narrative analysis revealed that after a desire for financial security, desires for mental wellness and intentionality are leading factors in individual decisions to delay marriage, delay children, or throw out traditional scripts entirely. The aspiration for mental well-being and true intentionality appears in considerations of a growing climate crisis, individual tensions with long-term monogamy, increased dialogues surrounding mental health and childhood trauma, and the modern pressure to, regardless of gender, firmly establish oneself in intellectual or professional circles. What grows in place of older hegemonic ideas of marriage and family are aspirations for intentional parenting and intentional partnerships based in equity and rooted in care for both the self and the other(s).

**Does Bias among Medical Professionals Correlate with Black-White Disparities in Postpartum Depression and Mental Healthcare?**

**Student Presenter:** Beverly-Danielle Bruno
**Faculty Mentor:** Stephanie Curenton-Jolly (Wheelock Education Leadership & Policy Studies; Applied Human Development)
UROP Award

The realities of the Black maternal mortality crisis inflict psychological trauma upon those impacted the most, which is reflected in higher rates of postpartum depression (PPD). Black-White disparities in PPD are rooted in structural racism in medical and social service delivery, which extends to mental health care. The current study descriptively examined Black-White disparities in prenatal care (PNC) in the Southeastern United States utilizing the Pregnancy Risk Assessment Monitoring System (PRAMS). PRAMS documents mothers' healthcare experiences and attitudes throughout and after pregnancy. Using STATA, independent group t-tests assessed differences in quality of PNC across Black and White mothers. Analyses were focused on providers' discussions with mothers about PPD, whether mothers received PNC as early as they wanted, and whether mothers wanted PNC. Examining group differences between Black and White mothers highlighted that Black mothers received less quality PNC. Although Black and White mothers were similarly likely to have conversations about PPD with their providers, preliminary descriptive analysis suggests that Black mothers ($M = 1.76$, $SD = .43$) did not receive PNC as early as they wanted compared to White mothers ($M = 1.83$, $SD = .38$), $t(2308) = 4.50$, $p = 0.000$. Black mothers were also less likely to want PNC, which may suggest dissatisfaction and/or distrust of medical treatment ($M = 1.06$, $SD = .24$), $t(415) = -2.68$, $p = 0.008$. These findings suggest the importance of research into structural inequalities and biases that create a gap between Black and White maternal healthcare experiences.

**The Western Shoshone Radiation Poisoning and the Nevada National Security Site**

**Student Presenter:** Fiona Captan
**Faculty Mentor:** Jayita Sarkar (Frederick S. Pardee School of Global Studies)
UROP Award

The Western Shoshone Nation lives in a vast region downwind of the Nevada National Security Site. The site itself is located on Indigenous lands, which the US government accessed through the 1863 Treaty of Ruby Valley. However, the United States overstayed its welcome in the territory, disenfranchised the Western Shoshone, and exploited their sacred land for gold-mining profits, nuclear-waste storage, and nuclear weapons testing. This research examines how the U.S. government breached the Treaty through the establishment of the Nevada National Security Site. Through decades of nuclear testing, both above ground and underground, 928 weapons tests were conducted at the site and led to severe nuclear fallout in the downwind regions. The Department of Energy, formerly the Atomic Energy Commission, spread disinformation about radiation dose pathways, blocked scientists from publicizing the connection between radiation exposure and cancer, and attempted to cover up its failed nuclear tests at the test site, which was leaking significant levels of radioactive gases into the atmosphere. Based on documents from the Western Shoshone Nation of Indians, United States Department of Justice, and Institute for Energy and Environmental Research, the paper makes three key findings: the Western Shoshone continuously suffer from deliberate disenfranchisement by the U.S. government, the Department of Energy withholds safety data and information from the public, and new corporations freely mine and exploit Western Shoshone land, thus exacerbating the health and environmental crisis.

**Characterizing Differences in Children's Executive Function for Forgiveness**

**Student Presenter:** Sophia Carias
**Faculty Mentor:** Peter Blake (CAS Psychological & Brain Sciences)
UROP Award

Forgiveness plays an important role in interpersonal interactions and has been correlated with many positive health outcomes, making it an important skill to cultivate early in life. However, little is known about the cognitive processes driving children's tendency to forgive, or the reasons why some individuals are more likely to forgive than others. Since forgiveness requires greater impulse control and an ability to adapt to changing circumstances, I predicted that executive function skills like inhibition and flexibility might promote forgiveness. We tested a total of 126 children between the ages of 6 and 11 years old in an ongoing peer interaction using the Child Repeated Prisoner's Dilemma (C-RPD) game, where children decide to cooperate with their partner by pushing three coins to them or to defect by pulling one coin to themselves. Forgiveness was measured from children's pushing or pulling responses to a defection by their partner. Additionally, we measured their executive function using the Hearts and Flowers task. Preliminary results suggest that both age and executive function are significant predictors for children's initial tendency to cooperate. Further analysis needs to be done to understand how this affects their forgiving tendencies. This study has implications for determining whether executive function interventions may support the development of forgiveness for mental and physical benefits later in life.

## Evaluating the Relationship Between Hormonal Contraceptive Use and Depression

**Student Presenter:** Julie challain
**Faculty Mentor:** Anthony Rosellini (CAS Psychological & Brain Sciences)
UROP Award

There is limited literature on the relationship between hormonal birth control and Major Depressive Disorder, despite the known potential of birth control to negatively affect mood. This study hypothesized that the longer use of hormonal birth control would increase the likelihood of later depression, and that this effect would be stronger in individuals who began taking birth control at a younger age (i.e., during early puberty).Data from the Collaborative Psychiatric Epidemiology Surveys (CPES) were used to assess the relationship between lifetime hormonal contraceptive use and the occurrence of depression in the past 12 months. Associations were evaluated using odds ratios and logistic regressions, with all models controlling for other psychiatric disorders and family history of depression. Duration of birth control use was not associated with an increased likelihood of depression within the last 12 months (OR = 1.006, Wald $\chi$ = 1.561, p = .211), including among the subset of individuals who began birth control use in early puberty (OR = .992, Wald $\chi$ = .035, p = .851). These results do not support our hypothesis. A number of other factors may account for this, however, such as type of birth control, consistency of birth control use, or other factors which we could not measure in this study.Further research is necessary to determine the effects of birth control on depression. This study may be used to help guide future studies, which could evaluate the relationship between birth control and depression severity or depression symptoms.

## How Forgiveness Related to Social Cognition

**Student Presenter:** Kira Charny
**Faculty Mentor:** Peter Blake (CAS Psychological & Brain Sciences)
UROP Award

Having the ability to forgive as a child is a very important skill to acquire. It helps with releasing anger/resentment and children's overall socialization development. In this study, I focused more directly on why some individuals are more likely to forgive than others and the cognitive processes that drive children's tendencies to forgive. The question that prompted my focus within the study was “How do children perceive their transgressors?” We tested a total of 126 participants, ages 6 and 11 in a strategic online game called the Child's Repeated Prisoner’s Dilemma (C-RPD). The participants play this game by having a choice to either “push,” which results in giving their partner three coins, or “pull,” which guarantees the participant gets at least 1 coin to keep. If they push the three coins to their partner, we consider that an act of cooperation, but if they pull one coin for themself, we consider that defection. After they play the game, we ask a variety of questions about how children think about their partner, about the fairness of the game, and their overall strategy throughout the game. Preliminary results show that age significantly predicts attitude towards a partner. When we asked questions like “do you think your partner is generous or smart,” older participants were more likely to feel more positive about their partners than younger participants. These preliminary results suggest that children’s ideas about fairness change as they grow older; future research will aim to better understand this developmental change.

**Production of Central Tendency Effects in Interval Timing Tasks via Reinforcement Learning**

**Student Presenter:** Nicole Chiulli
**Faculty Mentor:** Ben Scott (CAS Psychological & Brain Sciences)
UROP Award

In interval timing tasks during which participants are asked to reproduce a range of time intervals over many trials, participants exhibit a central tendency effect: responses are biased toward the mean of previous sample times. One widely accepted hypothesis for this behavior suggests that animals are aware of their perceptual uncertainty in estimating time, so they combine perceptual estimates with the prior expectation built from experience over past trials to compensate for perceptual uncertainty. This hypothesis focuses on how perceptual processes can lead to central tendency effects, but does not consider the possible role of altered production of time intervals (animals may choose to reproduce times that are biased towards the mean). We explored whether model-free reinforcement learning agents, which learn to produce the time intervals that lead to the greatest rewards without knowledge of endogenous timing uncertainty, would exhibit central tendency effects. We developed a discrete-time Q-learning model and a continuous-time Actor-Critic model which, when given a sample interval, output a reproduction time and received reward based on how similar the chosen time was to the sample interval. Both model-free reinforcement learning algorithms exhibited central tendency effects, indicating that it is possible to learn which actions maximize reward without explicit knowledge of endogenous timing uncertainty. We are currently developing a temporal reproduction task for rats to investigate the degree to which central tendency effects are attributed to inference-based perceptual processes versus altered production of time intervals.

**Children's Propensity for Generalizing (CPG)**

**Student Presenter:** Allison Chodes
**Faculty Mentor:** Kathleen Corriveau (Wheelock Applied Human Development)
UROP Award

How do children understand group and individual characteristics? This research examines children's generalization of characteristics from one member of a group to any other member of that group, which is thought to be a central part of stereotyping. Interventions focused on language describing group and individual characteristics may reduce children's stereotyping behaviors as a result. This study collects data on children's (aged 4 to 9) generalizations by stating facts about an individual, presented as a group member, and then asking the children if those facts are true for another member of that same group. Additionally, the children's parents are asked to respond to a survey measuring authoritarian beliefs. Data collection is still underway. Our previous research has shown that describing a group using statistical language instead of generic language leads to fewer generalizations about individual group members. The current study's results will expand on this work by measuring children's generalizations from one individual group member to another. We predict children to display lower rates of generalization under the conditions of this study than using the generic or statistical language of the previous research. In addition, this study looks at the impact parents have on their children's likelihood to generalize by measuring their parents' authoritarian beliefs. We expect individual differences in generalizing among children to be linked to authoritarian beliefs in their parents because parents are models for their children and have a strong behavioral influence. This study could improve our understanding of generalization and reduce harmful stereotyping in children.

**From the Net to the Met: Reducing the Barrier to Arts Engagement Through TikTok**

**Student Presenter:** Morgan Clark
**Faculty Mentor:** Jane Rayburn (COM Mass Communication, Advertising & Public Relations)
UROP Award - Humanities Scholar

Educational content on the video-based social media platform "TikTok" reaches new audiences and sparks interest in educational topics. Following the success of individual creators, how can art and educational institutions use this new social media landscape to promote learning and increase arts participation through their communication strategies? To investigate, I studied TikTok posts by creators Mary McGillivray (@_theiconoclass) and Dane Nakama (@umeboi), two leading content creators in educational art history videos. I aimed to determine what components of their content correlate with high engagement rates. After evaluating 40 videos (20 by each creator), I ultimately found that there was no significant correlation between video topic and how well it performed. Videos about artists and art appeared slightly more often and videos about art theory appeared slightly less often. However, in studying the tactics used to discuss the topics in the videos, I found that "explainer" style videos and videos that used trending sounds appeared most often in the sample. These results provide some information that can be used to model after McGillivray's and Nakama's success in engaging audiences in art history education. However, further research with focus groups would be beneficial in determining what aspects of this content resonate most with audiences.

**GDOC Freeze Frame Policies: Leaving Inmates Frozen in Time**

**Student Presenter:** Sadie Cowan
**Faculty Mentor:** Heather Schoenfeld (CAS Sociology)
UROP Award

Freeze-Frame policies limit the ability of transgender incarcerated people to access the appropriate and necessary transition-related and gender-affirming care that they need. They mandate that all inmates will be identified and treated as the gender that they were first identified as upon entering incarceration; thereby denying specialized care plans to allow some transgender inmates to receive or continue to receive hormone therapy and other care. In this article, I will analyze the use of Freeze-Frame policies by the Georgia Department of Corrections (GDOC) after formally rescinding such guidelines during Diamond V. Owens, which examined the mistreatment of a transgender inmate while under GDOC care. These policies continue to be used in ways that limit the scope of "medically necessary care" to narrowly cover only hormone treatment— treatment that is not always consistent, as recommended by physicians. Ultimately, this paper concludes that barriers to meaningful trans-affirming healthcare persist due to several factors: the law is too narrow (meaning that the law does not permit full protection for transgender inmates of various circumstances from the precedents set by freeze—frame), there are problems institutionally in terms of the feasibility of this kind of overhaul, and lastly, political disagreement or resistance in GDOC in regard to the policy itself have all contributed to these lasting problems. The paper concludes with recommendations for future research as well as policy interventions.

## French Critical Appropriations of Nietzsche: Deleuze and Foucault

**Student Presenter:** Maximillian Dahlstrom
**Faculty Mentor:** Allen Speight (CAS Philosophy)
UROP Award - Humanities Scholar

19th century German philosopher Friedrich Nietzsche occupies a peculiar spot in Western Philosophy, as his work has influenced people from across the political spectrum, ranging from prominent leftist thinkers to fascists. For this project, I analyzed several texts written by two French postmodernist thinkers, Michel Foucault and Gilles Deleuze, to understand how Nietzsche has been appropriated to put forth leftist critiques of oppressive power structures. The most important Nietzschean idea that Foucault and Deleuze appropriate is the method of genealogy, a method of analyzing history that treats history as a series of multiplicities rather than a clear linear progression. Nietzsche first used this method in his pivotal text, On The Genealogy of Morals, which sought to explain how and why a kind of nihilism emerged in Western thought. Instead of using genealogy solely for analyzing metaphysics and morals, Foucault and Deleuze extend its application to an analysis of how different power structures emerged, including the carceral state, capitalism, and even psychoanalysis. Unlike more traditional ways of analyzing history, genealogy has an explicit goal in that it seeks to expose and overcome the historical processes that gave rise to these oppressive power structures. Foucault and Deleuze's work is largely theoretical, but their appropriations of genealogy provide a strong critical lens of history that could prove useful to those who plan on envisioning alternative models of society that enable people to be truly free and active.

## Perceptions of Academic Misconduct at Universities in the United States

**Student Presenter:** Maura De Laney
**Faculty Mentor:** Andrea Mercurio (CAS Psychological & Brain Sciences)
UROP Award

Academic misconduct at institutions of higher education is an ongoing problem with life-altering ramifications for students found culpable. Due to the seriousness of the potential consequences, it is crucial that the processes of evaluating these cases are equitable and do not discriminate against some students over others. The purpose of this study is to examine how country of citizenship affects the perceived guilt and recommended punishments of a student who committed academic misconduct at a university. While previous research has established that Asian individuals face discrimination in academic and workplace settings, there is limited research examining whether international students are evaluated differently in cases of academic misconduct. We will use a between subjects design and randomly assign participants to either an international condition (student is from China) or a domestic condition (student is from the US). Then, participants will be asked a series of questions about the student's perceived level of guilt and what sanction, if any, would be most appropriate. We hypothesize that participants will be more likely to find international students guilty of committing academic misconduct and impose harsher sanctions compared to domestic students. IRB approval is underway and data is forthcoming. Our findings have the potential to inform universities of the prevalence of possible biases as well as the best practices for evaluating cases of academic misconduct.

**Disparities Amongst Popular Epidemiology Movements: How Power Structures Enforce Racism and Classism**

**Student Presenter:** Alexis DiFillipo
**Faculty Mentor:** Japonica Brown-Saracino (CAS Sociology)
UROP Award

This research seeks to uncover the role race and class plays in the political success or failure of community environmental groups' efforts. Low-income, racial minority communities have been historically marginalized due to racism and classism, and despite claims of social progression, people continually struggle to be heard and taken seriously when it comes to their health and well-being. To understand why these systemic issues exist and what role political and social structures play in managing these issues, three Massachusetts teams of the national environmental organization Mothers Out Front were studied. Teams were chosen based on their demographic compositions to add a variety of race and class perspectives. Participant observation and in-depth interviews were key methods to gain the trust and a deeper understanding of the structure and function of the teams. Although this research is ongoing, it is evident that the teams themselves, despite their race or class makeup, are all vocal advocates of environmental justice, but the efforts of the primarily white-appearing teams reflect problems they themselves experience. It is also apparent that the white-appearing, high-income team does tend to have more political success. To apprehend why these team structures exist and if political figures might be influenced by certain structures more than others, more interviews need to be conducted. With these findings, I want to give other organizations or individual community members a solid strategy and platform on how to effectively air their environmental grievances in a way they are sure to get a response.

**How Does Parental Social Support Buffer Against Stress from COVID-19 to Promote Parent and Child Mental Health?**

**Student Presenter:** Erin Duffy
**Faculty Mentor:** Nicholas Wagner (CAS Psychological & Brain Sciences)
Global Challenge Research Award

The COVID-19 pandemic has presented a unique set of challenges for families. Parents are experiencing increased stress and young children are dealing with the loss of dependable, stable routines that are vital for development. It is important to understand these effects, as well as what protective factors may be involved, in order to design effective interventions to support families. Using data from a remote study collected over six months during the pandemic, my project investigates how parental social support buffers against the negative impacts of stress on parent and child mental health. Each month for six months during the pandemic, parents (N = 169) with a child aged 3 - 7 years old completed online questionnaires regarding the impact of the pandemic. Preliminary bivariate correlations show that social support is inversely related to parent stress (r = -.32 – -.46), anxiety (-.32 – -.37) and depression (-.41 – -.50). Parent stress is positively associated with child anxiety (.30 – .48), conduct problems (.21– .30), emotional problems (.27 – .51), and challenging behavior (.38 – .51). Over 6 months, these correlations get stronger and new direct associations between social support and child outcomes appear. Further analysis will be conducted to determine the long-term buffering effects of parental social support. This study advances our knowledge of how the pandemic has impacted families and has important applications for developing strategies to protect against stress in times of crisis.

## Queer Womanhood and Body Image during the COVID-19 Pandemic

**Student Presenter:** Bella Faber-Rico
**Faculty Mentor:** Merav Shohet (CAS Anthropology)
UROP Award

The COVID-19 pandemic has created a mental health crisis in young adult populations, with eating disorders in particular on the rise (Baume 2021; Lang 2021). My work examining body image in lesbian, bisexual, and queer (LBQ) populations enriches research on how our relationships to our bodies were altered at this pivotal time by engaging with anthropological scholarship on body image and eating disorders, as well as with psychological research and queer theory examining the specific factors that shape body image in queer women. I first reviewed the literature on how queer women relate to their bodies and conducted a netnography, or Internet ethnography, of online queer spaces during the pandemic. I then recruited participants (LBQ women aged 18-22 in the US) utilizing both snowball sampling methods and social media, and administered 13 in-depth ethnographic interviews of 1.5- 3 hours each over Zoom. Interlocutors reported a diverse range of experiences, from finding peace in exploring their identities in isolation to struggling to recover from eating disorders as their bodies changed throughout the pandemic. They also expressed differing opinions as to whether queerness protected them from feelings of insecurity at this time, complicating the typical understanding of LBQ body image. I contextualize this ethnographic interview and netnographic data in an anthropological paper. In exposing both the positive and negative changes in body image experienced by college-aged queer women at this time, this research will contribute to investigations of the mental health impact of the COVID-19 pandemic on LGBTQ+ youth.

## Life and Roller Coasters: An Exploration on What it Means to be Alive through NBC's "The Good Place"

**Student Presenter:** Max Ferrandino
**Faculty Mentor:** Allen Speight (CAS Philosophy)
UROP Award - Humanities Scholar

What does it mean to be alive? This paper seeks to answer that question while utilizing NBC's "The Good Place" as the tool for analysis. This study is useful because it applies the philosophical insights of "The Good Place" to real-life to answer this complicated question. There was a necessary use of the works of philosophers mentioned in the show and applying their points to our real lives in slightly less dense and incomprehensible terms. This paper aims to access the complicated works of philosophy for all audiences.This simplification comes mainly from the roller coaster example at the heart of this paper and how a stuck roller coaster can apply to all of our lives. This roller coaster can be applied to the original conclusions of both ancient philosophers like Plato to modern philosophers like Todd May to design an example of a fulfilling life. The goal of both the applications of modern and ancient philosophers on the roller coaster is to demonstrate that you cannot be fully alive without genuine connections to the people that help you reach your full potential. All this is to say that guidelines provided by the roller coaster can help maximize your enjoyment of life while still living a good and helpful life.

**The Racialized Dating Experiences of Asian, Black, and Latine Members of the LGBTQ Community**

**Student Presenter:** Evan Gilbert
**Faculty Mentor:** Sarah Miller (CAS Sociology)
UROP Award

Online dating has become increasingly popular and destigmatized, especially since the onset of the COVID-19 pandemic. Lesbian, Gay, Bisexual, Transgender, Queer, and Questioning (LGBTQ) young adults are especially drawn to online dating apps because the internet provides a forum that allows them to connect with like-minded individuals more safely than in offline contexts. However, online dating algorithms are mainly designed for white, cisgender, heterosexual users, and prior research on online dating excludes queer people of color's dating experiences. This research fills this gap by examining how queer people of color manage their intersecting racial and queer identities within their online dating lives. Through interviews with 10 Asian, 10 Black, and 10 Latine members of the LGBTQ community, themes of code-switching, same-race matching, and anti-Blackness emerged. Interviews included questions relating to online profile development, racial dating partner trends, and intersectional identity navigation. Findings indicate that, unlike their white counterparts, queer people of color must more strictly compartmentalize their racial and queer identities when coping with the negative outcomes of their dating experiences. These results suggest that racism and racial bias exist within the non-white LGBTQ community, and that racism, homophobia, and transphobia compound to produce new social mechanisms within an online dating context.

**Determining The Effects of Laser Stimulation and Injection Surgery on Behavior During Complex Instrumental and Pavlovian Tasks**

**Student Presenter:** Benjamin Graham
**Faculty Mentor:** Mark Howe (CAS Psychological & Brain Sciences)
UROP Award

The striatum is a subcortical brain structure widely implicated in many neurological diseases and disorders. To gain insight into these debilitating disorders, advanced optical techniques for cell-type and region-specific manipulations, such as optogenetics, can be applied in animal models to test causal relationships between striatal activity and different aspects of behavior. We are applying optogenetics to inhibit different areas of the striatum in a temporally and spatially specific manner to test their involvement in instrumental and Pavlovian learning. The first step is to conduct control experiments to verify that surgical procedures and light delivered to the brain to activate inhibitory optogenetic proteins does not directly impact behavior. I conducted sham optogenetic inhibition experiments in wild-type mice during which non expressing virus was injected into the brain preceding task training and light was delivered intracranially during behavior to assess the impact of both laser stimulation and viral injections on normal task behavior and learning. I have analyzed behavioral readouts such as velocity, acceleration, percent trials correct, and anticipatory licking to assess the impact of the sham light delivery and surgery on behavior and learning. I have also begun developing a pipeline for detailed video analysis of behavior using specialized machine learning software for limb tracking (DeepLabCut). Preliminary results indicate no significant effects of the tissue illumination or injection surgeries on any behavioral measure across all mice. These data will provide a control for future inhibition experiments and will help to isolate true effects of neural inhibition on learning and behavior.

## Do Economic and Social Resources Buffer the Impact of Life Shocks on Housing Instability?

**Student Presenter:** Christian Hahm
**Faculty Mentor:** Thomas Byrne (SSW Social Work)
UROP Award

It has been implied in past research that "life shocks," such as a job loss, the onset of a serious health condition, and the abrupt disturbances of a natural disaster often spark homelessness. Homelessness prevention strategies have been implemented to help people weather the potentially adverse impacts of such life shocks on homelessness. Unfortunately, research has largely failed to investigate factors that might be associated with an ability to maintain housing stability after experiencing a life shock. In this study, we tested the hypothesis that economic (e.g., income, savings, receipt of a housing subsidy) and social resources (e.g., strong ties to family/friends who could offer housing) would mitigate the impact of a life shock on housing stability. We use data from the "Boston University - Utah State -University of Alabama-Birmingham Rural-Urban Housing History Survey" data that collected information on income, family status, federal housing, housing instability (eviction, temporary loss of housing, foreclosure), credit history, etc. We used multiple logistic regression, testing the association between our economic and social resource measures and the probability of maintaining housing in the context of 4 different life shocks. In our results, the only economic resource significantly associated with the outcomes of interest was having poor credit history. The social resources that had an impact were having someone to live with and having community resources. These results indicate that people see credit as a barrier to housing and that having social support is key to ease housing instability.

## Affective Auditory Stimuli and its influence on the Pupil

**Student Presenter:** Marine Kaufmann
**Faculty Mentor:** Sam Ling (CAS Psychological & Brain Sciences)
UROP Award

How do affective arousal and brightness modify pupil size? Under brighter lighting, our pupils constrict or become smaller, and under darker environments, our pupils dilate or become larger. When controlling brightness, pupillary oscillations help us monitor levels of physiological arousal an individual is experiencing, wherein high levels of arousal increases pupil dilation. Our laboratory's previous work finds this arousal-driven pupillary effect appears to interact with retinal illumination, although it remains unknown whether this interaction generalizes to other forms of arousal. This study examines whether affective (emotion-based) arousal would have a similarly potent effect on dilation patterns as cognitive (mental-effort based) arousal. While it's been determined that affective arousal has a distinguishable effect on pupil size, further work will explore whether this translates across different lighting conditions. To examine this, we employed pupillometry, a measure of pupil diameter, using an advanced video eye-tracker. Participants listened to negative or neutral audio clips while we manipulated the brightness of their visual display. Preliminary results show that negative audio clips cause more dilation across luminance levels than neutral clips. Next, we'll concentrate on how different types of arousal-inducing stimuli, principally auditory versus visually affective stimuli, impacts the pupil, in order to better understand how different modalities of stimuli influence pupil responses. This research could potentially contribute to advancements in cybersecurity. Insight into biometric scanning technology such as eye-tracking will become increasingly important in being able to understand the selectivity of internal arousal states and subsequently, to gauge familiarity with physiological tells of human behaviour.

## Teacher Happiness: Examining and Measuring Emotional Labor in Education

**Student Presenter:** Simon King
**Faculty Mentor:** Elizabeth Bettini (Wheelock Special Education)
UROP Award

Much of the research on teachers' affect has focused on their experiences of negative emotions, demonstrating the implications for outcomes such as teacher attrition and burnout. More research is needed on teachers' experiences of positive emotions in order to understand how they may serve as protective factors in schools. In this paper, we reviewed the literature regarding the construct of teacher happiness, to examine 1) how researchers have defined the construct of happiness and 2) how they measured it. We then interviewed eight educators to understand their own definitions of teacher happiness and used thematic analysis to understand how their explanations of this particular emotional experience influences their work. We found that the majority of educators defined happiness in terms of fulfilling professional goals and that they attributed their levels of happiness at work to both internal and external factors. This study demonstrates the importance of emotion in the work of educators and provides school administrators with valuable insight regarding how to best support teachers in navigating the affective aspects of their work.

## Investigating the Compartmentalization of Hippocampal DG Spatial Memory Engrams

**Student Presenter:** Ivan Kondratyev
**Faculty Mentor:** Michael Hasselmo (CAS Psychological & Brain Sciences)
UROP Award

The Dentate Gyrus (DG) region of the hippocampus is heavily implicated in memory-guided navigation behavior. Recently, the DG has been shown to contain a sparse sub-population of cells, commonly referred to as an "engram," that is necessary for spatial memory tasks, such as the Delayed-Non-Match-to-Place (DNMP) task. However, it is unclear whether complex spatial memories involving multiple routes are stored as a single engram, or as multiple sub-ensembles, each representing a specific spatial trajectory. We trained male and female wild type mice to perform the DNMP task on a T-maze for water reward and used the fos tet-tag activity-dependent labeling system to tag the active DG ensembles with eGFP as mice explored a novel T-maze context. The animals were re-exposed the following day to the same maze context, a subsection of that maze, or a novel open field context. Immunohistochemical staining for the colocalization of eGFP and c-Fos was used to assess the degree of overlap between the initial DG spatial engram and the ensemble representation during subsequent exposure to the different maze contexts. This revealed a significant difference in overlap between all groups, the full maze group having the most overlap and the open field group having the least. Moreover, the half-maze group showed significant variance, suggesting the use of different navigational strategies and a corresponding difference in engram reactivation. Overall, these findings suggest that the neural representation of a maze context with multiple distinct routes consists of multiple sub-engrams, which dynamically code the spatial trajectories of an environment.

**Spatial Linguistics: Movement as Morphology, Structuralist Syntax, and the Oratory Ornament**

**Student Presenter:** Elizabeth Kostina
**Faculty Mentor:** Japonica Brown-Saracino (CAS Sociology)
UROP Award

Spatial Linguistics returns to the intermittently popular theory in 20th-century architectural theory that the built environment is a language, and its practice is a way of speaking. This (short-lived) movement in architectural practice was influenced by the linguistic turn - a 'way of doing' philosophy that applied the logic and framework of linguistic problems to philosophical questions.

Spatial Linguistics traces architectural, philosophical, and linguistic movements from the turn of the 20th century to the present day, using architecture as the connecting node and rejecting all extreme positionalism. In light of modern architectural practices, trends, and sociopolitical contexts, 'architecture as language' still bears relevance as a theory but is in desperate need of a holistic overview of its literature, establishment as a part of the theoretical canon, and critical appraisal to be appropriate and relevant to our times. This research hopes to respond to this need by entertaining both the semiotic and the mechanical interpretations of linguistic theory in architectural practice and by offering a new, more relevant interpretation and justification for the 'return' of aspects of the linguistic turn.

**Electroconvulsive Therapy: Family Member Experiences**

**Student Presenter:** Meera Krishna Kumar
**Faculty Mentor:** Martha Tompson (CAS Psychological & Brain Sciences)
UROP Award

Electroconvulsive therapy(ECT) has been considered a new and radical form of treatment for depression. Although having a negative connotation, this form of therapy has been very successful in treating cases of depression that have not had successful outcomes with any other form of treatment. With my work this summer, I have been able to extensively understand the impact of this form of therapy on family members of those who have gone through it. For this study, I have been recruiting members all throughout the country working through NAMI (National Alliance on Mental Illness) to find loved ones of ECT participants. In addition most of my research involved coding and transcribing subject interviews to get a better understanding of how the ECT experience was and whether or not this form of therapy was impactful in reducing depression as making a genuine difference in the lives of these patients. There is much stigma around this form of treatment, but it may also be one of the most groundbreaking approaches to managing depression. As interviews are ongoing, we will continue to code and transcribe them to facilitate an accurate analysis of the experience. With increased understanding of the process this study will guide future research that can improve the ECT experience to be positive for both patients and their families.

## Using Automated Activity Monitoring to Detect Preference in Drosophila

**Student Presenter:** Mattie Love
**Faculty Mentor:** Kyle Gobrogge (CAS Neuroscience)
UROP Award

Drosophila melanogaster has proven itself to be an excellent model organism to study both behavior and disease, in part due to ever-growing genetic manipulation tools as well as the fly's relatively short life cycle. As experimental Drosophila use has increased, the tools available to collect data on Drosophila behavior have become more advanced. This study aimed to determine if Drosophila Activity Monitors (DAMs) are a viable tool to gather data on Drosophila in a two-choice preference assay. DAMs use infrared beams to cross-section small clear tubes, each containing one fly. Data is collected when the fly breaks these beams by passing through them. Through these time-stamped position readings, the DAMs generate large amounts of quantitative data that can be used to generate movement and position graphs, which can then be analyzed to determine activity levels and position preference. In this study, flies deprived of food were run in the DAMs with a choice between food and nothing. The resulting data showed initial preference for the food side of the tube, as well as later oscillating preference that (when cross-referenced with the movement graphs) correlated with patterns of activity and rest. Preliminary data was also collected using ethanol-addicted flies given a choice between ethanol- and non-ethanol-containing food. Although a larger sample size is needed, given the DAMs have shown the ability to display food preference, in the future they could be used as a quantitative position- and movement-based ethanol preference assay, an alternative to the current odor and consumption level assays.

## Disciplinary Talk and Spatial Talk Analysis in Urban Head Start Preschool Classrooms

**Student Presenter:** Alexi Man
**Faculty Mentor:** Stephanie Curenton (Wheelock Education Leadership & Policy Studies; Applied Human Development)
UROP Award

Scientific talk in preschool classrooms is critical for children's later scientific learning. Two forms of scientific talk are disciplinary talk (DT), which supports students to speak like experts in a discipline, and spatial talk (ST), which refers to the language used to denote spatial relationships. This study investigated whether the frequency and proportion of DT and ST differed (a) among teachers and students; and (b) among dual-language-learners (DLLs) or monolingual-learners, as well as (d) whether teacher and child DT and ST were correlated. Twenty-two science-related activities were videotaped and transcribed. Transcripts were coded in CLAN and reviewed for activity-specific words. Results of independent group t-tests performed in Stata indicated that DLL students used a higher proportion of ST than non-DLL students (t(110)=.-2.29, p

## Environmental Remediation of the Marshall Islands' Nuclear Past

**Student Presenter:** Caitlin Meyer
**Faculty Mentor:** Jayita Sarkar (Frederick S. Pardee School of Global Studies)
UROP Award - Humanities Scholar

From 1946 to 1958, the United States tested 67 nuclear weapons in the Marshall Islands, vaporizing atolls, damaging the surrounding ecosystem, and subjecting the Marshallese to dangerous amounts of radiation in the process. While the United States partially cleaned up the leftover radioactive waste and provided some compensation ($531 million out of the $2.3 billion recommended by an independent nuclear claims tribunal) to Marshallese victims of chronic radiation poisoning, neither project sufficiently reimbursed the Marshallese for this injustice. This research project analyzes the forms of political, legal, and social disenfranchisement resulting from the US nuclear weapon tests that continue to hinder environmental remediation efforts in the present day. Based on primary and secondary sources and media reports, the preliminary findings of this research are as follows: no oversight for the United States-Marshall Islands trustee relationship, a lack of independent research on the impacts of radiation in the Marshall Islands, and Article 6 of the newly enacted Treaty on the Prohibition of Nuclear Weapons have hindered Marshallese environmental remediation efforts. This extensive history of disenfranchisement resulting from Euro-American and Japanese colonialism in the Marshall Islands also hinders present-day Marshallese climate change initiatives.

## Understanding the Influence of the Gut Microbiome on Serotonin via the Gut-Brain Axis

**Student Presenter:** John Miller
**Faculty Mentor:** Kyle Gobrogge (CAS Neuroscience)
UROP Award

The human gut produces over 90% of the serotonin used by the entire body, and is directly linked to the brain via the gut-brain axis. This study investigates that link in the context of two important behavioral assays: movement and rest. While the gut-brain axis has been studied extensively, the manner in which the gut's "microbiome" affects serotonin usage in the brain remains unclear. In this study, drosophila melanogaster (the common fruit fly) were genetically manipulated using the GAL4/UAS system to inhibit serotonin receptors. By comparing these genetically altered flies to others with manipulations in their gut microbiomes, this study can begin to answer questions about the microbiome's influence on serotonin. This study found both a decrease in total movement and an increase in total rest in flies with inhibited serotonin receptors compared to wild type flies. Further, a slight decrease in total movement and a slight increase in total rest was observed in flies with altered gut microbiomes. The results of this study suggest that major changes in the gut microbiome may have significant effects on how serotonin is used in the context of movement. Future research shows promise in solving the puzzle of the gut-brain axis and its influence on serotonin.

**Onwards and Underground: Nuclear Waste Storage and Community Consent at New Mexico's Waste Isolation Pilot Plant (WIPP)**

**Student Presenter:** Cristina Morrison
**Faculty Mentor:** Jayita Sarkar (Frederick S. Pardee School of Global Studies)
UROP Award - Humanities Scholar

Nuclear waste storage is one of the most pressing challenges facing the United States in both its energy and nuclear enterprises. Understanding the historical, scientific, and legal contexts of the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico offers a detailed study of the establishment, construction, and operation of a successful nuclear waste storage facility. Based on qualitative textual and spatial data from primary and secondary sources as well as quantitative data and reports from government and research institutions, I developed an in-depth case study analyzing the legal constructs of community consent in nuclear waste contexts. I employed inductive reasoning to develop generalizable observations associated with community consent and identify ways in which the experiences at WIPP may influence future waste site decisions. In contrasting WIPP with the proposed Yucca Mountain Nuclear Repository, I found that community involvement is the most crucial factor in determining the ultimate success or failure of a proposed nuclear waste site. During my research period, another nuclear waste facility was proposed for southern New Mexico. Recognizing and applying the lessons of WIPP to the ongoing dialogue surrounding this proposal demonstrates the immediacy and applicability of this research now and into the future, as the nation continues to grapple with the radioactive remnants of its nuclear legacy. This case study will be integrated with two of my previously researched works to create a comprehensive study into the nuclear industry in New Mexico, exploring uranium mining, atomic weapons testing, and nuclear waste storage within the state.

**Supporting Students with Learning and Attention Issues During COVID-19: Insights from General Educators**

**Student Presenter:** Isabel Mullens
**Faculty Mentor:** Jonathan Zaff (Wheelock Applied Human Development)
UROP Award

In January 2021, the National Center for Learning Disabilities commissioned the CERES Institute for Children & Youth at Boston University Wheelock College to examine general educators' experiences during COVID-19, with a specific focus on their experiences teaching students with learning and attention issues. Following three focus groups with representatives from the Understood Teacher Fellows, the CERES Institute administered two surveys to a national sample of over 1,000 general educators in March and May. I then analyzed the data to understand educators' experiences during COVID-19 and identify specific supports teachers believe students need to be successful when returning to school. In addition, my analysis aimed to examine if there was variation in teachers' responses related to key instructional and sociodemographic factors (e.g., instructional modality, economic makeup of the school); this was done using logistic regressions on STATA.
Teachers' survey responses describe both the struggles and successes of the 2020-2021 school year and shed light on important gaps in instruction and challenges for historically marginalized student populations, including students with learning and attention issues. In all, the results highlight teachers' dedication to their profession, their resilience in adapting during a year of unparalleled challenges, and the need for additional resources and strategies to support their efforts to best serve all students, especially students with learning and attention issues. These findings will inform the creation of resources for policymakers, advocates, school administrators, and teachers as they strive to support students with learning and attention issues upon their return to school this fall.

**Precommitment: Exploring the Effect of Volatility in a Decision Environment**

**Student Presenter:** Yeshim Onipede
**Faculty Mentor:** Joseph McGuire (CAS Psychological & Brain Sciences)
UROP Award

A lack of self-control is associated with the inability to effectively achieve long-term goals. In certain circumstances, precommitment can be utilized as a self-control tool to combat impulsivity. Precommitment is the proactive choice to restrict certain options ahead of time in order to stick to a previously established choice, this better helping achieve a long-term goal. This research seeks to understand precommitment as a value-based decision by exploring the effect of volatility in a decision environment. This is done through a computerized behavioral task in which participants sell books to one of two vendors to earn points. Participants may choose either to precommit to a vendor based on interim prices or wait to take the chance of being able to choose based on final prices in either a stable or volatile condition. This allows for statistical analyses of whether participants precommit more frequently in more stable environments. Analyses test for a direct positive relationship between participants' earnings and and precommitment rates in the stable group, as it is more advantageous to precommit in a stable setting. Meanwhile, a negative relationship between earnings and precommitment rates is predicted in the volatile group, as it is less advantageous to precommit in an unstable setting. Further research will investigate the time course of behavioral adaptation in each condition to characterize precommitment trends over time.A better understanding of precommitment and the conditions in which it is most advantageous will ultimately help people avoid error-prone self-control decisions and more effectively achieve long term goals.

**Uncertainty Effect in Evaluating Moral Decisions in a Foreign Language**

**Student Presenter:** Eli Panetta
**Faculty Mentor:** Catherine Caldwell-Harris (CAS Psychological & Brain Sciences)
UROP Award

Differences in emotional engagement between native and foreign languages carry many implications, particularly in decision-making. Decisions made in a foreign language are found to be less biased. This phenomenon, called the foreign language effect, can be attributed to the effect of reduced emotionality and increased psychological distance incurred when processing in a foreign language. In this study, the lab presented 53 bilingual Turkish university students to different versions of the classic "trolley dilemma" (switching a train car from hitting 5 people to instead hit one) in Turkish and in their second language, English.

In moral dilemmas where the sacrifice was most gruesome, participants were more likely to engage in morally questionable behaviors presented in English than in Turkish. When moral dilemmas that involved less gruesome deaths or no deaths at all were presented in Turkish, over 50% of participants agreed with the moral decision (the normative response). However, when dilemmas were presented in English, the percent of participants agreeing with the statement was lower. This research shows the uncertainty effect in moral decision making. Implications of research that focuses on the foreign language effect engages with a wide range of fields such as bilingual education and international policymaking.

## Female Labor Participation, Crime Rates, and Entrepreneurship

**Student Presenter:** Krizia Pascuccio
**Faculty Mentor:** Rachel Brule (Frederick S. Pardee School of Global Studies)
UROP Award

I researched the relationship between female labor force participation, crime rates, and murders, and the potential impact of entrepreneurship on these through audiovisual materials, peer-reviewed articles, journals, and the plethora of information contained in international archives. While researching, I came across the case of Peru with a 68.7% female participation rate in the labor force making it the leading country for working women in this region.Peruvian entrepreneurship programs relating to poor rural students have also increased, allowing individuals to equip themselves with the necessary tools needed in the labor market. Additionally, due to the efforts of different government and non-profit initiatives of the last decades, Peruvian women have been accessing higher education more significantly, accounting for 90% of women with a higher education diploma. Conversely, Guatemala, another Latin American country part of this research, has only identified 37% of women participating in the labor force. It is also important to note that in Guatemala only half of the population has a primary education and about 65% of women are illiterate. Concluding, it is important to highlight that in Peru, crime rates have decreased making it the 65th country regarding murders and crimes while, in Guatemala, crime rates are increasing making it the 3rd most dangerous country. Upon observing this, it can be concluded that with the factors being taken into account for the purposes of this study, higher education and female participation in the labor force can potentially affect crime rates by substantially decreasing poverty and consequently, murders.

## Statistical Properties of Chorus-induced Electron Bursts with Butterfly Distributions Observed by Van Allen Probes

**Student Presenter:** Yulu Peng
**Faculty Mentor:** Wen Li (CAS Astronomy)
UROP Award

Whistler mode chorus waves are naturally occurring electromagnetic emissions, which can cause energetic electron acceleration and pitch angle scattering in the Earth's outer radiation belt. Although such effect is modeled using quasi-linear theory in many studies, some observations revealed the nonlinear interaction features, such as the rapid formation of the electron butterfly pitch angle distribution. In this study, we report 81 events of electron butterfly pitch angle distribution with a high correlation with bursts of chorus waves using Van Allen Probes observations. For the identified events, we analyze the corresponding chorus wave properties (wave spectra, wave normal angles) and the spatial distribution. Our statistical results show that such events tend to occur in the post-might sector at large radial distances (> 5 Earth radii) under disturbed geomagnetic conditions and have relatively strong magnetic wave amplitudes with small wave normal angles. Moreover, the two flux peaks of pitch angle are found to move closer to 90° as the corresponding chorus wave frequency increases. Our findings are critical for understanding the nonlinear interactions between chorus waves and energetic electrons in the Earth's outer radiation belt.

## How a Lesson on Earth's History Impacts Judgments about Environmental Transgressions

**Student Presenter:** Jensine Phillips
**Faculty Mentor:** Deborah Kelemen (CAS Psychological & Brain Sciences)
UROP Award

Do people who know more about the Earth's history care more about it? Exploring this question as the earth faces a growing environmental crisis is relevant as scientists search for effective environmental education strategies. Previous research has found that children who recalled more facts from a video about Earth's history gave harsher judgments of environmental transgressions, but this effect has yet to be replicated with older populations. The current project explores whether learning about Earth's history influences an adult's moral judgments of environmental transgressions. Participants (n=126) were randomly assigned to one of two conditions, an irrelevant control video or a video about Earth's history. Subsequently, participants judged the severity of four situations describing environmentally damaging acts and justified their judgements. Justifications were classified as anthropocentric (focused on human welfare) or biocentric (focused on nature's intrinsic value). Results showed that there were no significant differences in the moral judgments of the situations between participants in the history condition and participants in the irrelevant condition. Likewise, there were no significant differences between conditions in the biocentric justifications provided by participants. However, people who judged environmentally damaging acts more harshly tended to reason in biocentric Earth-focused ways. Findings indicate that in contrast to children, learning about Earth's history does not appear to impact adults' reasoning about environmentally damaging acts. Knowledge about Earth's history might not have been novel for adults as it was for children, so further research could keep exploring what other education strategies might be more effective for adults.

## Developing Pedagogical Approaches for Facilitating Active Learning in Remote Engineering Laboratories

**Student Presenter:** Alexis Pickering
**Faculty Mentor:** Kathleen Corriveau (Wheelock Applied Human Development)
UROP Award

The health risks posed by the COVID-19 pandemic often necessitate the translation of traditional undergraduate laboratory instruction to hybrid and remote formats, posing a challenge to STEM educators who wish to promote active learning opportunities. Active learning, associated with improved student learning, involves students' engagement in the learning process through activity. Previous research indicates both hands-on learning and collaborative discussion are important to facilitate active learning. However, remote laboratory course instruction complicates facilitation of both hands-on/direct learning and collaborative/social learning. Direct learning asks students to complete independent data collection, which may limit collaborative discussion, whereas social learning asks students to collect data cooperatively, which may limit hands-on learning opportunities. The current study will illuminate whether direct or social learning instructions increase students' verbal engagement and collaboration.I transcribed approximately 50 hours of recorded engineering labs between 13 lab groups at an utterance level to allow for in-depth coding and interaction analyses via a coding scheme I co-developed. Utterances are being coded for three dimensions of group verbal interactions: (1) collaboration (collaborative, directive or neutral); (2) content (causal, fact, or procedural); and (3) troubleshooting topic (lab-related, interaction-based, or technical). Proportion scores will be calculated to assess different lab partners' level and quality of contributions to the interaction. Quantifying students' collaborative speech in each learning condition will show the relative importance of direct vs. social learning instructions in affecting the quality and nature of groups' engagement in active learning opportunities, which will aid in designing pedagogy for future remote labs.

**Gender and Professional Military Education (PME) in the United States: A Case Study of the Naval War College**

**Student Presenter:** Sydney Pickering
**Faculty Mentor:** Sandra McEvoy (CAS Political Science)
UROP Award - Humanities Scholar

Militaries are dependent on gender hierarchies, wherein women are often perceived as weak victims with peaceful interests and men are expected to embody hegemonic masculinity associated with aggression and war. U.S. Professional Military Education (PME) institutions are tasked with developing military leaders' and decision makers' ability to navigate complex security environments. Feminist security scholars assert this goal is only possible if military officers understand the importance and utility of a gendered lens. This study assesses the extent to which gender and gendering, the process of assigning masculine/feminine characteristics to someone or something that is not inherently gendered, is present in PME by focusing on the curriculum.

Research was administered, firstly, through a comprehensive literature review on the intersections of feminist security studies, gender, and PME, and, secondly, through a Naval War College Case Study by analyzing the syllabi of two core classes for senior rank officers. Syllabi were analyzed by coding for keywords and concepts including: gender, women, sex, male, masculine and feminine in order to understand frequency and context. In both syllabi, there was very limited reference to these concepts. Content analysis from lesson overviews highlighted gendered myths and assumptions, including in foundational, introductory lessons and throughout descriptions of authors. Findings extracted from the Naval War College Case Study evidence that, despite attempts by the military to be more gender inclusive, U.S. PME significantly lacks integrated gender lenses in its curriculum.

**Qualitative Approach in Investigating Parental Autonomy Supportive Behavior and Child Engagement**

**Student Presenter:** Lucia Pintor-Hoffmann
**Faculty Mentor:** Kathleen Corriveau (Wheelock Applied Human Development)
UROP Award

Prior research on parent-child interactions indicates that parents who display autonomy supportive behaviors (i.e., behaviors aiding children's ability to complete a task and learn independently) have children rated higher in various facets of engagement including but not limited to academic achievement and emotional self-regulation. However, most studies have focused on verbal speech in autonomy support instead of non-verbal behaviors. This project created a coding scheme to assess how often parents exhibit autonomy supportive non-verbal behaviors when teaching their children about science in informal settings, and how this in turn relates to child level of engagement. Forty-seven parent-child dyads participated in a 15-minute study on scientific conversations. Children were 4-to-6-years-old (Mage = 5.43; 38.5% Female). Each parent-child dyad interaction will be coded for the number of times the parent provides non-verbal autonomy supportive behavior(s) and how engaged the child was afterwards – both verbally and non-verbally. In order to contextualize the parental autonomy supportive behaviors during the parent-child interaction, I will also code for the child's behavior prior to parents providing non-verbal autonomy supportive behaviors (e.g., if the child had difficulty with the task and/or asked for help). Across all episodes, multiple linear and logistical regressions will be used to analyze any differences in the number and type of parent autonomy-supportive nonverbal behaviors and any differences in children's engagement.This research may inform parents on what practices promote child engagement in an informal setting, as well as add to the literature on non-verbal behaviors and autonomy-support's effects on children's engagement.

## Strength of Aversive and Appetitive Associations and Maladaptive Behaviors

**Student Presenter:** Leanna Reynolds
**Faculty Mentor:** Steve Ramirez (CAS Psychological & Brain Sciences)
UROP Award

Addiction is a disorder in which episodes of relapse are highly common. Relapse-prevention strategies aimed at reducing the likelihood and severity of relapse following abstinence, focus on reducing cravings that lead to drug-seeking. Factors precipitating drug-seeking include drug-related cues, exposure to the drug itself, and stress. One factor not yet directly investigated is the contribution of drug-related memories on relapse. Conditioned Place Preference (CPP) has been extensively used to study relapse and is demonstrated when preference for a location emerges based on previous pairing with something rewarding. To investigate the role of memories on relapse, we infused adeno-associated virus: AAV9-cFos-tTA-TRE-ChR2-eYFP targeted at the dentate gyrus, in c57BL/6 mice to "tag" cells involved in a cocaine-related memory. Mice underwent CPP training where they learned to associate cocaine with one side of the chamber and saline with the other. Following conditioning, all mice preferred the cocaine-paired side. We then extinguished this preference and hypothesized that both a priming injection of cocaine (20 mg/kg, i.p.) as well as optogenetically reactivating the cocaine-related memory we had tagged, would reinstate CPP. Thus, this study began an exploration into priming reinstatement using the memory of a drug, in comparison to the drug itself. We replicated previous studies showing cocaine-induced reinstatement of CPP. However, our histological analysis revealed that our viral injections were mistargeted in our optogenetic group. Therefore, although we will need to rerun this group, we are considering this first experiment a pilot, as we successfully established dosing, optical, structural, and behavioral parameters.

## Hypergamy in America

**Student Presenter:** Sarah Richter
**Faculty Mentor:** Erika Wells (CAS Psychological & Brain Sciences)
UROP Award

Hypergamy is the social behavior where people date above their socioeconomic status (SES). The current study aims to research hypergamy based on the participants' gender and SES, the imagined potential relationship duration, and their potential date's own socioeconomic status. The study included 262 English speaking, heterosexual, adult males and females located in the United States. Participants were recruited through Amazon MTURK and data collected via Qualtrics. Participants were asked to rate the likelihood of attending a second date after reading three different first date scenarios. The first date scenarios were identical except for date's gender and perceived SES described in the scenario. Furthermore, participants were randomly assigned to imagine the potential partner as someone they would date short term or long term. A repeated measures ANCOVA with Greenhouse-Geisser corrections revealed no main effect in the willingness to go on a second date for gender of participants or the imagined length of the relationship. However, there was a main effect for the identified SES of the potential first date. Specifically, participants were more willing to go on a second date when the potential partner was believed to be of higher SES. The covariate of participant SES appeared to interact with willingness to go on a second date with a high SES potential partner. Specifically, participants with lower SES exhibited greater hypergamy as demonstrated as more willingness to date partners of high SES. Further research should continue to study the impacts of hypergamy and relationship lengths on males' and females' dating strategies.

## Framing and its Uses in a Second Grade Science Investigation

**Student Presenter:** Gabrielle Riese
**Faculty Mentor:** Eve Manz (Wheelock Science Education)
UROP Award

This study took place in the context of second grade science investigations. A challenge is that students can view science as part of "playing the game of school" and focus on answering teachers' questions or getting correct answers. Therefore, we asked ourselves when and how students see their work as purposeful (e.g., arguing over evidence or revising explanations). Frames describe an interpretation of "what's going on here?" and provide resources for how to approach a situation. We were interested in if certain frames supported students and teachers to take up a shared purpose for investigations. We focused on two frames, "figuring something out" and representation, and then their interactions. We analyzed 13 lessons (30-45 minutes) from one second grade investigation on seed travel. For each episode, we coded for indicators of each frame. We then noted when the frames co-occurred as a secondary analysis. We found that when a teacher's question included the purpose of the investigation, responses sustained "figuring something out" layered with representation frames as a justification. We also learned that students use both frames during informative comparisons that referenced the natural world. In contrast, when the teacher does not maintain the purpose of the investigation and instead focuses only on small details, students shift to less productive frames. This work can inform the design of professional development for teachers to consider frames as a tool to design investigations and support productive discussions.

## Women of Color Party Too

**Student Presenter:** Kelsey Russell
**Faculty Mentor:** Sadia Grundy (CAS Sociology)
UROP Award

My research for a sociology honors thesis compares women of color's interactions at predominantly black fraternity parties to white women's interactions at mostly white fraternity parties. The investigations of this study add a new perspective into the current research of party culture, hookup culture, and college life by centering on women of colors' experiences. Thirty in-depth interviews from BU female students of color to answer the question: How do women of color's cultural scripts at black fraternity parties compare to white women's cultural scripts at white fraternity parties? The students interviewed so far have showcased a preference for predominantly black fraternity parties, lower levels of alcohol consumption, and a different approach to the hookup culture researchers have established. This research will pivot from conversations dominated by white women's experiences and shed light on how women of color have interacted with party scenes on campus. Additionally, the research will open doors to explore the role, lack of privilege, classism, and gender politics of predominantly black fraternities at PWIs.

**Online Professional Development to Assess and Improve Teachers' Comprehension of Natural Selection**

**Student Presenter:** Lily Russo
**Faculty Mentor:** Deborah Kelemen (CAS Psychological & Brain Sciences)
UROP Award

Both children and teachers often have misconceptions about natural selection, despite its significance as the central biological mechanism of evolution. One common misconception is the "teleological bias," or the idea that animals evolve specialized traits for a purpose. Our study targeted elementary school teachers' understanding of natural selection and equipped participants to teach these concepts to their students accurately. It used a pretest-intervention-posttest design in which we manipulated exposure to information about students' common misconceptions about natural selection. All participants received a lesson on natural selection through a storybook, then were randomly assigned into three groups. In the (first) control condition, participants did not receive any additional information about misconceptions about natural selection. In the (second) light explanation condition, participants received examples of childrens' misconceptions. In the (third) deep explanation condition, participants received examples of children's misconceptions along with a cognitive developmental explanation of how children develop those misconceptions. The participants completed an assessment on natural selection before and after the intervention. Teachers in the deep explanation condition performed better on the posttest assessment of natural selection understanding than those in the control condition. Participants in the light and deep explanation conditions accurately identified more student misconceptions than teachers in the control condition. These findings indicate that receiving both examples and explanations of misconceptions helps teachers to better identify them. Findings from this study may inform future professional development programs designed to combat teacher misconceptions.

**Applying Animal Camouflage Training to Enhance Neural Network Detection of Brain Tumors from Imaging Data**

**Student Presenter:** Faris Rustom
**Faculty Mentor:** Arash Yazdanbakhsh (CAS Neuroscience)
UROP Award

Convolutional neural networks (CNNs) are powerful tools that can be trained on image classification tasks and achieve a high level of accuracy. Among other methods used to improve a network's performance on a given task, trained CNNs can be repurposed and used for entirely new tasks in a process called transfer learning, similar to how humans learn skills from one task that may benefit them in others. This research investigated how to implement differently trained CNNs and transfer learning patterns that can accurately classify various types and grades of brain tumors. Additionally, the effects of these training patterns were further examined through a feature space – a multi-dimensional visualization of a CNN's representation of the data. The results thus far have consistently demonstrated that a CNN is capable of classifying early grade brain tumors at a higher accuracy when transfer learned from a camouflage animal recognition task, as opposed to when trained exclusively on tumor MRIs. In-depth analysis of the networks' feature spaces revealed that the animal camouflage transfer learning was responsible for expanding the size of individual tumor regions within the space while also minimizing the confusion between each region. These networks may prove to be valuable assets in the detection and diagnosis of early grade brain tumors as we continue to push their accuracy forward.

**Working Conditions and Instructional Decision Making in Classrooms for Students with Emotional and Behavioral Disabilities (EBD)**

**Student Presenter:** Ana Santos
**Faculty Mentor:** Elizabeth Bettini (Wheelock Teaching and Learning)
UROP Award

Students with emotional and behavioral disabilities (EBD) depend upon special education teachers (SETs) to provide specialized reading lessons. SETs, in turn, rely on school leaders to provide working conditions necessary to engage in quality reading instruction to improve student learning and outcomes. Yet, SETs often describe working conditions that do not adequately support their instruction. We conducted a mixed methods analysis to examine the relationship between SET's working conditions, their instructional choices, and the quality of a reading lesson for elementary students with EBD in self-contained settings. We collected videos of typical reading instruction from 9 teachers, as well as 2-3 interviews with each participant regarding their beliefs about instructional roles, and elicitation interviews in which participants watched their reading instruction and explained their instructional decisions. During analysis, we coded interviews to examine the nature of instructional decisions and factors that shaped decision making, including teachers' beliefs and working conditions. We also rated SETs instructional quality using the POISE observation instrument, which examines classroom management, explicit and systematic instruction, and responsiveness to individual learning. Currently, we are developing qualitative case summaries for each participant to describe their working conditions. We plan to integrate qualitative and quantitative data sources to develop assertions about how teachers' working conditions shaped lesson quality. From our analysis we will better understand how working conditions relate to quality of reading lessons, and how school leaders might intervene to better support SETs, and thus improve the quality of reading instruction for students with EBD.

**The Fukushima Disaster: The Management of Radiation, Victims, Public Health, and Global Relations After a Decade from the 2011 Accident**

**Student Presenter:** Angela Song
**Faculty Mentor:** Jayita Sarkar (Frederick S. Pardee School of Global Studies )
UROP Award

It has been a decade since the Fukushima Daiichi Nuclear Power Plant Accident happened; it was caused by a magnitude 9 earthquake and a tsunami following the natural disaster. This damaged the city of Fukushima and the nuclear power plant, resulting in a nuclear fallout with the radiation contamination as severe as the Chernobyl Accident. On April 13, 2021, the Japanese government announced that they will start to discharge the contaminated water in the ocean, claiming that it will be treated enough to be unharmful to humans and the environment. Japan was also planning on restarting their nuclear power industry while promoting Fukushima food to be safe enough to eat. This research delves into the narratives that resonate around the Fukushima Accident. The driving motive for this topic was to investigate how the government was managing the repercussions of a nuclear accident and how other countries responded to this right after the accident and in the present day. The research was conducted through comparisons of academic papers and qualitative analysis with the research that was done beforehand. Both humanities and scientific papers were used in order to combine the two fields for a better understanding of Fukushima and the victims today. The report, therefore, has three main parts: the conflicting reports on the radiation level in Fukushima; the traumas and lack of support to the victims; and the international response to Fukushima and the nuclear power industry.

**Investigation of Chronic Hyperactivity for the Induction of Neurodegenerative Pathology**

**Student Presenter:** Michelle Surets
**Faculty Mentor:** Steve Ramirez (CAS Psychological & Brain Sciences)
UROP Award

Alzheimer's Disease (AD) affects a third of people over the age of 85 but only about 3% of cases are due to a genetic predisposition. The other 97% are sporadic, yet all of the mouse models currently used for Alzheimer's research rely on transgenic mice. This demonstrates the need for a more accurate modeling system. Hyperactivity has been shown in mouse and human studies to be one of the first symptoms to appear in AD patients. Therefore, we induced a state of hyperactivity in the ventral hippocampus of mice to investigate whether it alone could result in the development of neurodegenerative pathology similar to that of AD. The DREADD AAV-CaMKIIa-hM3D(Gq)-mCherry was injected into the experimental group and AAV-CaMKIIa-mCherry was injected into controls. The water soluble ligand Deschloroclozapine Dihyrochloride (DCZ) was then continuously administered to the mice in order to activate the viruses. At their appropriate endpoints of either 3, 6, or 9 months, animals were run through a battery of behavioral tasks. Immunohistochemistry (IHC) was used to identify markers of AD including beta-amyloid plaques and neurofibrillary tangles in both control and experimental groups. Although the IHC is still being processed, preliminary results suggest that chronically hyperactivating ventral CA1 cells is sufficient to produce significant behavioral changes across all three time points. For future studies, a specific cell population constituting a negative memory will be hyperactivated rather than the entire neuronal population at the ventral hippocampus to observe whether that yields a more representative picture of AD pathology development.

**Perkins Automation Project**

**Student Presenter:** Bhargavi Thakar
**Faculty Mentor:** Philip Muirhead (CAS Astronomy)
UROP Award - Clare Boothe Luce Summer Undergraduate Scholar

My project is to upgrade the control system of BU's 72" Perkins Telescope in Flagstaff, Arizona. The upgrade involves changing the telescope program "MOVE", from the Intel Fortran language and DOS computer architecture, to a modern programming language with a new network motor control card to allow for remote telescope operations. This is the first crucial step at making the observatory fully autonomous. A new network control card is necessary since the previous control card could not be connected to the internet, which prevented remote contact. This automation increases research output by increasing efficiency and flexibility, and makes the observation process more environment-friendly by reducing frequent travel to the observatory. The upgrade entailed translation of ~400 subroutines to Fortran 95 and C languages, debugging and thorough testing of functionality. This first required understanding the complex interdependencies of all the subroutines and operation of the new control card. After writing the new code in Fortran 95, I compiled and linked all the subroutines using the GFortran compiler. In order to better document changes to and debug the new code, I ensured proper version control by using GitHub. I have established remote contact with the new control card, which paves the way for implementing the rest of the program changes. We will proceed to communicate motion commands and refine the functionality of the new MOVE program.

**Identification of 63 New Pulsating White Dwarf Stars with TESS**

**Student Presenter:** Madison VanWyngarden
**Faculty Mentor:** JJ Hermes (CAS Astronomy)
UROP Award

White dwarf stars make up the final stage in the stellar life cycle for approximately 98% of all stars in the universe. At a narrow range of mass and temperature, white dwarfs known as DAVs exhibit short period pulsations that allow astronomers to learn more about white dwarf structure, rotation, and the unique conditions that exist at the core of these dense, retired stars. Using data from NASA's TESS mission (Transiting Exoplanet Survey Satellite) and in collaboration with Dr. S. O. Kepler at the Universidade Federal do Rio Grande do Sul, we identified 63 new bright DAVs, a 25% increase from those previously published. Using python-based programs to generate graphs of the star's flux vs. time, we searched for periodic changes in luminosity in the thousands of white dwarfs observed by TESS. We then performed a Lomb-Scargle periodogram on the objects to identify the individual frequencies contributing to the changing flux of the star. After examining the flux variability, periodograms, and effective temperature of these stars, 63 new DAVs were identified, 10 of which I was the sole contributor. Additionally, we found patterns in the pulsations that allowed us to calculate the rotation period of four stars, ranging from 15 to 30 hours. These results will be incorporated in a future publication (Romero et al. 2021, in prep). This information provides invaluable resources for future studies in astroseismology, high-density physics, and the guiding forces that dictate the fate of our universe.

**Providing Quality Career Programming in Elementary Schools: What Does it Take to Do it Well?**

**Student Presenter:** C. Priya Voetsch
**Faculty Mentor:** Kimberly Howard (Wheelock Counseling Psychology & Applied Human Development)
UROP Award

Typically, college career readiness (CCR) and career development (CD) activities are geared towards high school students. However, implementing CCR and CD in the middle and elementary school levels through school counselors provides a solid foundation to support future aspirations of college and career opportunities. This research sought to understand the person-level variables and context-specific conditions associated with the delivery of quality career education programming by school counselors at the elementary school level. Findings from the study showed that a majority of elementary school counselors struggle with having enough time to fully educate their students on ways to become interested in future career paths post-high school. Many report being poorly prepared for providing CD programming to students, and thus having to rely on their own initiative to seek out training, knowledge, and resources to support their career development practice. Additionally, elementary school counselors need administrative and teacher support in order to ensure the continuity of the lessons and activities for efficient CD and CCR. Barriers to implementing CCR and CD at the elementary level include stereotyped beliefs held by others in the school community about career development and competing demands for school counselor time. Including CCR and CD at the elementary school level ensures that students are able to fully understand the requirements that come with various career paths.

## Exploring the Logical Strategies Children Use to Remember Hidden Objects

**Student Presenter:** Rakiya Washington
**Faculty Mentor:** Melissa Kibbe (CAS Psychological & Brain Sciences)
UROP Award

Working memory is known for its limited capacity. Adults can use reasoning by exclusion to save up information stored in working memory to overcome such limitations. The 'reasoning by exclusion' strategy is the ability to infer the correct alternative by logically excluding the other potential alternatives (i.e., Given A and B, if not A, then B). In the study, we aimed to examine whether 4-6-year-old children have the same ability to use the 'reasoning by exclusion' strategy to help them 'remember' more in their working memory. We performed a hide-and-seek task (3 practice trials; 16 test trials) where children were asked to identify objects when they were provided with all information (Face-up block), or partial information (Exclusion block) during the display. We found that 4-6-year-olds were able to use reasoning by exclusion to infer the unknown object through excluding the known objects to achieve similar or even higher task memory performance. We also found an age-related difference in the task performance where 5-year-olds performed better than 4-year-olds but worse than 6-year-olds. Future work includes comparing children from different social-economic backgrounds in similar tasks. Such work will help us understand when and how children start to strategically use deductive reasoning processes. Overall, understanding how young children's memory works can provide teachers with insights into education goals and intervention programs.

## The Direct and Interactive Effects of Identity Centrality and Community Connectedness on Mental Health Among LGBQ+ people

**Student Presenter:** Nikka Yamin
**Faculty Mentor:** Anthony Rosellini (CAS Psychological & Brain Sciences)
UROP Award

Minority stress theory posits that stigma and discrimination against LGBTQ+ people leads to negative health outcomes. It is important to determine what could protect LGBTQ+ individuals who are exposed to these stressors from experiencing adverse mental health outcomes. The goal of this project was to better understand the direct and moderating effects of identity centrality (importance of sexual orientation identity to overall identity) and community connectedness (desire/strength of LGBTQ+ community affiliation) on LGBTQ+ mental health. Data were analyzed from a longitudinal nationally representative survey of LGB people recruited in 2016 (n = 1,518) and reassessed in 2017 (n = 894). Hierarchical multiple linear regression was used to test hypotheses that (a) community connectedness and identity centrality predict later mental health symptoms (Kessler-6 scale), (b) connectedness and centrality would moderate (buffer) the adverse impact of stigma and discrimination on and mental health (two-way interactions), and (c) the combination of stigma or discrimination with high identity centrality and low community connectedness would predict the worst mental health outcomes (three-way interaction). Results found that community connectedness predicted mental health symptoms ($b = -0.66$, $t = -2.10$, $p = 0.036$), and that community connectedness significantly weakened the positive association between stigma and health symptoms ($b = -0.79$, $t = -2.31$, $p = 0.021$). Other two- and three-way interactions were not significant. These results suggest that spaces, organizations, or events, that foster community connectedness could protect LGBTQ+ individuals from mental disability.

**Assessment of a Manual Tracking Algorithm for Dense Reconstruction of Transgenic Zebra Finch Neurons**

**Student Presenter:** Young Ye
**Faculty Mentor:** Ben Scott (CAS Psychological & Brain Sciences)
UROP Award

Technological advances in research often result in the enhanced capacity to generate data. However, improvements in data generation cannot directly lead to increased results unless downstream elements of the research process such as data processing are scaled up to accommodate such improvements. Thus, the implementation of carefully assessed and streamlined data processing pipelines are necessary to unlock the full potential of enhanced data generation. This principle can be applied to data generated by in vivo 2-photon imaging of neurons densely labelled using transgenic GFP-expressing zebra finches. This labelling method vastly increases the amount of neuron images generated compared to previous oncoretrovirus-based techniques, but image data must be manually processed to extract meaningful quantitative neuron data. Here, I assess the accuracy and efficiency of a manual neuron tracking algorithm to streamline processing of neuron data generated using transgenic zebra finches. 11 neuron trackers were recruited through BU undergraduate student groups or inquiries to the Scott Lab, and trackers were either trained hands-on or using instructional materials. Tracking was conducted using the multipoint tool and ROI manager in FIJI, an image-processing software. Preliminary data from three experienced neuron trackers were compared to determine consensus in tracked neurons. Using consensus neurons as the ground truth, individual trackers' hit and false alarm rates were determined and used to inform tracker accuracy benchmarks. These benchmarks serve as an evaluative framework for new trackers, and allow for future optimization of recruitment, training, and data assignment of trackers.

**Associations of Category Fluency Clustering and Switching Performance with in vivo Brain Pathology in Autosomal Dominant Alzheimer's Disease**

**Student Presenter:** Defne Yucebas
**Faculty Mentor:** Alice Cronin-Golomb (CAS Psychological and Brain Sciences)
UROP Award

Category fluency, a cognitive task consisting of rapidly naming words in a category(e.g., animals) is impaired in Alzheimer's disease(AD). Beyond the total number of words generated, it is possible to study clustering(i.e., words recalled from a sub-category simultaneously) and switching(i.e., between sub-categories) on fluency tasks, which provide insight into cognitive inefficiencies that may be impacted early in AD. We examined animal fluency clustering and switching and their associations with AD brain pathology markers in non-demented mutation carriers of an autosomal dominant AD(ADAD) mutation and non-carriers. 48 carriers of the Presenilin1 E280A ADAD mutation and 51 non-carrier family members from Colombia completed cognitive testing, including category fluency(animals); 30 carriers and 32 non-carriers also underwent neocortical amyloid and temporal lobe tau with positron emission tomography imaging. Non-demented ADAD carriers and age- and education-matched non-carrier family members did not differ on fluency total score, clustering, or switching. ADAD carriers; however, exhibited a stronger association between clustering and both AD brain pathology(amyloid: $\rho$=-.45, p=.01 vs. $\rho$= .15, p=.43: z=2.38, p=.009; entorhinal tau: $\rho$=-.59, p=.001 vs. $\rho$=-.13, p=.49; z=2.05, p=.02); and age($\rho$=-.34, p=.02 vs. $\rho$=.11, p=.46; z=2.24, p=.01) – all proxies for disease progression in ADAD – suggesting a potential AD pathology impact on executive functions that may underpin efficient word retrieval. Future research may extend this work by using three-trial category fluency and object naming tests which may provide additional perspectives on quantitative and qualitative aspects of fluency in ADAD.

**Fiber Digestibility in Wild Bornean Orangutans:**
**Age-Sex Class Differences and Implications for Slow Juvenile Growth**

**Student Presenter:** Victoria Zdanowicz
**Faculty Mentor:** Cheryl Knott (CAS Anthropology)
UROP Award

Bornean orangutans (Pongo pygmaeus wurmbii), with their long lifespans and inter-birth intervals, and late age at first birth, have the most extended life history of all primates. According to the Ecological Risk Aversion Hypothesis, slow growth is a strategy to avoid starvation in unpredictable environments. When fruits are unavailable, bark and leaves, high in indigestible fiber, dominate orangutan diets. Orangutan hindgut fermentation is critical in the extraction of nutrients from fibrous fallback foods. However, body size and gut passage times are predicted to influence digestive efficiency. We investigated age-sex class differences in fiber digestibility in response to fluctuations in fiber intake. Researchers at Gunung Palung National Park, Indonesia, collected fecal samples during focal follows from 2016-2019 which were analyzed at Boston University's Primate Ecology Lab. Samples (N=143) were weighed and dried overnight before grinding in a Wiley Mill. Seeds separated from the fecal matter were counted, measured, photographed and identified using our reference database. Dry matter and percent organic matter were determined through drying, ashing, and hot weighing. We used an ANKOM 200 Fiber Analyzer to determine NDF and compared the percent fiber excreted by mother/offspring pairs with feeding data. While adult female and juvenile diets showed similar percentages of fiber intake, juveniles excreted 50% more fiber than their mothers. Our results highlight the influence of body size, with smaller individuals demonstrating a lower capacity for fiber digestion. Juvenile digestive efficiency likely constrains growth, development, and survivorship during periods of low food availability when orangutan diets are high in fiber.

# *Arts and Humanities*

**Radical Characters: A Curatorial Project Exploring Design and Culture in the Chinese and Chinese American Community**

**Student Presenter:** Danielle Chang
**Faculty Mentor:** Mary Yang (CFA Graphic Design)
UROP Award - BU Arts Initiative Research Award

Typography is the arrangement and presentation of a text of words. Using Chinese typography as a tool allows designers to understand the ideogrammic language expressing Chinese culture. Radical Characters is a new study group for Chinese and Chinese American designers to strengthen their relationship between design and culture. Its first exhibition, Radical Return, will be on view at IS A GALLERY in Shanghai, China and Boston University Art Galleries in Boston, Massachusetts from November to December 2021. By creating an open space that features Chinese and Chinese American designers' work, we hope to form a dialogue and community around design and culture. Our research on the history of Hanzi character grids and Chinese poems influences each project for Radical Characters, which are thematically inspired by specific Chinese characters. Radical Return is based on 回 [huí], meaning "to return." Our approach is to visually draw connections between different concepts of returning, including an Image Research Booklet and Mind Map. These documents inform the exhibition's organization into "Drop," "Fold," and "Join", illustrating the three strokes found in 回. This research solidifies the design of the visual identity, website, and Instagram for Radical Characters. After ten days of posting the call for submissions for Radical Return, we gained around 150 Instagram followers. The significance of curating an exhibition is not just about forming a conversation, but sustaining it. We plan to publish a publication and hold workshops and lectures to continue building collective knowledge for Chinese and Chinese American designers.

**Digital Humanities: The China Historical Christian Database**

**Student Presenter:** Wanyi Chen
**Faculty Mentor:** Daryl Ireland (CAS History)
UROP Award

The China Historical Christian Database (CHCD) is a Digital Humanities project that seeks to map the place of Christianity in modern China. It quantifies and visualizes where Christians and Christian institutions were located in China between 1550 and 1950. With these useful data points and historical evidence, there are almost endless possibilities for the use of this database. My role was to use my statistical knowledge, as well as to collect and add new data from Protestant Christian sources. First, I obtained and read through many related sources, then organized each person into data points according to their missions, locations, marital status, and education level. When reading through the sources, I revised and updated the database if needed. Specifically, I looked for duplicated data points, incorrect location names and codes, and ambiguous identity information. Also, I made sure the data points are entered correctly and aligned properly. Now, there are hundreds of thousands of data points entered and they can be manipulated and visualized. Researchers are excited to use the CHCD because this data can reveal how biomedicine circulated in China, which religious actors opened new vectors for trade, and how Chinese Christians reacted to natural disasters. The CHCD will be a useful tool for all of these questions related to Christians in China, and they can be answered and supported with hard evidence. In other words, the CHCD is not simply designed to visualize what is already known. It is also built to explore undiscovered history.

## Mapping the History of Christianity in China from 1550-1950

**Student Presenter:** Victoria Cheng
**Faculty Mentor:** Eugenio Menegon (CAS History)
UROP Award

The CHCD project, under the direction of the Center for Global Christianity and Mission, attempts to map and document the spread of Christianity through China by means of foreign and domestic missionaries. The project is the first of its kind to allow people to learn about Christianity in this specific part of the world by viewing data points on a digital map. By mapping these data points, users can visually see exactly where and when foreign missionaries spread their knowledge in China, and the information from this data reveals much about Sino-Western relations throughout history.Throughout this summer, I researched the Directories of Protestant Missionaries in China (1927 and 1926), and extracted from them information regarding the missionaries, their organizations, their roles and the locations they travelled to. Through these data points, specific social, economic, geographic and religious trends emerged, which allowed me to draw conclusions concerning Chinese relations with European nations as well as the spread of Christianity in China. By analyzing these directories, I learned that thousands of missionaries journeyed to East Asia, sent by a great number of different organizations from several European and North American countries. Missionaries not only introduced their knowledge of western religion, but also introduced new forms of medicine and technology, brought over books and even cultural pastimes, such as basketball. These people acted as bridges that carried in and out of China all kinds of ideas, practices and philosophies that connected China and the Western world.

## The Creation of Subconscious Agents as Religious Practice: Consideration of the Tulpamancy Case

**Student Presenter:** Luca Del Deo
**Faculty Mentor:** Deeana Klepper (CAS Religion and History)
UROP Award - Humanities Scholar

This summer research period supported the beginning stages of what will become a senior thesis in the study of religions. I authored the term Subconscious Agency Creation (SAC) to identify immaterial agents that one may hear, see, or touch, often in experiences deemed religious. Their presence may arise after a pattern of behavior characterized by an increased expectation of the eventual encounter with an immaterial agent. Preliminary research identifies these agents in sixteenth-century Kabbalah, Early Modern Christian visionary experiences, and Socrates' daimonion. The existence of similar phenomena across religious cultures invites a comparative study approach. Furthermore, the application of cognitive science to the study of religions provides theoretical and methodological models for understanding trends in experiences deemed religious.My research focused on a New Age religious practice called "Tulpamancy." It is a tradition where practitioners use meditation techniques to create autonomous agents only they can see. Their formulaic approach to meditation provides evidence that encounters with religious agents may mirror cognitive processes identified as fostering altered sensory experiences over time. A tulpa may be a model from which one could extrapolate the general characteristics of encounters with "subconscious agents." Far from indicating pathology, tulpas provide a model which implies subconscious agents are an intuitive result of practice and expectation. In future research, I plan to explore the SAC phenomena using the tulpa as a comparative model.

## Sexual Restriction in Religions of the Ancient Mediterranean

**Student Presenter:** Alexandra Denker
**Faculty Mentor:** David Frankfurter (CAS Religion)
UROP Award - Humanities Scholar

Today, religion and sex can make uncomfortable bedfellows, but in the ancient world, sexuality was a ubiquitous concern of religious life. My research surveys a diversity of religions in Greco-Roman antiquity, exploring how their rituals, beliefs, and narratives impacted sexuality. Through this wide variety of sources, I highlight a prevailing theme: restriction. I present my findings in three sections, beginning with close readings of Greek and Roman erotic media. These mediums allowed for the safe indulgence of sexual fantasy, expressing desires that conflicted with cultural mores. I then compare three pre-Christian religious groups to begin identifying modalities of sexual restriction, such as bodily cleanliness and elimination of desire. I conclude by reviewing the diversity within early Christian sexuality, further developing labels of restriction and drawing connections to other religions, time periods, and regions. My research supports the existing consensus that the ancient Mediterranean was a heterogeneous world filled with ardent conflict. I argue that it was also under perpetual control. Individuals regulated their minds and bodies to maintain status or earn salvation; communities did so to ensure their survival or uphold social order. Studying these restrictions allows us to uncover essential truths about mankind's relationship with the body. In the future, I hope to continue this research, focusing primarily on the female perspective. Gynocentric religions, like ancient fertility cults, remain relatively unexplored and misunderstood. More intensive studies may help us to better understand the evolution of women's role within religion.

## The Development of the Artist in Franz Kafka's Fiction

**Student Presenter:** Dina Famin
**Faculty Mentor:** Abigail Gillman (CAS World Languages & Literatures)
UROP Award

Franz Kafka (1883-1924), long a focus of literary study and debate, is seen as both the prophet of the modern world and a universalist scholar of human nature. "Late style," a literary criticism catchphrase coined by Theodor Adorno and discussed by Edward Said, is applied to Kafka's output in his final years. Scholars use both traditional critical approaches and new methods of visual and sound studies and material culture to interpret Kafka's late works.

The figure of the artist is the focus of discussions of Kafka's final works: on his deathbed in 1924, Kafka was editing four previously-published short stories to be reprinted in the collection A Hunger Artist (1924). The focus of these works is the performance artist, but art—visual and performance artists, and music and singing also appears in Kafka's earlier prose. Leitmotifs around art include performance, the role of silence, the artist as a mirror to the self, the Modernist vs. Romantic discussion of art, and the components of an artist's performance.

My research compares the artist figures in Kafka's early, middle, and late work, arguing that it is not the artist's presence that distinguishes Kafka's late style, but rather the discussion surrounding the figure. Using the framework of literary studies to speak of authorial style in terms of periods or phases, it explores what the artist in late works can tell us about the early works, and vice versa, in the context of existing scholarship on Kafka's late literary style.

## Richard Wright and James Baldwin: The Role of the Black American Writer

**Student Presenter:** Maggie Farren
**Faculty Mentor:** Anita Patterson (CAS English)
UROP Award - Humanities Scholar

The fraught relationship between James Baldwin and Richard Wright after the publication of Baldwin's "Everybody's Protest Novel" in 1955 is clearly evident in the writers' works published after Baldwin's apparent betrayal of Wright; however, the reasons for their explosive disagreement are less clear. Baldwin's harsh critique of Wright's Native Son reveals that the two men have very different conceptions of the role of the Black American writer and how best this writer should engage with politics and protest in their work. The crux of Baldwin's argument is that he does not think that 'protest fiction,' as he deems Native Son, is a legitimate form of art. This project aims to chart the differences in the two writers' particular conceptions of their role and in general the role of the Black American writer while simultaneously examining shared experiences, including their expatriation to Paris and their less than amicable relationship with the U.S. government. The project also explores the ways that Wright's work influenced Baldwin despite Baldwin's rejection of his mentor and the ways that their split was influenced by the pressures placed uniquely on Black American writers.

## Trust in Music Education - Understanding How Trust is Facilitated in A Music Making Space While Dismantling Power Structures

**Student Presenter:** Delaney Finn
**Faculty Mentor:** Karin Hendricks (CFA Music Education)
UROP Award

Trust in education is often discussed through the lens of power structures, such as in Megan Tschannen-Moran's book Trust Matters, which is intended for an audience of school administrators who supervise teaching professionals. However, hierarchies associated with teacher-student dynamics in music making spaces can often be a hindrance to trust, as unequal power dynamics place individuals in spaces where they lack a sense of agency over their emotional, physical, and/or spiritual vulnerability, which leads to potential trauma. In this case study, we interrogated the practices and perspectives of Meg, a Conflict Transformation Facilitator who has vast experience working as a music facilitator in areas of conflict such as Belfast and Palestine. The purpose of our research was to study the ways in which she encouraged dismantling power structures to create a space of authentic trust. We conducted two interviews with Meg and studied her website, music recordings, and videos. We coded the interviews according to a priori categories related to the seven facets of trust (confidence, vulnerability, benevolence, reliability, honesty, openness, and competence). Five main themes emerged: crystallization of the seven facets of trust; layers of presence; competence as self-awareness; vulnerability and choice; and trust in music. Implications from this research include shifting from performance-based music practice rooted in power structures to transformation-based music practice that honors and values everyone's contribution within a more equal power dynamic. Transformation-based practice may allow for a greater facilitation of trust.

## Listener Perception and Identification of Asian American Speech

**Student Presenter:** Kate Fraser
**Faculty Mentor:** Charles Chang (CAS Linguistics)
UROP Award - Humanities Scholar

Asian Americans as a demographic have undergone little linguistic study, despite their long and rich history in the U.S. We conducted a study investigating listener perception of speaker characteristics, with the aim of discovering whether or not Asian Americans can be identified as such on the basis of voice alone. A problem with studying Asian Americans linguistically is the question of who counts as Asian American - Asia extends from Syria to Japan, yet only East and Southeast Asians are generally considered to be "Asian" in the U.S. Therefore, only audio recordings from Filipino Americans, Chinese Americans, Korean Americans, and Vietnamese Americans were used to represent the voices of Asian Americans in this study. In the first task (identification), participants (17 in all) listened to audio recordings of 24 different speakers (including 8 of Asian Americans) and identified speaker characteristics such as gender, age, race, and ethnicity. In the second task (discrimination), participants listened to pairs of audio recordings and discriminated the two recordings in each pair in terms of speaker characteristics (e.g., gender). The results of the identification task showed that all of the Asian American speakers were identified by a fraction of the participants as being Asian, but were more often misidentified as white European Americans. Interestingly, the Asian American speakers were also often misidentified as Latinos (either white or mestizo). With respect to the discrimination task, results were too varied to draw any conclusions.

## Critical Pedagogy in School Music Programs: Examining the Disconnect from Teacher Preparation to Active Teaching

**Student Presenter:** Isabella Harkopf
**Faculty Mentor:** Kelly Bylica (CFA Music Education)
UROP Award

Music education scholarship has long called for more critical, socially just approaches to teacher preparation. These include curricular opportunities to work with students from diverse contexts in practicum settings, social-justice-oriented readings and professional development, and guided reflection opportunities. However, scholars also note that practicing educators often revert to "traditional" methods of teaching once they enter the field, suggesting a disconnect between music teacher education and practice. The purpose of this qualitative case study was to examine the experiences of three Boston University Music Education alumni through interviews. Drawing from the critical pedagogy work of Freire (1970), I analyzed the ways in which these teachers engage in socially just practices in their music classrooms. In particular, I explored how their experiences at BU impacted their practices as they relate to social justice as well as possible barriers that may make socially just engagements challenging. Findings suggest that engaging in both theoretical and contextually applied approaches to critical pedagogy is particularly important. Findings also suggest that practicing educators may face challenges including navigating accountability measures and finding a balance between meeting the needs of students in the classroom while simultaneously challenging oppressive structures. This project has the potential to inform how we can best incorporate a more inclusive and critical pedagogy in ways that are practical for teachers as they enter their first year of teaching and may also result in resources to support critical pedagogy and social justice in music classrooms.

**Moctezuma Xocoyotzin: The Benefits of Historical Fiction in Depicting the Indigenous Perspective of the Mexican Conquest**

**Student Presenter:** Deidra Hoyt
**Faculty Mentor:** Maria Datel (CAS Romance Languages)
UROP Award - Humanities Scholar

The studies of history and historical fiction have been considered binary practices for a long time. Because fiction invents and history recalls, historical fiction is often not seen as a legitimate way of interpreting past events. However, historical events with many uncertainties and overlooked perspectives such as the Mexican conquest may benefit from fictional interpretations. Historical fiction provides a way to conjecture about the indigenous side of history that has been written over and under-documented. This research aimed to study three historical fiction novels (El Corazón de piedra verde, Malinche and Llanto: Novelas Imposibles) about the Mexican conquest to discover how historical fiction can shed light on historical events. This study focuses on the figure of Moctezuma, who appears in each novel and is essential in understanding their perspectives.



**Analysis of Online Anti-racist and Ethical Research Training Modules**

**Student Presenter:** Yongyuan Huang
**Faculty Mentor:** Carrie Preston (CAS English)
UROP Award

This project analyzes the impact and effect of Boston University Undergraduate Research Opportunities Program's (UROP) anti-racist and ethical research training modules implemented by the Stateless Collective and designed by two former Boston University undergraduate students. We used the web platform on which the training modules are hosted to collect summer 2021 UROP participants' demographic information, objective measures of students' content mastery of the training material, as well as participants' written reflection on the training content. We analyzed the demographic data and written reflection to identity both the knowledge gap and areas of improvement for the aforementioned training modules. We also did a holistic review of the strengths and weaknesses of the training modules in order for UROP to decide on the future use of the modules. In addition, we conducted a literature view of the effectiveness of diversity training and its intersection with e-learning/documentary-based learning, and compare the findings from existing literature to our own review of the UROP modules. While to some extent the lack of significant impact of diversity training carried over to the UROP modules, guided by the training content, we found that participants reflected much more on their own thinking and experience given the uniquely dialogic format of the training and its emphasis on active self-examination. Our key findings suggest that a more dialogical curriculum should be more commonly used in existing online-based diversity trainings, and we plan to explore this style of learning further.

**Longitudinally Modeling the Predictors of Political Propaganda Valence in the US: 1800-2000**

**Student Presenter:** JohnMichael Jurgensen
**Faculty Mentor:** Laurence Breiner (CAS English)
UROP Award

Few studies on political propaganda have embraced quantitative analytical methods seen across historical and longitudinally focused literatures such as evolutionary biology and economic history. Informed by recent work in cliodynamics, we employ a novel approach to studying propaganda quantitatively through a 200-year survey of US history, testing hypotheses on the effects of political and economic predictors on the degree of favorability for government activities, found when aggregating propaganda campaigns by their individual favorability scores. We also test the strength of various historical predictors commonly utilized in the political science literature for study of this history. Preliminary results from a sequential canonical analysis of valences associated with propaganda indicates, for example, that GDP per capita significantly predicts government budget and revenue over time, with US government budget predicting the relative degree of democracy. The degree of democracy, in turn, negatively and significantly predicts the regulation of US political participation, with such regulation slightly impacting state coercion and the degree of political competition. Our findings further indicate that the favorability of political propaganda is correlated with both the degree of democracy and regulation of political participation, but not with economic factors such as GDP per capita and government budget.

**Defending Intersectionality: Aemilia Lanyer, Emilia, and White Feminism**

**Student Presenter:** Sophia Kim
**Faculty Mentor:** Erin Murphy (CAS English)
UROP Award – Humanities Scholar

This research examines Aemilia Lanyer, a seventeenth-century poet often wrongly referred to as the "Dark Lady" of Shakespeare's sonnets. Though her achievements included becoming the first female poet to publish a complete book of original poetry in England, A. L. Rowse's 1973 claims suggesting a sexual relationship with Shakespeare continue to cloud her reputation, as can be seen in the 2016 production, Emilia. Drawing on Rowse's false narrative, this play's mission of female empowerment leads to an inaccurate depiction of Lanyer as a progresive protofeminist. Emilia claims inclusivity by casting Lanyer as a black Briton. Despite this superficial inclusion, the play fails to adequately address intersectionality, pushing a narrative claiming the feminist cause as superior. I surveyed attitudes and biographical information on Lanyer in databases and popular anthologies, and gathered information about the production of Emilia. My analysis of Salve Deus Rex Judaeorum, Lanyer's book of poetry, and this recent production reveals a lack of regard for intersectionality. Emilia fails to address modern viewpoints on Lanyer's shortcomings, including the oversimplification of intersections of race, gender and sexuality, revealing the dangers of immortalizing historical figures as contemporary activists. This project contributes to a long-overdue conversation on how popular media often oversimplifies multifaceted issues in the name of raising awareness, and the need to accurately represent historical movements in contemporary scholarship on gender, race, and sexuality. Ultimately, this project aims to start an inclusive conversation to account for intersectional identities, demonstrating the importance of intersectional feminism outside academic spaces.

## The Development and Impact of Popular Education in Early Modern Germany

**Student Presenter:** Noah Kunkel-Smith
**Faculty Mentor:** Phillip Haberkern (CAS History)
UROP Award - Humanities Scholar

The origin of the modern western education system is often attributed to the late 17th and early 18th century during the Industrial Revolution; however, nearly half a century before, an education system reminiscent of our modern one, was taking shape in Prussia. This project focused on understanding the development of this education system and its connection to the Lutheran revival movement known as Pietism. Both Pietism and education suffer from a lack of historical scholarship, particularly in the United States. For this research, numerous primary and secondary sources were analyzed to gain a comprehensive understanding of Pietsim's doctrines and development. Further research focused specifically on the work of August Hermann Francke and his Halle Gymnasium, made possible by the extensive archives of the Franckesche Stiftungen. These efforts culminated in a paper that discussed the entanglement of Pietist ideals and their necessity to establish a robust education system for transmission of their teachings. This research seeks to bring education into the central folds of historiography and provide a contemporary analysis of the Pietist's educational reforms.

## The Perceptions of and Participation in Policy Among Boston Music Educators

**Student Presenter:** Ying Hei Leung
**Faculty Mentor:** Kelly Bylica (CFA Music Education)
UROP Award

Education policy is crucial to how curriculum is structured, how programs are funded, and the ways in which resources are allocated. This means that student learning and educational outcomes are both directly and indirectly impacted by educational policies. Although education policies tie tightly to educational outcomes, the current structure of the policy making process often leaves classroom teachers out, focusing on the ideas and opinions of administrators. Recent budget cuts as a result of COVID-19 have further illuminated this long-lasting representation gap in the current policy making process. In this study, I investigate two Boston music educators' participation in education policy making. In particular, I explore their knowledge of policy knowhow within open enrollment and magnet school contexts. Policy knowhow is "the capacity to understand, speak, and act with a policy frame of mind that is relevant to educators" (Schmidt, 2020). Through a qualitative case study design that utilized semi-structured interviews, I explored how these music educators perceive the impact of their participation on the policies that have been and continue to be created within these institutions. Despite enacting policies on the ground-level, music educators in this study felt inadequately included in the administrative processes that design and enact these policies. This suggests that there is a need to change perceptions of policy participation and decision-making structures at the school level. Such findings may be beneficial to music educators interested in developing their policy knowhow; findings may also help administrators and other policymakers further support active policy participation among teachers.

**Comparing the Construction and Maintenance of Religious Worlds and Video Game Worlds**

**Student Presenter:** Jieyu Liu
**Faculty Mentor:** April Hughes (CAS Religion)
UROP Award - Humanities Scholar

Video games are becoming more and more prevalent in our daily lives. An interesting phenomenon about video gaming is that while the games themselves are primarily based on technology and codes, a lot of them embrace religious content, including introducing unknown gods or teaching religious rituals. This paper sets a new frame from which to explore the potential relationship between religion and video games through a Buddhist-themed video game—"Sekiro: Shadow Die Twice."

Throughout the research, the concept of world-making and reality collide in both religions as well as in video games. We think we live in a society within a world, yet, in fact, we human beings construct and maintain the world we live in through our society. Moreover, the truth of the reality in the world is not from our perceptions but instead our belief of that reality. For instance, when the technology can fully transfer our perceptions into a digital world, perception then will not decide what reality is anymore, instead our beliefs will set the digital world as the new reality.

Therefore, human beings are the core subject in world construction and maintenance, which is a process of human society. This conclusion opens not only a new way of thinking about religions presented in video games but also extends religious tolerance and education. In other words, video games possess tremendous potential for teaching and understanding religions in the future.

**Constructing the Religious Other: Space and Spatial Practice in Medieval Christian-Muslim travel narratives**

**Student Presenter:** Lincoln MacVeagh
**Faculty Mentor:** Deeana Klepper (CAS History; Religion)
UROP Award - Humanities Scholar

Communities of people invariably define themselves relative to a cultural other. They also crystallize their understanding of self and other through interaction with physical space. Space and interaction with space can demark those who belong to certain cultural groups from those who do not, for example, divisions between the religious same and the religious other. To better understand the history of Medieval Christian-Muslim interaction (or relations), I have synthesized methodologies from religious studies, history, and philosophy to evaluate the descriptions of space in Medieval pilgrim narratives. I attempted to contrast descriptions of space with positive or negative depictions of the religious other in order to identify correlations between the two. My research consisted of selecting and analyzing six pilgrim narratives. I also examined academic literature concerning medieval travel and medieval narrative norms. Both Muslim and Christian Medieval pilgrim narratives reflect and reinforce literary norms. Christian texts exhibit the spatial disorientation and encounter with the exotic religious other that characterized Christian travel literature. In contrast, Islamic narratives demonstrate literary constructions of sameness inherent to the Rihla (Islamic travel or travel narrative). Constructions of otherness and sameness, in Christian and Muslim texts respectively, are found not only in descriptions of physical space, but also in descriptions of spacial practice and inter-religious interaction in space. My research may be used as a jumping-off point for investigations of twenty-first-century interreligious interaction and may provide insight into the ways in which social media and other modern media impact modern understandings of the religious other.

## A Cultural History of the American Strip Mall

**Student Presenter:** David Malkin
**Faculty Mentor:** Andrew Robichaud (CAS History)
UROP Award - Humanities Scholar

The purpose of this study was to conduct a cultural history of the American Strip Mall. This study looked at this important facet of American life through the lens of public space or sphere. A public space, an area of social life, is necessary for private individuals to meet and discuss a range of issues concerning themselves or their community. Shopping is also a huge aspect of American social life and for many Americans, shopping at large shopping malls, shopping plazas, and strip malls will be the only time in their day they might encounter new ideas, sentiments, and the public at large outside of their private home, but the objective was only to look at strip malls. The "strip mall" became notable as a distinct typology following World War II. This work looks at the history and historiography of suburbanization, strip mall development in America, and noted the ideas and cultural sentiments that emerged from middle class life to and around consumerism, roads, and the automobile that accompanied the evolution of the strip mall as a public space. This work examined how the birth of the strip mall came as a result of private corporate interest lobbying campaigns, municipal zoning policy, Federal Housing Administration subsidies, and federal tax codes, legislation, and transportation policies, that arrived with the emergence of the automobile, transforming American roads, suburbs, and the way American shopped and interacted.

## In Defense of the Humanities: A Play

**Student Presenter:** Alexandra Mascarello
**Faculty Mentor:** Kyna Hamill (CAS Core)
UROP Award - Humanities Scholar

My research project is a play about the importance of studying the humanities. The play format allows for a creative way to ask questions and generate discussion. The characters are figures from the Core Curriculum, such as Aristotle, Shakespeare, and Rousseau, and the research consists of reading texts from the curriculum as well as articles illustrating the practicality of a degree in the humanities. Overall, the broader significance of the project lies in advocating for a more diverse and inclusive canon of literature that promotes a multitude of perspectives. In the future, the play will be read and performed for orientation and admissions purposes.

## Gender and Nationalism in Palestinian Resistance Literature

**Student Presenter:** Moriah Mikhail
**Faculty Mentor:** Margaret Litvin (CAS World Languages & Literatures)
UROP Award - Humanities Scholar

Resistance literature in the Palestinian context has been used to articulate experiences of exile, occupation, and loss. Ghassan Kanafani, a Palestinian writer who coined the term resistance literature, has used prose to fuel nationalist agendas and inspired generations of Palestinian writers to do so as well. Gendered symbols are often employed to align the nationalist cause with gendered structures of Palestinian society. This project investigates different uses of gender in Palestinian literature and discourse between authors that support or challenge the status quo on gender and nationalism. Through a study of works by Palestinian writers including Ghassan Kanafani, Sahar Khalifeh, Leila Abdelrazaq, and Adania Shibli, I ask how themes of family, gender roles, power dynamics, and nationalism are discussed. I analyzed texts in English and selected passages in Arabic, compiled quotes and themes from texts into a database, and critically read interviews and articles by the authors and other scholars. Through my research, I found that Sahar Khalifeh challenges and disrupts nationalist ideals that rely on gendered symbols. Sahar Khalifeh and other Palestinian women writers push against ideas of female honor, masculinized nationalism, women as symbols of the nation, and the romanticization of martyrdom. This study demonstrates how prose fiction provides a space for discourse between Palestinian writers where ideas of gender and nationalism can be challenged and redefined. Further research will compare how organizations like the Palestinian Liberation Organization (PLO), and the General Union of Palestinian Women use gender to articulate nationalism in official documents.

## Weaving as Metaphor: An Arts Investigation of Female Labor, Memory Retention, and Storytelling through the Fiber Arts

**Student Presenter:** Jayna Mikolaitis
**Faculty Mentor:** Felice Amato (CFA Art Education)
UROP Award - BU Arts Initiative Research Award

Weaving is present throughout history as a survival tool and as a vehicle for metaphor. Woven materials not only supply shelter, garments, blankets, and baskets, but are also laced with deeper narratives about community, human life, and the domestic sphere. The goal of this project is to study the practice of weaving and to reevaluate (1.) how we think about the female body and female labor, (2.) the ways in which we store and recount memory, in particular female legacy and achievement, (3.) the parallels among weaving, women, and one's environment, (4.) and how weavings can function as artifacts that engage in storytelling. This project studies these concepts through physical making. The project is divided into three phases; collection, material studies, and large-scale projects. During the collection phase, existing literature is researched and a database of over fifty artists exploring fibers, women's legacy, and environmental relations is created. The material studies phase includes smaller, tangential exercises that include creating paint and fibers from foraged material, generating visual imagery informed by previous literature, and papermaking. And finally, the project culminates with the execution of both small and large-scale weavings. These weavings, alongside the exercises from the material studies, are synthesized into an exhibition, Borderline Impressions, on display at Boston University's Center for Teaching and Learning. This project bridges different fields to include philosophical, cultural, scientific and artistic perspectives. Ultimately, this work presents an opportunity to critically reflect on the significance of a story and the way in which it is told.

## Multilingualism in Limol, Papua New Guinea

**Student Presenter:** Leela Munsiff
**Faculty Mentor:** Kate Lindsey (CAS Linguistics)
UROP Award

Ende is a Pahoturi River (PR) language spoken by the Ende tribe in Limol, southern Papua New Guinea, an area known for its widespread multilingualism. In 2018, 73 people in Limol were surveyed in a sociolinguistic questionnaire about multilingual practices in their community. In June 2020 I recruited Ende speakers to translate the interviews from Ende to English, and I have since conducted a qualitative analysis on language practices in Limol. I found that the current state of multilingualism in Limol is not stable, and is heavily influenced by marriage, migration, travel, and education, which introduce Ende speakers to new languages. The expanding education opportunities and subsequent rise in travel have facilitated the generational shift in the languages people speak. English and Tok Pisin, which are used in school, when travelling, and with young people, are quickly overtaking Motu and other PR and local languages, which are primarily spoken by elders, as lingua francas of the region. Migration due to inter-tribe marriages encourages language mixing, or kollokoe in Ende, the common practice of switching between multiple languages while speaking. The interviews revealed that language mixing may lead to the loss of the highly valued old way of speaking Ende, and is thus criticized heavily. Some speakers expressed that documentation of Ende is the best way to sustain its vitality and stop the landscape of Ende from changing in the future.

## Abridged Versions of Don Quixote: A Study

**Student Presenter:** Maria Osipovich
**Faculty Mentor:** James Iffland (CAS Romance studies)
UROP Award - Humanities Scholar

Don Quixote de la Mancha (Part I, 1605; Part II, 1615), written by Miguel de Cervantes, is widely regarded as the first modern novel and a monument of Western literature, preceded only by the Bible in number of translations. Enjoying unprecedented popularity, the novel has endlessly played a part in the wider social and cultural process. People all over the world are often able to identify (albeit superficially) the essential elements of the novel without ever having read it, and recognize themselves in a text produced in vastly different social and material conditions than those of today. The text's reach has been magnified by scores of abridged versions produced by a wide range of commercial publishers,national and local governments, universities, and philanthropical institutions. Each version is suffused, consciously or unconsciously, with ideological aims unrelated to those of the original narrative. For this project, working with Prof. Iffland, I analyzed various widely available adult and children's editions of Don Quixote to determine how elements of the text are modified depending on the intended readership. Children's editions, for example, often exclude Don Quixote's abandonment of his chivalresque project and his death, with all the subsequent changes in the work's ideological ramifications. My systematic documentation of the parts that have been abridged or eliminated will be used by Prof. Iffland in a book project under way in which he studies what he calls the "social destiny" of Don Quixote.

## Developing an Annotation Scheme for Referring Expressions

**Student Presenter:** James Roberts
**Faculty Mentor:** Elizabeth Coppock (CAS Linguistics)
UROP Award

Referring expressions are phrases that discriminate an object from others in a scene. Producing them comes naturally to humans, but there is still room for improvement among computers. This project aims to improve machine-generated referring expressions. Our summer goal was to create and implement an annotation scheme for human-generated examples that accounts for all the major attested linguistic strategies while still being simple enough to use as training data. We sorted the individual predicates comprising a referring expression into four semantic categories. We then designed a web-based annotation interface that allowed us to divide referring expressions into their component predicates and semantically categorize each one. The annotation also noted cases of ungrammaticality and tracked the number of candidate referents left at each stage as modifiers are added, allowing us to learn about when modifiers are used overinformatively. We used this interface to annotate hundreds of expressions provided by the RefCOCO corpus. The process revealed several unanticipated linguistic strategies for referring to objects within the corpus, discussed in the comprehensive annotation codebook summarizing our annotation scheme. Statistical observations regarding grammaticality, overinformativity, and the use of various strategies in the corpus will be presented in the poster. It is our hope that the data provided by this system will be ultimately be used as training data in referring expression generation.

## Puente: The Development of an International Latin American Theatre Conference.

**Student Presenter:** Gisela Rodriguez
**Faculty Mentor:** Kristin Leahy (CFA School of Theatre)
UROP Award - BU Arts Initiative Research Award

Latin America (LATAM) is a region rich in history, culture and heritage. Unfortunately, due to many factors, the arts continue to be severely underfunded in most countries, halting innovation and the further development of the Latin American voice onstage. With the development of an international LATAM Theatre Conference, we look to bridge the gap of innovation between Latin Americans living in the region, and the Latin community that work in more developed industries around the world. Uniting two different groups in discussion will aid them to collaborate on how to globalize and innovate within the Latin American identity, and to diversify the current narrative of what it means to be a Latin American (as told from a cultural perspective in the arts). In order to understand the impact a lack of resources and opportunity can have on the arts, we underwent a series of interviews with artists throughout the region, as well as reflecting our own personal experience in the industry in LATAM.The main topic to address is universality in our work, and what we can do as artists to connect with audiences inside and outside of our region, while also showcasing our culture, history and our people. The International LATAM Theatre Conference wouldn't provide a short term solution to a lack of innovation and funding of the arts in LATAM, but it will create the networking opportunity to connect artists in the region with artists abroad interested in propelling the Latin American voice to a world-wide stage.

**Documenting and Illustrating New Findings on the Mughal Gardens of Kashmir, India**

**Student Presenter:** Nicholas Rowe
**Faculty Mentor:** Jan Haenraets (CAS Preservation Studies)
UROP Award - Humanities Scholar

At the height of Mughal power in South Asia in the sixteenth and seventeenth centuries, Mughal engineers and gardeners created many works of landscape architecture in the Himalayan region of Kashmir. Work on this project focused on developing multilayered maps to show the current and historic states of selected gardens (baghs) and encampment sites (serais) by using Adobe Illustrator. Maps for several sites were created with reference to textual sources, satellite data, and on-site sketches, notes, and photographs. The goal of this project is to create maps that can be interpreted collectively to create a comprehensive picture of the state of Mughal gardens and routes in the region. This phase of the project saw the development of a number of new maps, and the revision and expansion of existing site-specific and regional maps. Sites included a bagh of a Sufi saint, a fort with a serai on the Mughal road to Lahore, and a royal encampment bagh on the same road. Historic maps of Srinagar were also interpreted to create maps showing the layout of baghs in the Kashmir valley. Presently many of these historic Kashmiri sites are endangered by rapid urbanization and a lack of formal protections, with some having been already partially or completely destroyed. The greater purpose of this project is to produce a robust framework which later Mughal scholars may rely on, as well as providing academic resources which can be used to advocate for greater protections for the Mughal landscapes in Kashmir.

**Socializing Under Siege: Cataloging Relationships in Minnie Vautrin's Nanjing**

**Student Presenter:** Nicholas Speranza
**Faculty Mentor:** Daryl Ireland (STH Mission)
UROP Award

Few atrocities in the Pacific theater of World War II are as notorious as the Nanjing (Nanking) Massacre, in which hundreds of thousands of Chinese civilians were murdered and abused by victorious Japanese forces. Christian missionary and educator Wilhelmina "Minnie" Vautrin chose to stay in the city of Nanjing as the Japanese siege began, and her diaries from the time are a priceless eyewitness account of both Japanese cruelty and the generosity of the many people who worked to shelter refugees. Foreign officials and Chinese nationals worked closely together to protect Chinese civilians, and yet their efforts to this end are surprisingly overlooked. Using the China Historical Christian Database (CHCD), the many social and institutional relationships mentioned in Vautrin's diaries are being recorded and organized in a uniform manner. Although the scope of Vautrin's diary entries--updated daily for almost three years--means data entry is still ongoing, the relationships recorded already demonstrate just how interconnected foreign academics, Chinese Christians, and missionaries were in wartime Nanjing, how far their social networks stretched across the country, and the inroads their relationships made with the nationalist government ruling China at the time. As the CHCD approaches its official online launch, it will even be possible for data from Vautrin's diaries to be visualized, creating interactive models that reveal important patterns and webs of connection that served to protect civilians amidst war crimes and crimes against humanity.

**China Historical Christian Database, Mapping Christianity in China, 1550-1950**

**Student Presenter:** Dayi Ting
**Faculty Mentor:** Daryl Ireland (STH Mission)
UROP Award

The Chinese Historical Christian Database (CHCD) is a relational tool working to map the expansion of Christianity in China between 1550 to 1950 and the patterns and connections within Chinese history that came along with it. The online database uses data visuals to display connections between Christian missionaries, hospitals and more in order to allow people to easily find patterns and connections in Chinese history. The aim of my project was to complete the records on Protestant missionaries in China in order to further grow the social network maps and detailed trails for scholars and professionals across various fields. By expanding the data, people have a much greater picture and thus ability to understand the growth of not only Christianity but also the history and sociology of related topics such as the spread of literacy amongst Chinese girls or healthcare in China. In order to achieve this goal, I retrieved and studied data from the Directory of Protestant Missions in China and Japan from the years 1921, 1923, 1924, 1928, 1936. Through the work done this summer, the Protestant portion of the database has been essentially completed, and various questions that have arisen from data mining have been collected and may be used for future researchers who study the religious, historical and sociological foundations of modern China.

**Hyakunin Isshu: Learning the Hundred Classical Japanese Poems with Maps**

**Student Presenter:** Jiayi Wang
**Faculty Mentor:** Sarah Frederick (CAS Japanese and Comparative Literature)
UROP Award - Humanities Scholar

My project is a map-based studying tool of Hyakunin Isshu (One hundred classical Japanese poems) on ArcGIS StoryMap. It has two main components. First, there will be 20 sets of slideshows of the first 20 poems that introduce the poems, background, poets, unfamiliar items introduced in the poem, classical Japanese grammatical breakdown, as well as some panels answering poem-specific questions at the end. The second component is the maps for each individual poem that shows locations related to that specific poem, as well as a map of Japan mapping out all one hundred poems each represented by one most related location. Above is the description of the portion of this project done in the summer, which is only a start to the project. Currently, there are twenty slideshows that are in Japanese and English. Eventually, I will make a slideshow for each one of the hundred poems and create versions of the StoryMap in all three languages: Japanese, English, and Chinese, and potentially other languages if future collaborators speak other languages fluently.

**Reconstructing the Past in Stephen Sondheim and John Weidman's "Assassins" and "Pacific Overtures"**

**Student Presenter:** Carrie Welter
**Faculty Mentor:** Phillip Haberkern (CAS History)
UROP Award - Humanities Scholar

Musicals are an underutilized form in portraying history; they convey forgotten or unpopular narratives in a manner that is more impactful than simply reading about it. I investigated the Stephen Sondheim and John Weidman musicals *Assassins* and *Pacific Overtures*, looking into their use of historical fact and theatricality, as well as how professional productions were received, in order to illustrate how musicals can bring forgotten and ignored historical moments into the public eye. *Assassins* tells the stories of nine successful and unsuccessful assassins of American presidents, exploring their motivations within a system that failed them, while *Pacific Overtures* covers Commodore Perry's mission to "open" Japan to the West from a Japanese perspective. Neither of these shows were popular when they opened, due to *Assassins*' controversial subject matter and general disinterest towards Japanese history. I did several close readings of both texts and looked at changes that were made for revivals. I also researched the authors' writing and research styles, especially regarding their prior knowledge on the shows' content. Finally, I researched reviews of major productions and interviews with the creative team to learn about their experiences. While time has been kind to the shows, they remain lesser-known in the musical theater canon, indicating that their content is still deemed harder for audiences to engage with. Since this research is for my thesis, I will continue to work on this project throughout the year; I hope to explore what these shows say about America and its relationship to history.

**Establishing Prestige: Holland's Golden Age in the Modern American Museum**

**Student Presenter:** Sophia Yakumithis
**Faculty Mentor:** Charles Dellheim (CAS History)
UROP Award - Humanities Scholar

In the decades after the Dutch revolt, seventeenth century Holland's national identity took shape in one of the most influential artistic movements in history: the Dutch Golden Age.
The Golden Age of painting bred a group of skilled masters — including Rembrandt and Hals, among others — whose innovative techniques and professional distinctions quickly transformed the international art market. Their celebrations of Holland's cultural pride especially appealed to early American consumers, as parallels between the Dutch identity and their own designated Dutch art as the evocation of a collectively imagined past. American collecting the Dutch masters perhaps saw a peak in the early twentieth century, when civic-minded industrialists, under the guidance of artistic experts, began collecting works of art with the intention of immortalizing a legacy in which the general public could experience.
This careful survey of the country's most esteemed Dutch collections reveals that museums' emphasis on a painting's physical qualities is rooted in the reliance wealthy collectors placed on industry experts to authenticate works of art. The notoriously difficult authentication process of Golden Age works therefore implied "prestigious" collections are housed by institutions with access to top-tier curatorial and conservational resources, presented in this research as case studies in the Metropolitan Museum of Art, Boston's own Museum of Fine Arts, along with several in the Midwest.
Through correspondences and provenances selected from archival sources, this project ultimately identifies Gilded Age collectors as setting the standard for institutional prestige among American museums of art.

**The Catholic Missions in Modern Chinese History: Case-Studies based on the U.S. Passionist Archives (1921-1951) and the Maryknoll Archives (1918-1955) for the Boston University China Historical Christian Database (1550-1950)**

**Student Presenter:** Jintao Zhai
**Faculty Mentor:** Eugenio Menegon (CAS History)
UROP Award - Humanities Scholar

The China Historical Christian Database (CHCD) maps out missionary activities conducted in China and the Sinophone world at large spanning four centuries in the modern era. This project seeks to portray Christian activities through a cross-cultural, multi-lingual, and interdisciplinary lens, documenting and quantifying the intricate minutiae that can contribute to an understanding of the reciprocal influence between China and the outside world. My research, in particular, focuses on two Catholic religious groups active in southern China during the Republican period (1912-1949): the Congregation of the Passion (Passionists) and Maryknoll, recording missionaries therein, foreign and Chinese, and their impact on modern China. This research has been conducted by entering specific data-points (dates, places, names etc.) archived in a diverse array of personal and church records that reflects the vast nature of Christian modern history in China. The research collects the personal, occupational, temporal, spatial, political, socioeconomic, and religious outcomes collectively obtained by Passionist and Maryknoll churchmen and their Chinese communities. The project has broad implications, especially in the contemporary landscape: it defies the common misperception that China was impermeable to religious and social exchanges or always played a passive role in such encounters (in fact, many churchmen in these two congregations were Chinese themselves and accommodated their doctrines to the real world). The CHCD project will continue to record and interpret these data-points, uncovering new dimensions neglected so far.

# *Sargent College and Public Health*

### Evaluation of the Influence of Social Media on College Students

**Student Presenter:** Carolina Becerril
**Faculty Mentor:** Paula Quatromoni (SAR Health Sciences)
UROP Award

Social media continues to promote diet culture which presents a risk to public health by exacerbating eating disorder risk factors. Our study explored the influence of social media use on eating disorder risk factors among college students via an online survey evaluating three outcome variables: eating competence, body appreciation and eating disorder risk. The exposure variable assessing daily social media use was divided into three categories: less than 30 minutes, 30 to 60 minutes and more than 60 minutes. Among our total respondents, the average age was 21.65 years old, 65% of participants were female, 32% were male and 3% transmale. Recruitment emails were sent to BU professors teaching in summer term, 2021. Of 68 survey attempts, there were 34 completed surveys. Most participants in our sample (n=30, 88%) used social media for more than 1 hour daily, few used social media between 30-60 minutes/day (n=4, 12%) and none used social media

### The Effect of Lateral Trunk Position and Hip Adduction on Frontal Plane Hip Moments

**Student Presenter:** Hadwin Belcher
**Faculty Mentor:** Cara Lewis (SAR Rehabilitation Sciences)
UROP Award

Anterior knee pain can cause many downstream musculoskeletal problems such as weak supporting muscles. Individuals may adjust their everyday movements to reduce pain, and these modifications can exacerbate the existing problems. A single leg squat is often used by clinicians to gain information on these compensations. Through analyzing common movement modifications such as contralateral pelvic drop (Trendelenberg pattern), we are better able to understand how an individual with anterior knee pain may change their movements, as well as how these changes can affect them in the long term. Kinematic and kinetic data were collected on 119 participants while they performed single leg squats. Data were processed using Visual3D to determine frontal plane trunk angles and hip angles and moments. Statistical analyses were conducted through SPSS software. Regression models showed that a small portion of the frontal plane hip moments observed during the squat could be explained by the frontal plane trunk angle. However, the hip adduction angle explains a larger portion of the variance in the hip moment. As the hip adduction angle increases, activation needed from the abductors increases as well. Future research may continue to investigate this relationship to determine if it occurs both when the hip angle is increased by the angulation of the femur and from drop of the pelvis. Clinicians will be better able to understand how movement compensations may contribute to altered mechanics in patients with hip and/or knee pain.

**Investigating the Role of Soft Robotic Exosuits in Gait Training Post-Stroke: The Beginning Stages of a Parallel Group Randomized Controlled Trial**

**Student Presenter:** Nora Chan
**Faculty Mentor:** Louis Awad (SAR Physical Therapy)
UROP Award

After a stroke, impaired walking is common, due to ankle mobility deficits. There are wearable devices, called exosuits, that sense movement and provide individualized assistance to the ankle. While these suits have been observed to improve walking while being worn, the Robotic Exosuit Augmented Locomotion study is looking to determine whether using them in a rehabilitation setting results in lasting changes to a stroke patient's gait, even when the exosuit isn't worn.To determine whether there was a statistically significant difference to using the exosuit during rehabilitation in comparison to non-exosuit rehabilitation, participants were randomized to treatment with or without the exosuit. Pre- and post-evaluations, including gait assessment, timed walking tests, video recording, and biomechanical measures, were then used to quantify gait changes. In between these evaluations, the participants received 12 training sessions. Four weeks following the post-evaluation, a retention evaluation was carried out to determine any maintained changes. This study recently resumed in the spring of 2021, with each participant taking at least 2 months to complete the protocol. The study is a parallel group randomized controlled trial designed for at least 80 participants. As that enrollment endpoint hasn't been reached yet, the data haven't been quantitatively analyzed. Qualitative feedback from participants and clinicians to date is encouraging in terms of exosuit use during rehabilitation.The format of physical rehabilitation post-stroke could be changed if exosuits create lasting gait changes in post-stroke patients, so we will look forward to future results.

**Assessing heat exposure in Chelsea and East Boston through a summer field study: Boston University School of Public Health & GreenRoots, Inc., Chelsea, MA**

**Student Presenter:** Julie deLange
**Faculty Mentor:** Madeleine Scammell (SPH Environmental Health)
UROP Award

Heat islands (HIs) are urban neighborhoods that become hotter due to lack of vegetation and high concentrations of buildings and pavement. HIs disproportionately affect vulnerable populations and historically redlined neighborhoods. These neighborhoods are often excluded from heat studies, which can be deadly to the residents. In this study, we installed 19 ambient temperature sensors in East Boston and Chelsea, Massachusetts, environmental justice communities experiencing the urban heat island effect. Sensors were installed in trees in residential streets, popular bus stops, and commercial streets and data was collected hourly over Summer 2021. Additionally, we recruited a cohort of 22 Spanish and English speaking residents who completed comprehensive questionnaires about their actions and symptoms related to heat and recorded indoor temperature sensors in their bedrooms. Results showed that commercial areas recorded the hottest temperatures, while parks had the coolest temperatures, with differences up to 7ºC. On a hot week, indoor residential temperatures were higher than outdoors 87% of the time. Meanwhile due to COVID-19, participants were reluctant to leave their homes to find a cooler area. Instead, participants preferred to turn on their AC, remove clothing, and open windows. As the earth temperatures rise, HIs will become more prevalent, increasing heat-related illnesses and deaths. Understanding differences in extreme heat exposure for vulnerable populations is important for local governments to implement interventions such as heat warning systems, AC installation and subsidies, green space, or infrastructure changes such as reflective or porous pavements, white and green roofs, accessible misting stations, and shaded bus stops.

**How Global LGBTQ+ Identities Affect Health, Relationships, and Experiences: Qualitative Interviews with Queer Individuals from Around the World**

**Student Presenter:** Charlotte Greenhill
**Faculty Mentor:** Kaytlin Eldred (SAR Health Sciences)
UROP Award - Humanities Scholar

LGBTQ+ individuals exist in communities everywhere, despite different religions, laws, languages, and customs. In order to illustrate this global diversity, our research team set out to interview queer people from as many countries as we could. Information from these interviews will be gathered in a book showcasing queer stories around the world. To prepare for interviews, we built a website for outreach, an online interest form for participant intake, and developed an interview topic guide. We performed participant outreach using our personal and professional networks as well as social media. We created online consent forms and developed processes to carry out interviews on web conferencing platforms. Following best practices in qualitative research and journalism, I conducted 10 in-depth interviews with individuals from 6 different countries. Participants spoke about their experiences accessing healthcare services, finding community support, and navigating the complexities of coming out within their specific cultural contexts. They shared formative memories and discussed what their LGBTQ+ identity means to them. Our team is currently using these interviews to produce articles and digital content about each participant. The articles will be compiled in an anthology that explores the intersection of health, gender, sexuality, and community. This project seeks to elevate the stories of LGBTQ+ individuals in communities worldwide. Our work is ongoing: if you would like to learn more or know someone who might be interested in participating, please contact eldredresearch@gmail.com.

**Examining the Effects of Parent-Child Interactions during Storybook Reading on Language Delay**

**Student Presenter:** Shana Kilcawley
**Faculty Mentor:** Jennifer Zuk (SAR Speech, Language, & Hearing Sciences)
UROP Award

A child's home environment is a rich learning environment and a significant predictor for future language development. For children with Late Language Emergence (LLE) who experience a slower acquisition of language skills than their expected age group, it is particularly crucial to investigate how language exposure and input children gain in their home may impact their language development. Parent-child shared reading experiences provide an opportunity for parents to introduce their children to concepts beyond their own home. In fact, shared reading tends to include more language-rich vocabulary than conversational interactions, and the time spent reading in early childhood has been positively linked with later language outcomes in typically developing children. However, this remains understudied among children with LLE. Thus, this ongoing project aims to characterize the quantity and quality of parent-child interactions during shared reading experiences, and determine whether there are differences among children with versus without LLE. To characterize the quantity and quality of mother-child conversations during shared storybook reading sessions, this research uses Systematic Analysis of Language Transcription (SALT) to transcribe and analyze video recordings of conversational interactions. Initial summer work focused on establishing a protocol for analysis and testing the viability of this approach in a small preliminary sample. Future work will be necessary to implement this method with a larger dataset when feasible. With a more representative sample in the future, this work has the potential to provide parents with the tools to create a home environment that maximizes language learning, critical for children with LLE.

**Effect of Gradually Reduced Portion Size Estimation Training on Portion Size Estimation Accuracy and Plausibility of Reported Energy Intake from a Web-Based Food Diary**

**Student Presenter:** Sarah Liao
**Faculty Mentor:** Megan McCrory (SAR Health Sciences)
UROP Award

Portion size estimation training is essential for accurate dietary assessment and for understanding the role of diet in maintaining health and preventing chronic disease. However, the effectiveness of portion size estimation training in increasing estimation accuracy varies across numerous studies, largely due to differences across studies in training methods and foods used, and demographic factors examined. Few studies have examined the effect of gradually reduced guidance and feedback on portion size and daily EI (energy intake) estimation. Three training meals and one test meal were designed using a combination of food replicas and real foods based on typical American meals. Instruction and feedback were provided to participants through a mixture of oral guidance and written feedback for the first, second, and third training meals while gradually reducing interference during entry. No instruction was provided for the test meal, but oral feedback was provided afterwards. Daily EI was assessed by using a web-based food diary (ASA24). Participants (n= 29) had a mean age 23.0±4.8 years, BMI 22.7±3.2 kg/m2, and n=11 (37.9%) females. While portion size estimation for meal 4 differed significantly from meal 1, portion size estimation tended to worsen with meal progression. Participants estimated poorly with amorphous foods compared to solid and liquid foods. In addition, correlations between portion size estimation accuracy and EI estimation accuracy were either not significant or inverse. Future studies could investigate demographic and eating behavior characteristics associated with portion size and daily EI estimation accuracy.

**Building Prosodic Profiles for Pediatric Autism Spectrum Disorder and Developmental Language Disorder**

**Student Presenter:** Ione Madsen Hardy
**Faculty Mentor:** Jennifer Zuk (SAR Speech, Language, and Hearing Sciences)
UROP Award

Prosody is an aspect of language that includes stress and intonation and helps to convey emotion and meaning. Atypical prosody is a widely reported characteristic of autism spectrum disorder (ASD); however, the specific differences in prosody between people with and without ASD are not consistently described in existing literature. Additionally, no study to date has compared prosody in those with ASD and those with developmental language disorder (DLD), even though co-occurring language issues are often present in those with ASD. This study compared characteristics related to fundamental frequency (the rate at which vocal folds vibrate to produce voicing) and speech rate between four groups, which included age-matched male participants between the ages of 6 and 12: those with ASD only (n=10), with DLD only (n=10), with both ASD and DLD (n=7), and those who are typically developing (n=10). Fundamental frequency features (range, mean, and standard deviation) and duration of participant utterances during a wordless picture book narration were extracted using Praat acoustic analysis software. Preliminary analyses revealed no significant differences between groups in prosodic features of spoken language. Within-group prosodic variability will be examined and discussed. This ongoing analysis adds to the existing literature on prosody in children with ASD. Future analyses will include more participants, female participants, and additional prosody measures. Ongoing analyses have the potential to shed light on the nature of atypical prosody in ASD and whether some of those features may be best accounted for by the language difficulties that can accompany an ASD diagnosis.

**Analysis of the Utilization of Intervention Foods as Nutritional Supplementation in the TB-LION Study**

**Student Presenter:** Lydia Mahan
**Faculty Mentor:** Lindsey Locks (SAR Health Sciences)
UROP Award

While tuberculosis (TB) affects India more than any other country, and malnourishment is a leading risk factor for developing active TB, the TB-LION study follows household contacts of tuberculosis, providing nutritional supplementation to those who are malnourished. The goal of the study was to quantify consumption of intervention foods in study participants to date. We analyzed 109 24-hour diet recalls from 15 malnourished participants and 20 nourished participants (BMI>18.5) with at least 2 recalls before the intervention (to estimate average intakes at baseline) and at least 1 recall during the intervention. We used Excel to analyze data that had previously been collected in the DietSoft software, to estimate average consumption at baseline and during the intervention. Median overall calorie consumption among malnourished participants increased from 1928 to 2600 kcal and slightly decreased from 2170 to 2079 kcal among controls. Peanut consumption increased substantially among malnourished participants relative to controls (from 156 to 569 vs. 47 to 62 kcal respectively). We did not identify a clear trend in change of lentil or rice consumption. The results of this study are encouraging for the intervention as a whole. However, the lack of clear trends in rice and lentil discussion has led the TB-LION team to begin discussing ways to improve the study intervention and also data collection to ensure accurate estimation of the consumption of lentils and rice in mixed recipes with varying rice and lentil quantities.

**Resistance to Frailty: Investigating Evidence of Osteoarthritis in a Mouse Model of Longevity**

**Student Presenter:** Deborah Malekan
**Faculty Mentor:** LaDora Thompson (SAR Physical Therapy & Athletic Training)
UROP Award

The most common bone disorders, osteopenia and osteoporosis (OP) occur due to bone deterioration over time. In humans, OP alters bone quality, including bone mineral density (BMD) and bone mineral content (BMC) and increases the risk of fractures. The Ames Dwarf (Df) mouse (deficient in GH, TSH, prolactin) is important in aging studies, as these mice live longer, and exhibit differences in metabolism and physiology. To investigate bone characteristics in the Df and their WT (lifespan-matched) littermates, tibia and femur Dexa scans of male Df adult (n=4, 421-507days) and old (n=6, 750-863days), and WT adult (n=5, 371-374days) and old (n=5, 665-696days) mice were obtained using a PIXImus densitometer. From these scans, ROI calculated BMD and BMC of the whole bone (WB), as well as cortical (CB) and trabecular (TB) regions of the femur. Significant differences in BMD and BMC were found between the WB, CB, and TB of the Df and WT mice. The WB area for Df mice was significantly smaller, given the breed's small body size. For all measures, the WT consistently had significantly higher values than the Df. When comparing Df old to WT old, the WT had significantly higher values for all bone characteristics. The same was true when comparing Df adult to WT adult. Within each genotype, no age-related difference was found. These results suggest there is no age-related deterioration in bones within each genotype; however, the lower BMD and BMC within the Df may predispose this mouse to OP later in the lifespan.

**Racial Disparities in Child Exposure to Neighborhood Firearm Violence Before and During the COVID-19 Pandemic**

**Student Presenter:** Rachel Martin
**Faculty Mentor:** Jonathan Jay (SPH Community Health Sciences)
Global Challenge Research Award

Neighborhood firearm homicide has harmful mental, physical, and emotional effects on children. While racial disparities in child exposure to firearm violence are known to exist, no study has examined how neighborhood firearm violence relates to the racial segregation of children nationwide, or how these disparities changed during COVID-19. To estimate racial disparities in child exposure to neighborhood firearm violence, we used counts of children ages 5-17 years, disaggregated by race, for every census tract in the U.S. (n = 73,056). Neighborhood firearm violence was the number of fatal shootings per census tract, based on 2015-2021 Gun Violence Archive data. Time periods were "pandemic years" matched to patterns of societal disruption since the pandemic began. Results showed that children of every other race experienced greater firearm violence exposure than White children. Additionally, Black children experienced the most disparate exposure, with 4.7 times more fatal neighborhood shootings than White children. This disparity increased 12% during the COVID-19 pandemic. Hispanic children experienced the next-largest disparities, which also rose during COVID-19. Racial disparities persisted even after controlling for county mean levels and neighborhood measures of social disadvantage. Because firearm violence exposure increased substantially during the pandemic, and disparities grew, it is crucial to increase investments in community violence intervention programs. Firearm violence exposure is particularly important to understand for children, as youth exposure has negative implications for physical and mental wellbeing and for future firearm victimization.

**Building response capacity to extreme heat exposure in Chelsea and East Boston through Participatory Action Research**

**Student Presenter:** Abgel Negassa
**Faculty Mentor:** Madeleine Scammell (SPH Environmental Health)
UROP Award

Epidemiological data has shown that heat, extreme weather, and a lack of cool spaces are harmful to human health. Nonetheless, there is a lack of research regarding individual-level experiences with heat, particularly in urban heat islands. The objective of this project is to use quantitative and qualitative approaches to identify and evaluate heat islands in the City of Chelsea and on the East Boston side of Chelsea Creek. Personal, household, and ambient temperatures were measured using HOBO monitors during Summer 2021. In partnership with the youth group Environmental Chelsea Organizers (ECO) at Greenroots (a grassroots community-based organization), we also collected surface temperature measurements at local Chelsea parks and observational data at hydration stations installed by GreenRoots across the city of Chelsea. From these data we seek to uncover any correlation between surface and ambient temperatures, and determine if hydration stations are being used by residents. We hope to gain insight into whether parks function as a cooling refuge, and at what temperature do these green areas lose their perceived cooling ability. These measurements and observations are complemented by Photovoice, which is a participatory action research method in which participants use photographs and narrative to convey their opinions and experiences with heat. The study's findings will be used to guide targeted intervention strategies, and heat adaptation planning. Throughout, we are documenting issues of extreme heat and information about heat coping techniques in real time on Twitter and Instagram accounts.

**Density of Inhibitory Populations of Neurons In First and High Order Thalamic Nuclei (LGN and MD) in Neurotypical Primate Brains**

**Student Presenter:** Julie Ngo
**Faculty Mentor:** Basilis Zikopoulos (SAR Health Sciences)
UROP Award

First-order sensory perception and higher order cognitive processes play a crucial role in attentional processing and emotional event filtering in typical brain function. Studying these processes in a neurotypical brain will help us understand why these are among the most affected in psychiatric disorders. This study distinguished inhibitory neuronal populations between the lateral geniculate nucleus (LGN), part of a first-order, sensory processing system, and the mediodorsal nucleus (MD), part of a high-order, association system. Tissue sampled from the LGN and MD of neurotypical primate brains was immunohistochemically stained for inhibitory GABAergic neurons and Nissl-stained for all cells. We used Brightfield microscopy to identify regions of interest, and quantified GABAergic neurons using unbiased sampling and stereology, which created a 3-D model of 2-D cross sections to estimate GABAergic neuronal density in each region. In general, the higher order nucleus (MD) had more GABAergic labeled neurons compared to the first order nucleus (LGN). In the MD, there was a trend of higher density laterally compared to medially, suggesting that GABA inhibition plays a bigger role in cognitive functions than emotional processing. In the LGN, higher GABAergic density was detected in layers associated with motion processing versus object recognition. This study provides guidance for future pathological studies that may show reduced inhibition in areas involved in executive functioning and filtering out excessive stimuli in psychiatric disorders like schizophrenia, autism, and depression. Future studies can apply the same stereological approach to neurotypical and neuroatypical human brains to understand inhibitory populations of various psychiatric disorders.

**Designing, Pretesting and Finalizing of the REDCap Database for the A-PLUS Growth & Microbiome Study**

**Student Presenter:** Annalie O'Brien
**Faculty Mentor:** Lindsey Locks (SAR Health Sciences)
UROP Award

My research focused on the feasibility of designing a Research Electronic Database Capture (REDCap) database for longitudinal data collection of multiple case report forms (CRFs) that included the collection of biospecimens and questionnaires, and could be utilized by a global team. REDCap is a software used to create questionnaires and collect data securely for research studies. I needed to ensure this database would allow the team in India to collect quality data through multiple CRFs used during study visits.To successfully create this database, I used quantitative and qualitative research methods, including 1) collection of quantitative "test" data for CRFs; and 2) weekly focus groups where I elicited feedback on the database from research staff. This process helped identify errors in the database and places where data collection could be streamlined. I also worked closely with an Indian collaborator to translate and pre-test the final CRFs into Marathi, the language of the study population.My research experience revealed that it is possible to create a REDCap database that meets the needs of a global research team. The final version of the database is currently being finalized and the study is set to launch this August. This database will play an integral role in the larger study and is necessary for high-quality data collection. In the future, it will be important to ensure the database is working properly and to monitor the data the questionnaire collects. When the study begins, there will be many opportunities for data analysis.

**"I wish I actually had known what the heck sex was:" A Mixed Methods Analysis of What Adolescent Sexual Minority Males Wish They Knew Prior to their Sexual Debut with a Male Partner**

**Student Presenter:** Christian Paredes
**Faculty Mentor:** Kimberly Nelson (SPH Community Health Sciences)
UROP Award

Introduction: Adolescent sexual minority males (ASMM) are disproportionately affected by sexual health disparities and lack access to relevant formal sexual education. Understanding the sexual health needs of ASMM at the time of their sexual debut will help inform sexual health programs seeking to decrease sexual health inequities experienced by ASMM.Body: In 2020, sexually active ASMM (n=102, age 14-17) in the United States completed thebaseline assessment of an online sexual health intervention pilot trial. Participants were askedclosed- and open-ended questions about their sexual behavior and the skills and knowledge theyknew and wish they knew at sexual debut with a male partner.Results: On average, participants were 14.5 years old (SD=1.4) at their debut. Participants reported knowing how to say no to sex (80%) and wishing they knew how to talk with partners about what they would (50%) and would not (52%) like to do sexually. Personal research (67%) was the most common knowledge source. In open-ended responses participants desired sexual communication skills and information on what sex is, how to have sex, and the emotional experience of sex.Summary: Results suggest that sexual health programs for ASMM should: (1) occur early inadolescence, (2) teach media literacy skills to help youth deduce credible and accurate sexualhealth resources, and (3) teach sexual communication skills. Incorporating the sexual health needs and wants of ASMM into sexual health programs will likely improve acceptability and efficacy of such programs and, ultimately, help decrease the sexual health inequities experienced by ASMM.

**Registered Dietitian/Nutritionists (RDNs) in Intensive Outpatient Program (IOP) Treatment for Eating Disorders**

**Student Presenter:** Eliza Price
**Faculty Mentor:** Paula Quatromoni (SAR Health Sciences)
UROP Award

Current guidelines in the field of eating disorder recovery advocate for Registered Dietitian/Nutritionists (RDNs) being included on the multidisciplinary care team across the continuum of care, yet this practice is not consistently upheld, particularly at lower levels of care. This study investigates the prevalence of RDN collaboration at the Intensive Outpatient Program (IOP) level of care for eating disorder treatment and explores treatment experiences of those who do and do not work with an RDN. The medical records of past participants of Walden Behavioral Care's IOP were screened for eligibility, documenting whether an RDN was on the care team. Of 300 medical records reviewed, 105 (35%) worked with an outpatient RDN while they were undergoing IOP treatment for an eating disorder while 195 (65%) did not. In our ongoing work, we will evaluate treatment outcomes among these two distinct patient subgroups and interview 20 participants (10 from each subgroup, chosen at random) to characterize their treatment experiences. Our findings will be presented to Walden Behavioral Care to drive innovations in clinical care. We hypothesize that the inclusion of RDNs in IOP treatment may result in improved treatment outcomes and higher quality care. Evidence to define best-practice for treatment is missing from the current literature. Despite the recommendation that patients should independently engage an outpatient RDN to complement the IOP treatment team, our results confirm that most patients do not. Our ongoing research will determine whether or not this makes a difference in terms of patient outcomes and experiences.

## The Impact of Remote Communication on Relative Fundamental Frequency

**Student Presenter:** Laura Raiff
**Faculty Mentor:** Cara Stepp (SAR Speech, Language, and Hearing Sciences)
UROP Award

Remote communication has provided an innovative infrastructure to stay connected, learn, and access health care. However, remote communication modalities may adversely affect vocal function. Poor vocal function often manifests as an increase in vocal effort and laryngeal tension. Relative fundamental frequency (RFF) is an acoustic correlate of vocal effortand laryngeal tension. This study sought to determine how remote communication modalities affected RFF in speakers with typical voices.
Twelve adults with typical voices recorded three 10-minute standardized conversations with an experimenter using different communication modalities: in-person, remote-audio, and remote-audiovisual. From the acoustic recordings, RFF was calculated for the 10 voicing cycles before (offset) and after (onset) voiceless consonants. Two two-way repeated-measures analyses of variance were constructed to determine the effect of modality (in-person, remote-audio, remote-audiovisual), voicing cycle (1-10), and their interaction on mean RFF off/onset. Significant effects were evaluated with post hoc Tukey's tests.
There was a significant effect of voicing cycle on both RFF off/onset. Communication modality had a statistically significant effect on RFF offset, with lower values during remote-audio communication compared to in-person communication, but no other differences. Communication modality did
not have a statistically significant effect on RFF onset.
RFF offset was lower during remote-audio communication. This suggests speakers may have increased vocal effort and laryngeal tension when using this modality. Therefore, remote-audio communication may pose a risk for developing a tension-related voice disorder. More work is necessary to understand the
effect extended use of remote communication has on the voice.

## Density of Parvalbumin, Calbindin, and Calretinin Inhibitory Neurons in Subgenual Cingulate Area 25 of the Neurotypical Human

**Student Presenter:** Maya Rakoczy
**Faculty Mentor:** Helen Barbas (SAR Health Sciences)
UROP Award

Brodmann Area 25 (A25) in the posterior ventromedial prefrontal cortex is linked with areas associated with learning, memory, motivation, and reward. Hyperactivity in A25 has been robustly observed in humans with depression. In marmosets, pharmacological overactivation increases anxiety and anhedonia-like behaviors. Inhibition is a critical component of neuronal circuitry, and disruptions in inhibition-excitation equilibrium can lead to pathological changes in brain circuits. Hyperactivity observed in A25 in depression may involve an imbalance between excitatory and inhibitory neuron activity. To investigate the inhibitory neuron composition of neurotypical subgenual cingulate in postmortem human brains, we used immunohistochemistry to label calcium-binding proteins parvalbumin (PV), calbindin (CB), and calretinin (CR), which label almost all cortical inhibitory neurons, which have different functional roles in local inhibition. We used stereology, an unbiased systematic random volumetric sampling method, to estimate the laminar density of PV, CB, and CR neurons in A25 of post-mortem neurotypical human brains for comparison with previous rhesus macaque data. We found that CR neurons are denser in A25 than PV and CB, and most dense in superficial layers I-IIIa. PV neurons are predominantly found in middle (IIIa-IIIb) and deep (IV-VI) layers, while CB neurons show more even distribution among layers, with slightly higher density in mid-superficial layers II-IIIa. CR and CB neurons in superficial layers may fulfill a disinhibitory or modulatory role, while PV neurons exert strong inhibition by targeting pyramidal cells perisomatically. These data provide the basis for future comparison with data from brains with psychiatric disease states, including depression.

**Investigating the Role of the Calponin-1 Isoform in Aortic Smooth Muscle Contractility and Signal Transduction Scaffolding in CNNI Knockout Mice**

**Student Presenter:** Samantha Sgrizzi
**Faculty Mentor:** Kathleen Morgan (SAR Health Sciences)
UROP Award

The aorta serves as a shock absorber for pulse pressures from the heart, protecting downstream organs from damage. Stiffening of the aorta is inevitable with aging. This loss in plasticity is not well understood and contributes to an increased risk of hypertension, heart disease, and cognitive decline in the aged population. This project investigates the role of the calponin-1 (CNNI) protein in aortic dysfunction. CNNI is hypothesized to participate in vascular smooth muscle (VSM) contractile tone regulation. In this study, CNNI was knocked out (KO) in C57BL/6J mice via a point mutation to the promotor sequence. To investigate alterations in contractility, biomechanical assays were performed on aortas of CNNIKO mice and compared to that of controls. Data from these studies show a statistically significant decrease in stress in aortas of males($p=0.0014$) and females($p=0.018$) in the absence of CNNI. In addition, a decrease in stiffness was observed in CNN1KO mice($p=0.0135$). This demonstrates a CNNI-specific regulation of VSM contraction. CNNI participation in signaling was further explored by probing for phosphorylated-ERK (p-ERK) in lysates of stimulated tissue. Studies from our lab have shown ERK-CNN1 binding in ferret aorta, suggesting a scaffolding function linking ERK signaling to thin-filament mediated contractile activity. Unexpectedly, despite changes in contractility, CNNIKO mice show no change in p-ERK levels. This suggests that calponin-1 regulates a novel contractile target in the mouse to that previously described in the ferret. Further investigation into the role of CNNI in aortic stress and stiffness signal transduction is necessary to understand age-related aortic dysfunction.

**Turn Detection in Post Stroke Walking Using Inertial Measurement Unit**

**Student Presenter:** William Swift
**Faculty Mentor:** Louis Awad (SAR Physical Therapy)
UROP Award

In most labs, human biomechanics studies are bounded and validated on straight line walking, despite the fact that humans regularly walk in non-straight lines. One difficulty in studying biomechanics at turns is our lack of ability to detect what constitutes a turn, especially in people with post-stroke hemiparesis, who tend to have abnormal movement deficits.This project focused on investigating how movement data captured by Inertial Measurement Units can be used to detect when a subject is turning or walking straight. We first isolated known straight line and turn walking data over three healthy and three post-stroke participants. We then quantitatively compared how angular rotation, angular velocity, and acceleration centered about the thigh differed during turns and straights. The study found that both medial/lateral, and flexion/extension rotation about the thigh were significantly different during turns and straights.These findings will prove useful for the creation of a turn detection algorithm, which will be built and tested in the near future. This algorithm will greatly improve the efficiency in which we can isolate straight line walking for data processing, as well as provide for new movement assessment paradigms that evaluate movement deficits during both turns and straight walking. Additionally, if a working, accurate turn-detection process can be created, we then plan to take this investigation further and look at how a participant's strides preceding a turn are altered from straight line walking. The potential discovery of significant, predictive gait behavior pre-turn would greatly improve our understanding of post-stroke biomechanics.

**Understanding Clinical Settings for Cervical Cancer Screening and HPV Vaccination in the U.S.**

**Student Presenter:** Kailin Xu
**Faculty Mentor:** Eleanor Murray (SPH Epidemiology)
UROP Award

Cervical cancer is one of the most common cancers within the United States, and over 70% of the cases are related to human papillomavirus (HPV). HPV vaccine and cervical cancer screening (CCS) are the two strategies effective in preventing infection and cancer development, but gaps and disparities in CCS and HPV vaccine delivery exist.

A scoping review identified 18 sources through a systematic search of PubMed and Web of Science was conducted, and qualitative and quantitative evidence were combined to pin out gaps. Clinical settings, delivery approaches, providers, and patients are reviewed to evaluate the facilitators and barriers. It is found that in addition to traditional clinical settings such as physician's offices, alternative settings like pharmacies have great potential in delivering HPV vaccines in a more flexible and accessible manner. Sexually transmitted diseases clinics cover the population that is high-risk for HPV infection and underserved, however, neither CCS or HPV vaccination is generally provided due to funding issues, lacking of national HPV vaccination guidelines, and vaccine and screening age limitations. Moreover, regression analysis shows that poor screening outcomes represented by years since last screening was significantly associated with never had the HPV vaccine, living in rural area, and race. Addressing such gaps is essential to promote disease prevention in underserved and disproportionately burdened women.

# *Medical (Basic, Clinical, and Dental) Sciences*

### Differential Effect of Antibiotics Induced OMV on Receptor Expression in Alveolar Macrophages

**Student Presenter:** Ward Alktaish
**Faculty Mentor:** Yang Jin (MED Pulmonary)
UROP Award

Irreversible inflammation caused by a bacterial infection in the lungs is one of the most common diseases causing respiratory failure. Pseudomonas aeruginosa is a major causer of lung diseases such as ALI/ARDS where it can release proteolipid bilayered outer membrane vesicles (OMVs). Since then, antibiotic stress conditions have modulated the biogenesis of OMVs. Therefore, in this study, we performed the effect of different antibiotic-induced OMVs derived from P. aeruginosa in alveolar macrophages. We treated MHS 15 with three different OMVs, which were plain (Pl), gentamycin-induced (Gen), and ampicillin-induced (Amp) for either 1h or 24h, and then extracted using lysis buffer. Then, we analyzed the receptor expression of TLR4 and TLR5 and the activation of the signaling molecule through the immunoblotting technique. As a result, Amp induced OMV and Gen induced OMV showed higher expression for TLR 4 for 1h and 24 h, respectively. TLR5 showed higher expression in 1h treatment with all OMVs. Furthermore, the signaling molecule such as p-NFkB, p-P38, and p-P42/44 activation is induced by all OMVs in both time points, among them plain and Amp-induced OMVs in 1h treatment. Gen-induced OMVs showed higher activation of signaling molecules, and other OMVs persisting the activation of the signaling molecule in 24h treatments. Overall, our project showed that antibiotic-treated OMVs had differential effects on receptor expression and its downstream signaling molecules activation involved in the proinflammatory response in MHS-15 cells. These results could be helpful to understand the underlying mechanism of inflammation in the lungs by antibiotic-resistant bacteria.

### Investigating the Novel Molecular Regulators of Bacteria-Induced Inflammation and Sepsis in Mouse Alveolar Macrophages and Lung Epithelial Cells

**Student Presenter:** Nojus Ausra
**Faculty Mentor:** Yang Jin (MED Medicine)
UROP Award

Gram-negative bacteria are known to release Outer-Membrane Vesicles (OMVs) for a variety of functions that support bacterial survival, including the promotion of pathogenesis. Despite increasing research emphasis on bacteria-induced inflammation and sepsis, the molecular mechanisms governing epithelial- and macrophage-associated inflammation remain to be explored. The immune response to OMVs was therefore investigated in mouse lung epithelial cells (E10) alveolar macrophages (MH-S). E10 and MH-S cells were treated with OMVs for 24-48 hours and harvested for RT-qPCR and Western Blot analysis. Through this method, the abundance of RNA transcripts and proteins involved in inflammatory pathways was quantified to determine the key molecular regulators to the inflammatory response to OMVs. Results show increased expression of Toll-Like Receptor proteins (involved in the innate immune response) in MH-S cells upon infectious stimulation with OMVs, but results are inconclusive for E10 cells. However, cell death upon OMV treatment was still observed in E10 cells after treatment with OMVs. The pyroptosis and necroptosis pathways are currently being investigated to determine their involvement in the inflammatory response for E10 cells.

## Implementation of CenteringParenting during the COVID-19 Pandemic

**Student Presenter:** Yeelin Bacchus
**Faculty Mentor:** Renee Boynton-Jarrett (MED Pediatrics)
UROP Award

CenteringParenting (CP) is a group well-child care model that addresses child development and maternal well-being during the first 2 years of the child's life. Currently, there is limited data on CP implementation. In addition, the COVID-19 pandemic has introduced challenges that may impact the model's feasibility. Between July 2020 and July 2021, 4 clinical sites associated with the broader CK-Ready (CKR) Study received implementation support through tailored action plans, instructional presentations, and biweekly meetings. We facilitated the establishment of measurable goals and stepwise plans to reach them while allowing for iterative improvement. Progress was tracked and reviewed at weekly CKR internal meetings. Independent research was also conducted by attending webinars hosted by the Centering Healthcare Institute and Consortium calls that brought together CP leaders in New York. To date, CKR has facilitated the start of 6 groups across 3 clinical sites with novel CP programs. We uncovered that COVID-19 has had a varied impact. Clinical sites starting CP programs encountered challenges with recruitment, building patient trust in the model, ensuring participant safety, and mobilizing the broader clinical staff to support CP start-up. A CKR site that established a CP program prior to the COVID-19 pandemic encountered fewer challenges due to patient familiarity with the model, and existing organizational infrastructure and support. These findings give insight into the unique challenges of implementing a group intervention and provide initial information on how to promote successful implementation. Further research into the factors that support group interventions at clinical sites is needed.

## Contribution of Mutations in SMAD6 to Risk of Craniosynostosis

**Student Presenter:** Michelle Bernard
**Faculty Mentor:** Shannon Fisher (MED Pharmacology & Experimental Therapeutics)
UROP Award

Characterized by the premature fusion of one or more cranial sutures, craniosynostosis (CS) is a birth defect that occurs in ~1/2000 live births. As the brain grows, it pushes against the cranial bones, causing skull distortion and facial deformities that often require correction through surgery. Genome-wide association studies have identified human SMAD6 sequence variants associated with CS and several other developmental disorders. Normally, SMAD6 encodes an inhibitory protein that blocks osteoblast differentiation within the bone morphogenetic protein (BMP) signaling pathway. Previous work has shown that overexpression of wild-type SMAD6 RNA in zebrafish leads to suppressed BMP signaling, evident by the disruption of dorsal-ventral patterning during gastrulation. To investigate the role of Smad6 in craniofacial development, we created mutations in the zebrafish smad6b and human SMAD6 gene. CRISPR-Cas9 was used to generate a deletion in the first coding exon of smad6b. Fish with the intended mutation were identified by genotyping and will be used to generate a homozygous mutant that functions as a potential disease model for CS. Clones of SMAD6 with missense mutations associated with CS were created using site-directed mutagenesis. RNA transcribed from these sequences will be injected into zebrafish embryos at the one-cell stage to learn more about how the encoded protein functions in early craniofacial development. Understanding the genetic mechanisms behind CS, as well as the role that SMAD6 mutations play in BMP signaling, may offer insight into the high prevalence of SMAD6 mutations within the human population.

**The Effect of Perinatal Choline Supplementation on the Cognitive Function and Amyloidosis in the APPNL-G-F Mouse Model of Alzheimer's Disease**

**Student Presenter:** Mary Campion
**Faculty Mentor:** Tiffany Mellott (MED Pathology)
UROP Award

Age-associated dementias like Alzheimer's disease (AD) impair various cognitive abilities. We previously demonstrated that gestational supplementation of choline, an essential nutrient, ameliorates hippocampal amyloid-beta (Aß) plaque accumulation and increases hippocampal neurogenesis in hemizygous APPswe/PS1dE9 (APP.PS1) AD model mice. Here, we investigated the effects of similar treatment on behavioral phenotypes and amyloidosis in the APPNL-G-F mouse model for AD which, unlike other transgenic mouse models (e.g. APP.PS1), does not overexpress APP, and is a better-suited physiological model for AD research. We maintained the pregnant wild-type C57BL/6J control mice and homozygous APPNL-G-F mice on a control or choline-supplemented diet. Mice were examined in a cross-sectional fashion at 3, 6, 9, and 12 months old using the open-field, plus maze, Barnes maze, and contextual-fear-conditioning experimental paradigms. Compared to controls, APPNL-G-F mice exhibited abnormalities in anxiety-related behaviors at 3 and 6 months old, and learning and memory deficits at 9 and 12 months old. Perinatal choline supplementation ameliorated some memory deficits in the 12-month old APPNL-G-F mice observed in the contextual-fear-conditioning test. The data suggest that dietary choline supplementation during fetal development and early postnatal life prevents behavioral abnormalities in APPNL-G-F AD model mice. We are currently assessing amyloidosis levels in the mice's brains and expect to confirm the age-dependent plaque accumulation in the hippocampus and cortex of APPNL-G-F mice. Furthermore, we will measure the effects of choline supplementation during early development on amyloidosis in these mice in order to correlate neuropathological indices with observed behavioral phenotypes.

**Identification of Small Molecule Inhibitor IGGi-11 of GIV-Gai Interaction for Cancer-Associated Signaling Complex Targeting**

**Student Presenter:** Jessica Chen
**Faculty Mentor:** Mikel Garcia-Marcos (MED Biochemistry)
UROP Award

Nearly 90% of cancer deaths result from cancer metastasis, which is the spreading of cancer cells from their original site to different body regions. Studies have shown that GIV is a promising target in cancer metastasis, and that blocking the interaction between GIV and Gai could be a strategy to inhibit cancer metastasis. This summer, we continued our investigation into the ability of the small molecule IGGi-11 in inhibiting GIV-Gai3 interaction and blocking breast cancer cell migration. Results of in vivo migration assays and cell viability assays show that IGGi-11 has inhibition effect on breast cancer cell migration with low toxicity to the cancer cells, and preliminary mice model experiment shows that IGGi-11 can block the migration ability of metastatic breast cancer cells in vivo. These results all show that IGGi-11 has potential to be applied in breast cancer therapy. Next, we will continue to explore the ability of IGGi-11 on breast cancer cell migration in mice model.

## LC-MS/MS Analysis of Glycans Derivatized with a Reducing-end Fixed Charge

**Student Presenter:** Yongting Chen
**Faculty Mentor:** Cheng lin (MED Biochemistry)
UROP Award

To understand the diverse roles glycans play in living systems, it is necessary to define their many structural variables, including their branching patterns, linkages and stereochemical configuration. The recent advance in structural glycomics has been catalyzed by the development of tandem mass spectrometry (MS/MS) methods for glycan sequencing. Reliable glycan structural elucidation requires preservation of the original sequence during MS/MS analysis, though proton-mediated saccharide transfer could lead to erroneous structural assignments. Reducing-end modification with a fixed charge tag, such as methylated proton reagent for acid-catalyzed glycan sequencing (PRAGS), may be employed to eliminate proton-induced structural rearrangement. However, PRAGS-labeled glycans can only be analyzed in their unreduced forms, as reduction of the oxime leads to tag loss. This complicates LC-MS analysis due to anomerism-induced chromatographic peak splitting. To overcome this limitation, here we introduced the fixed charge by reductive amination with 3-aminopyridine followed by methylation of the pyridinyl nitrogen (denoted Me-3AP labeling). Me-3-AP-labeled glycans were subsequently analyzed by electronic excitation dissociation (EED) tandem mass analysis, either through direct infusion or following on-line separation by porous graphitic carbon (PGC) liquid chromatography. Our results showed that EED of Me-3-AP-labeled glycans produced an abundance of structurally informative glycosidic, cross-ring and secondary fragments that enabled accurate determination of both the glycan topology and linkage configurations. EED spectra of Me-3-AP-labeled glycans acquired following on-line LC separation were of high spectral quality, and this result demonstrated the feasibility of combining fixed charge tagging with LC-EED MS/MS for characterization of complex glycan mixtures from biological samples.

## A Novel Oxalate-Curcumin-Based Imaging Probe: Enabling to Visualize Reactive Oxygen Species in Atherosclerosis

**Student Presenter:** Fangzhou Cheng
**Faculty Mentor:** Jingyan Han (MED Vascular Biology)
UROP Award

Sustained overproduction of reactive oxygen species (ROS) in the vasculature is a unified mechanism linking various risk factors with atherosclerosis. Due to the high reactivity and short lifespan, ROS detection, particularly in vivo, has long been a significant technical challenge. Herein, we investigate whether a near-infrared fluorescence imaging probe (CRANAD-61)—via its oxalate moiety, reacts with ROS and shifts the wavelength from 675Ex/760Em to 640Ex/720Em—can be employed to detect lesional ROS. We injected CRANAD-61 intravenously in Western-diet-fed ApoE-deficient mice and waited for 30 minutes to detect the ROS signals. Also, we compared the ROS levels in the same lesion recognized by CRANAD-61 and Dihydroethidium (DHE, a widely used ROS probe). Our results showed that ROS mainly accumulated in macrophages in aortic lesions as reflected by the fluorescence signals at 640Ex/720Em (green channel) in Mac2 positive cells. Similar results were observed in aortic lesions incubated with CRANAD-61 in vitro. Lastly, we found that DHE-oxidation derived signals were mainly located in nuclei and were highly dependent on DHE concentration, whereas ROS signals detected by CRANAD-61 were in cytosol and remained constant regardless of CRANAD-61 concentration. We conclude that CRANAD-61 can achieve high accuracy in ROS detection in vivo and thus may be used as a new method for detecting ROS in the cardiovascular system and atherosclerosis.

## Oxycodone Behaviors in Cacna1h Knockout Mice

**Student Presenter:** Rebecca Cole
**Faculty Mentor:** Camron Bryant (MED Pharmacology)
UROP Award

Genetic studies have provided evidence of strong heritability in opioid use disorder (OUD), highlighting the importance of identifying genetic risk factors for opioid misuse. Previously, we screened for differences in semi-synthetic opioid oxycodone (OXY) reward across 29 mouse strains with the goal of identifying genetic variants affecting opioid sensitivity. Following an acute dose of OXY (1.25 mg/kg, i.p.), we observed notable phenotypic variation across strains in locomotor activation, a measure of drug sensitivity. Using haplotype association mapping, our collaborators identified a region of the genome associated with OXY-induced changes in locomotion that contains candidate gene Cacna1h. While Cacna1h, encoding for the calcium channel subunit alpha-1H, has been implicated in altering locomotor sensitivity to psychostimulants, its role in opioid sensitivity has not yet been explored. Here, we focused on the role of Cacna1h in sensitivity to OXY-induced locomotor activation, reward, acute analgesia, tolerance, and models for emotional-affective opioid withdrawal. Using conditioned place preference, hot plate analgesia, elevated plus maze, and light-dark conflict assays, we tested Cacna1h knockout (Cacna1h-/-) mice generated on a mixed 129/C57BL/6N background against wildtype littermates. We found no significant genotypic differences across behaviors, suggesting that Cacna1h does not influence sensitivity to any of these opioid traits. While it may be beneficial in the future to assay the effects of Cacna1h knockout on different mouse genetic background to test Cacna1h function on OXY addiction model behaviors, our current findings fail to validate Cacna1has a causal gene underlying variability in OUD-relevant behaviors.

## Setting Up Studies of Flamenco Mutant Flies and P-element Transposition in S2 Cells

**Student Presenter:** William Dorst
**Faculty Mentor:** Nelson Lau (MED Biochemistry)
Symposium Volunteer

Piwi-interacting RNAs (piRNAs) are vital for suppressing mobilization of transposable elements (TEs) that can cause insertion mutations. piRNA are generated from loci known as piRNA clusters, but enhancers of piRNA clusters are not well understood. We prepared a study to generate novel deletions in three regions of the Flamenco (Flam) locus, a well-studied piRNA cluster in Drosophila melanogaster, to assess phenotypical changes.Our approach to generate these deletions is to contract a company to inject sgRNAs and ssODNs into Drosophila embryos expressing Cas9 endonuclease to target sites in Flam for homology-directed repair. Before this, I sequenced the Flam enhancer region in two Drosophila lines expressing Cas9 to determine which was best for genome editing. The P0 flies were then crossed with the w1118 line and screened for deletions by genomic PCR. One candidate mutated line was then crossed to balancer lines to preserve the mutant enhancer for further study.Because certain Drosophila strains can make piRNAs against the P-element TE from the Flam locus, we want to also explore P-element transposition in vitro. P-transposase expression vectors were transfected into S2 cells to promote the transposition of P-element TEs out of plasmids and into the host cell genome. This study will be expanded to test if P-elements can transpose into mosquito cell cultures, which harbor a particularly robust piRNA-mediated system of TE suppression, but no P-element piRNAs are yet detected. Our long-term goal will be making P-elements transpose into a mosquito piRNA cluster to make P-element piRNAs in mosquitoes.

## Endothelial Scavenger Receptors in the Hematopoietic Niche

**Student Presenter:** Khaliun Enkhbayar
**Faculty Mentor:** Elliott Hagedorn (MED Medicine)
UROP Award

The hematopoietic stem and progenitor cell (HSPC) niche is a supportive microenvironment comprised of distinct cell types, including specialized vascularendothelial cells that promote HSPC function. We previously identified several molecules with endocytosis-related functions, including the stabilin scavenger receptors stab1/2, which are expressed selectively by niche endothelial cells in zebrafish. Ourobjective was to investigate the role of these receptors in vascular endocytosis and HSPC niche regulation.To evaluate endocytic activity in niche endothelial cells we intravenously injected a fluorescent endocytosis sensor into zebrafish embryos at 48-72 hours post fertilization. High-resolution live cell imaging was then used to visualize endocytosis. In parallel experiments we co-injected a scavenger receptor inhibitor and examined HSPC migration, in addition to vascular endocytosis, within the niche. The endocytosis sensor revealed robust uptake specifically within niche endothelial cells. The inhibitor blocked endothelial uptake and led to an accumulation of HSPCs in the niche. Injection of the same endocytosis sensor into stab2 mutant zebrafish showed reduced niche endothelial uptake, suggesting stab2 could be driving this activity.Collectively, our results demonstrate that niche endothelial cells are extremely endocytic and implicate a role for stab2 in HSPC migration within the niche. These studies could guide new strategies for targeting vascular endocytosis to modulate stem cell function or deliver nanoparticle-based therapeutics to the blood stem cell niche.

## Effect of Netarsudil on Volume of Giant Vacuoles in Schlemm's Canal Endothelial Cells of Human eyes

**Student Presenter:** Nikolas Fritea
**Faculty Mentor:** Haiyan Gong (MED Ophthalmology)
UROP Award

Primary open-angle glaucoma (POAG) is a leading cause of irreversible blindness and is associated with elevated intraocular pressure (IOP). One drug that is currently used to treat POAG is netarsudil, a rho-kinase inhibitor. The mechanisms by which netarsudil decreases IOP have not been fully explored. Previous studies found size of giant vacuoles (GVs) with I-pores was significantly larger than GVs without I-pores, suggesting the size of GVs plays a role in pore formation. This study aimed to test the hypothesis that netarsudil increases GV volumes when compared to control eyes. Two pairs of human donor eyes were perfused with netarsudil in one eye and GPBS in the other eye of each pair, followed by tracer perfusion to label the high-flow and non-flow regions of the outflow pathway. Tissue wedges from each region were processed and imaged (~1500 images per wedge) using serial block face scanning electron microscopy. 160 GVs, 10 with I- pores and 10 without I-pores from high- or non-flow regions of each eye, were identified, and traced. The volumes of GVs in treated and control groups were compared using RStudio.

Mean GV volume was significantly larger in netarsudil-treated eyes compared to control eyes ($p<0.01$) and GVs with I-pores were significantly larger than GVs without I-pores ($p<0.05$) in both groups. This data suggests that one mechanism by which netarsudil lowers IOP may be through increasing GV size and potentially number of GVs with I-pores. Further study is needed to confirm whether netarsudil increases number of GVs with I-pores.

**The Localization of Golgin and P2X7 in Cell-Cell Signaling and Migration in the Context of Corneal Wound Healing in Diabetic and Normal Mice Models**

**Student Presenter:** David Garcia
**Faculty Mentor:** Vickery Trinkaus-Randall (MED Biochemistry)
UROP Award

Recurrent, poorly-healing corneal erosions are a significant source of pain and vision loss in diabetic patients. While transplants are available in some countries, it is essential to understand signaling events underlying wound healing and how these events become mis-regulated in diabetes to develop other treatments. Previous work in the lab demonstrated that the receptor P2X7 is localized differently in the pre-diabetic cornea. In addition, P2X7 mRNA expression is elevated in diabetic corneas of humans and in diet and streptozotocin induced mouse corneas. In my project, immunohistochemistry and confocal microscopy will be used to visualize P2X7 and Golgin in diabetic and nondiabetic mouse corneas, and in vitro nondiabetic and diabetic cell lines. P2X7 localization will be compared between control and diabetic cells and a competitive inhibitor to P2X7 will be used to determine its role on wound healing. P2X7 is located along the cell border in control epithelium and inhibition reduces wound healing in control epithelium by 68%. Experiments in diabetic are not completed. It is hypothesized that the change in control may be due to protein trafficking. Therefore we are examining Golgin-97 in the diabetic and control to see if there are changes in localization after a wound and whether the changes depend upon the closeness to the wound edge. The anticipated result is a change in the localization of golgin-97 in diabetic cells relative to nondiabetic controls. The understanding of the role of Golgin-97 and P2X7 in normal corneal healing response provides a baseline for studying diabetic corneal systems.

**Retinal Regulation of Antigen Presentation and Processing**

**Student Presenter:** John Gardiner
**Faculty Mentor:** Andrew Taylor (MED Ophthalmology)
UROP Award

Purpose: Normal retinal pigment epithelial cells (RPE) suppress phagosome-maturation within antigen presenting cells (APCs) influencing their ability to process antigen needed to activate CD4+ T cells. Mice with ocular autoimmune disease this suppressive activity is diminished. Treatment with the neuropeptide alpha-melanocyte stimulating hormone (α-MSH) suppresses autoimmune disease. Therefore, we assayed whether α-MSH-treatment affects RPE regulation of APCs activation of CD4 T cells in mice with autoimmune-uveitis. Methods: In mice, uveitis was induced by an IRBP in adjuvant immunization. At the chronic-phase of uveitis, the mice were treated with α-MSH and allowed to recover. Then eyes were collected and dissected to make RPE-eyecups in culture. The RPE conditioned media (RPE-CM) was used to treat the APC while they processed ovalbumin (OVA). The APC were washed and OVA-specific CD4+ T cells were added. After 48 hours, the culture supernatant was assayed by ELISA for IFN-γ, IL-17, and IL-10 with flow cytometry done to measure the expression of CD25 and FoxP T cell markers.Results: APCs treated with RPE-CM of naive and α-MSH-treated uveitic mice, but not from untreated uveitic mice stimulated IL-10 but not IL-17 and IFN-γ production by the T cells. The APC treated with RPE-CM from α-MSH-treated uveitic mice were 80% suppressed in expansion of CD25+FoxP3- effector T cells. There was no detected expansion of CD25+FoxP3+ Tregs.Conclusions: APCs are influenced by molecules secreted from the RPE that make the APC unable to activate effector T cells. Also, α-MSH-treatment of uveitis can promote recovery of normal RPE regulation of APC.

## Developing a Caffeine-Inducible Split Recombinase System in Zebrafish

**Student Presenter:** Emily Hill
**Faculty Mentor:** Hui Feng (MED Pharmacology)
UROP Award

T regulatory cells (Tregs) are critically involved in immune homeostasis and self tolerance, butthey can be exploited by cancer cells to cause immunosuppression. Efforts to developimmunotherapies targeting Tregs have been hindered by difficulty in differentiating betweensystemic and tumor-infiltrating Tregs, and current mouse models are costly in time andresources. Therefore, I aimed to develop an inducible split-Cre recombinase system in zebrafish,which provides us with the ability to spatially and temporally control ablation of Tregs in aneconomic and physiologically relevant organism. We received split-Cre constructs, generated bysplicing full length Cre recombinase, from the Wong lab, and I proceeded to generate PCRproducts consisting of split-Cre constructs flanked by bacterial attachment (attB) sites. I followedMultiSite Gateway cloning protocols to produce destination vectors containing my gene ofinterest (GOI) and additional elements. When I inject this construct into transgenic zebrafish andincubate them in caffeine, the caffeine will bind to the constructs and produce reconstituted Crerecombinase. I have successfully generated entry vectors through Gateway BP cloning thatcontain my cloned PCR amplified products and subsequently verified the constructs via Sangersequencing. I am currently confirming my expression vectors produced through Gateway LRcloning and will ultimately inject zebrafish embryos with these constructs and image for GFPfluorescence, as the Cre recombinase will excise a polyadenylated stop suppressing GFP. Afteroptimizing the performance of these constructs via fluorescent proteins, we can aim to engineernew functionalities to target different tumor-infiltrating immune cells involved in variouscancers.

## Targeting UFD1 as a Novel Immunotherapeutic Approach for MYCN-Driven Neuroblastoma

**Student Presenter:** Sarah Huang
**Faculty Mentor:** Hui Feng (MED Pharmacology)
UROP Award

Neuroblastomas are responsible for about 15 percent of cancer-related deaths in children. Enhanced activity of the oncogene MYCN is found in over half of high-risk neuroblastoma, and elevated expression of the gene encoding ubiquitin fusion degradation 1 (UFD1) is associated with overall increased tumor aggressiveness and poor treatment survival for children. MYCN upregulates UFD1 and decreases MHC-I expression in human neuroblastoma cells, enabling MYCN-driven neuroblastoma to avoid immune T-cell detection. To elucidate the mechanism by which UFD1 increases MYCN-driven neuroblastoma aggressiveness and evades immune detection, zebrafish were bred to express MYCN and overexpress UFD1. It was found that fish with MYCN-driven tumors have elevated levels of UFD1 compared to their wildtype counterparts. Our overall goal is to study how inhibiting UFD1 will affect tumor-infiltration lymphocytes and immune evasion to suppress MYCN-driven neuroblastoma. Further projects will evaluate how effective UFD1 inhibition in zebrafish is in turning MYCN-driven tumor environments from immunosuppressive to immunopromoting. Additionally, we will determine the extent to which UFD1 inhibition in MYCN-amplified human neuroblastoma cell lines can promote immunogenicity.

**Effects of Corin on Epigenetic Change in Metastatic Melanocytes In Vivo: A Study with Xenopus Laevis Embryos**

**Student Presenter:** Ainsley Hutchison
**Faculty Mentor:** Laura Lowery (MED Hematology/Oncology)
UROP Award

Skin cancer is the most common cancer in the United States. While melanoma accounts for only 1% of skin cancers, it is responsible for the majority of skin cancer deaths, due to its ability to metastasize. Thus, blocking metastasis would be a significant breakthrough in treatment strategies. Although numerous genetic mutations have been characterized in melanoma, a frustrating challenge in treating this disease is that there are no clear differences in the genetic mutations in primary tumors versus those that metastasize. However, several studies of melanoma patient samples have identified that there are common epigenetic modifications that correlate with metastatic state. The drug that our collaborators have developed, corin, specifically targets the CoREST complex, which affects epigenetic modifications that occur during cancer metastasis. While they have previously shown that corin can block melanoma tumor growth, it is hypothesized that it might also be effective at blocking melanoma metastasis. Our aim is to demonstrate the efficacy of corin in reducing metastasis of melanocytes in a Xenopus laevis (African clawed frog) model, using the drug ivermectin to induce a metastatic-like state in the melanocytes of Xenopus embryos. The addition of corin in these preliminary treatments showed that corin could reduce the metastatic changes. Western blot data from lysates of Xenopus embryos treated with corin showed expected epigenetic changes. Future studies will continue to elucidate the mechanisms by which corin may block melanoma metastasis.

**Exploratory Factor Analysis of the Revised ADHD Stigma Questionnaire Among Parents of Children in Primary Care**

**Student Presenter:** Chelsea Ji
**Faculty Mentor:** Andrea Spencer (MED Psychiatry)
UROP Award

The stigma surrounding behavioral health conditions remains a barrier to help-seeking, including for children with attention-deficit/hyperactivity disorder (ADHD) and their families. Since it is a common, chronic, and debilitating disorder, treatment of ADHD requires frequent behavioral interventions and consistent monitoring of medication effectiveness. Children with ADHD may experience the stigma on various levels; not only do they face public stigma, commonly exhibited as prejudice and discrimination, but they also experience medication stigma and courtesy stigma (i.e. stigma against persons associated with a child with ADHD), which all contribute to peer rejection or hostility, label avoidance, and underutilization of medication. This study adapts the existing ADHD Stigma Questionnaire (ASQ) to include 8 medication and courtesy stigma items and evaluates the psychometric properties to validate the new revised ASQ (ASQ-R) among a sample of English-speaking parents of children aged 0-17 (n = 159) from Boston Medical Center between September 2018 and May 2021. The measured variables are organized into factors, revealing the underlying relationships between items. Exploratory factor analysis revealed a new four-factor model: 1) concern for public attitudes, 2) disclosure concerns, 3) medication stigma and 4) parenting inadequacy. Two factors reflected the original ASQ factors (concern for public attitudes and disclosure concerns). Another two factors were newly defined (medication stigma and parenting inadequacy), and 8 items (7 from ASQ, 1 from ASQ-R) were dropped due to redundancy and failure to load. Clinicians will be able to use the ASQ-R as a valid tool to evaluate ADHD stigma and improve treatment plans.

## Quantification of Cellular and Non Cellular Components of Arteriovenous Fistula Explants

**Student Presenter:** Connor Kim
**Faculty Mentor:** Vipul Chitalia (MED Medicine)
UROP Award

Dialysis Access is the lifeline of patients on Hemodialysis. The Arteriovenous Fistula (AVF) is used as the primary dialysis modality in patients with End Stage Kidney Disease (ESKD). This process is characterized by dilation of the vein, and remodeling of the venous wall consisting of vascular smooth muscle cell (VSMC) proliferation, extracellular matrix (ECM) deposition, etc. The cellular components driving the vascular remodeling are poorly understood. We set out to examine explanted AVF from 22 ESKD patients.H&E, Pentachrome, and Sirius Red staining were used to analyze the components from explanted AVF. Annotations were completed in a bioimaging software (QuPath). Image quantification was performed using a "Random Forest" learning classifier to identify the amount of cellular and non cellular components.Several pathologies were noted including calcification, bleeding, needle tracks, proteoglycan accumulation, and VSMC proliferation. Our analysis involved segmenting the tissue into three main regions: dominantly VSMCs; dominantly proteoglycans; and a mix of VSMCs, proteoglycans, and collagen. A machine learning approach was able to quantify the three regions of interest into percentages of the entire tissue.This is the first study examining the remodeling of AVF obtained from human patients. Color analysis performed on the whole slide image revealed that while saturation and value of yellow and blue colors vary, their hues are localized on a small range; this is the key to separating each region of interest. These results will pave the foundation to understanding the molecular modulators of venous remodeling during fistula maturation.

## The Marburgvirus Genome Does Not Follow the Rule of Six

**Student Presenter:** Piers Klein
**Faculty Mentor:** Rachel Fearns (MED Microbiology)
UROP Award

Marburgvirus is a non-segmented negative-sense RNA virus of the Filoviridae family that is the causative agent of a high mortality viral hemorrhagic fever. In the related Paramyxoviridae family, a total genome length divisible by six is essential for efficient viral replication. This requirement is termed the "Rule of Six." Previous studies on Marburgvirus have demonstrated that the viral promoter region follows this Rule of Six but whether the complete viral genome follows the rule is unknown. This question was investigated using a Marburg minigenome system, a plasmid-based system that permits the study of highly pathogenic viruses at a lower biocontainment level. The minigenome system uses plasmid-expressed viral proteins along with an RNA template containing viral cis-acting elements and reporter genes, rather than the viral genome, permitting the study of the replicative functions of the virus without the production of infectious virions. Sequential nucleotide insertions were made into the minigenome, providing template lengths from 6n+3 to 6n+9. The system was expressed in mammalian cells and a luciferase reporter was used to quantify minigenome expression. No correlation was observed between total template length and luciferase expression for the tested minigenomes. This result indicates that the Rule of Six does not have a significant effect on the replication and transcription of Marburgvirus, suggesting that the replication strategy of Marburgvirus is substantially different from that of the paramyxoviruses. Further study is required to determine why the Rule of Six is required for the Marburg promoter but not for the complete viral genome.

**Investigating SR-18292 and ZLN005 as Fetal Hemoglobin Coactivators for their Potential as Sickle Cell Anemia Therapies**

**Student Presenter:** Nika Kozlov
**Faculty Mentor:** Shuaiying Cui (MED Medical Oncology and Hematology)
UROP Award

Sickle cell anemia (SCA) is a prevalent blood disorder that affects millions all over the world. By studying genetic changes which take place across the human lifespan, scientists have been able to pinpoint why SCA worsens with age. As fetal gamma-globin proteins (HBG) are replaced with adult beta-globin proteins (HBB), the disease progresses as the mutation which causes the characteristic sickle cell phenotype is in the adult HBB gene. Our lab is studying two potential chemical inducers which can increase HBG expression and therefore compensate mutated HBB proteins and alleviate the symptoms of SCA: SR-18292 and ZLN005. These chemical inducers have proven to influence a coactivator of HBG expression in the human genome, PGC-1α. In vitro studies in HUDEP-1 and human primary erythroid progenitor CD34+ cells showed that HBG expression was significantly amplified upon treatment with ZLN005 or SR-18292. In vivo studies of sickle mice treated with ZLN005 exhibited only a slight increase of HBG expression but robust increase of murine endogenous βh1-globin expression, which is a homologue of HBG. This suggested that ZLN005 can in vivo increase endogenous embryonic/fetal globin gene expression. Chromatin immunoprecipitation (ChIP) assays revealed that PGC-1α has stronger binding between 1700 - 1900 bp upstream of the HBG gene transcription start site which is not present in the knock-in fragment of HBG (1400 bp) in sickle mice. Further trials may require a different sickle mouse model for in vivo studies.

**Parvin-ILK-PINCH (PIP) Protein Complex is Essential for Normal Kidney Podocyte Adhesion**

**Student Presenter:** Aksel Laudon
**Faculty Mentor:** Weining Lu (MED Medicine)
UROP Award

Chronic kidney diseases (CKD) affect an estimated 13% of the global population. Many CKD including proteinuric kidney diseases feature progressive loss of podocytes, which are special octopus-like cells in the kidney glomerulus. Podocytes adhere to the glomerular basement membrane (GBM) through integrin adhesion complexes that link the podocyte actin cytoskeleton with the GBM extracellular matrix. Parvin, integrin-linked kinase (ILK), and PINCH (PIP) form a ternary complex at podocyte integrin adhesions. We have previously shown that podocyte-specific ILK knockout (ILK cKO) mice exhibit progressive glomerular morphological changes including podocyte detachment and loss. However, the role of the PIP complex in podocyte adhesion is not well understood. Through immunofluorescence staining followed by confocal microscopy and Stimulated Emission Depletion (STED) super-resolution microscopy analyses of glomerular protein expression, we found that α-parvin and PINCH-2 colocalize with podocyte-specific marker nephrin in wild type control mouse glomeruli. However, in ILKflox/flox/PodCre+ podocyte-specific ILK knockout (ILK cKO) mouse glomeruli, α-parvin and PINCH-2 exhibit redistribution and loss of colocalization with nephrin, suggesting that loss of ILK disturbs the PIP complex and alters α-parvin and PINCH-2 expression and localization in podocytes. This finding indicates that α-parvin and PINCH-2 function in podocytes is ILK-dependent. Our results also suggest that the PIP complex is required for normal podocyte adhesion. Future study is needed to investigate a mechanistic role for PIP complex in proteinuric kidney diseases and therapeutics.

## Effect of Chronic Social Defeat Stress on the PACAP System

**Student Presenter:** Teresa Le
**Faculty Mentor:** Pietro Cottone (MED Pharmacology)
UROP Award

Stress is a physiological construct and when it becomes chronic, neuroplastic changes occur in the brain, which causes the emergence of psychiatric diseases, including anxiety, depressive, and trauma-related disorders. The central nucleus of the amygdala (CeA) is an area of the brain responsible for activating behavioral responses to stress. Pituitary adenylate cyclase-activating polypeptide (PACAP) and its receptor PAC1R are highly expressed in the Ce) and have been proposed to play a role in the response to stress. In order to further investigate this, mice were subjected to chronic social defeat, a clinically relevant rodent model of psychosocial stress that produces robust maladaptive behaviors in rodents. For ten consecutive days, experimental mice were defeated by larger territorial mice, and 24 hours after the last defeat, mice were subjected to a social interaction test to screen them for either susceptibility or resilience. Mice were then euthanized via intracardiac perfusion and their brains were removed and sliced. Upon analysis, there was a significant PACAP increase in the CeA of defeated animals compared to controls, suggesting that chronic stress recruits the PACAP system in this area. Currently, I am further analyzing these brains to study the effect of chronic social defeat on the activation of PAC1(co-localization with the neuronal activation marker c-Fos) in the CeA and on the activation of PACAPneurons in the parabrachial nucleus. This research will increase our understanding of the long-lasting neuroadaptations that follow chronic stress and may open new avenues for the treatment of psychiatric disorders.

## Clinico-radiographic Predictors of Progression in Benign Lung Nodules Found on Screening CT Scans

**Student Presenter:** Pearl Lee
**Faculty Mentor:** Kei Suzuki (MED Surgery)
UROP Award

Lung cancer screening with low-dose CT scan is recommended for high risk patients as this has been shown to improve lung cancer mortality. Screening CT is categorized per the Lung CT Screening Reporting and Data System (Lung-RADS) from 1-4 based on the nodule appearance, diameter, and presence of growth. Lung-RADS 2/3 are associated with probably benign pulmonary nodules that have a low likelihood of becoming clinically active cancer in which the malignancy rates for score 2 is

**Application of Telemedicine Consultations for Chronic Pulmonary Disease: A Scoping Review**

**Student Presenter:** Brandon Li
**Faculty Mentor:** Seppo Rinne (MED Medicine, Pulmonology)
UROP Award

Introduction: Telemedicine consultations have the potential to expand access to specialty services and ensure equitable, high quality, and efficient care delivery. However, limited research has described application of telemedicine for patients with chronic pulmonary diseases. This scoping review aims to identify, characterize, and analyze gaps in the published literature on telemedicine encounters that health providers can use to manage patients with chronic pulmonary diseases. This project is part of a larger effort to create standardized guidelines for the use of pulmonary telemedicine.
Body: We created a search strategy for several medical literature databases (PubMed, Embase, Web of Science, Cochrane Libraries) which captured 3,118 articles related to telemedicine and chronic pulmonary diseases. With clearly defined inclusion criteria, two independent reviewers screened identified articles and extracted data from those that met inclusion criteria.
Results/Discussion: The preliminary screening process has identified 106 articles. Articles vary in the type of telemedicine studied (video-call, phone call, electronic consultation), the type of chronic pulmonary disease studied, and the study design. We are in the process of conducting in-depth analysis and data abstraction of the included articles.
Summary: This study helps characterize existing pulmonary telemedicine literature and offers a focus for future efforts to guide pulmonary practice. We found diverse literature on pulmonary telemedicine, although these articles tend to focus on specific diseases (asthma and COPD), and few of these studies examined appropriate use of telemedicine care delivery. Future research is needed to understand how to optimally use these technologies for different pulmonary conditions.

**Role of Neutrophil Elastase (NE) on Autophagy Activities in Mouse Livers**

**Student Presenter:** Ben Lin
**Faculty Mentor:** Zhen Jiang (MED Pharmacology)
UROP Award

Autophagy is a natural, conserved degradation of the cell that removes unnecessary or dysfunctional components through a lysosome-dependent regulated mechanism, to maintain cells, tissues, and whole-body system homeostasis, the state of optimal function. Neutrophil elastase (NE) is a serine protease that is exclusively expressed in neutrophils and is associated with some inflammatory diseases. The regulations of autophagy play a crucial role in liver homeostasis and pathogenesis of liver diseases. This project utilized 3 groups of wild type mice fed with a normal chow diet, high-fat diet, and high-fat high-fructose diet. A group of neutrophil elastase knockout (NEKO) mice were also fed on a high-fat high-fructose diet. The knockout of neutrophil elastase demonstrated a significant decrease of fibrosis and inflammation in mouse liver. Autophagy related proteins were also shown to be increased in NEKO mice. Further studies are necessary to understand the mechanisms in which autophagy-related signaling pathways have been influenced by depletion of NE from neutrophils. However, there are studies indicating that inhibition of NE have influenced several pathways related to homeostasis and autophagy. Thus, our studies in autophagy in mouse liver may lead to a better understanding of the pathogenesis of liver diseases and to the identification of new therapeutic targets to treat these diseases.

## Characterizing the Role of Aortic Carboxypeptidase-like Protein in Connective Tissue Disease

**Student Presenter:** Amber Liu
**Faculty Mentor:** Matthew Layne (MED Biochemistry)
UROP Award

The regulation of connective tissue stiffness is essential for proper tissue function, and when this regulation is disrupted, disease can occur. Aortic carboxypeptidase-like protein (ACLP) is a collagen-binding extracellular matrix protein that regulates connective tissue assembly and fibrosis. Mutations in the gene that encodes for ACLP have been linked to Ehlers-Danlos syndromes (EDS), a hereditary disorder of connective tissue characterized by joint hypermobility, tissue fragility, impaired wound healing, and vascular disruptions. The goal of this project was to develop an in vivo mouse model of ACLP deficiency and to identify cellular changes elicited by loss of ACLP function in vitro. Using a mouse model harboring a floxed ACLP allele, ACLP was conditionally deleted in mice through tamoxifen injections in order to assess the effects on connective tissue integrity and structure. Mouse aortic smooth muscle cells were isolated and treated with tamoxifen to optimize in vitro ACLP recombination and produce ACLP-null cells. We also constructed an in vitro model of specific human ACLP mutations implicated in EDS by cloning. Human ACLP mutants were successfully generated and future studies will examine their subcellular localization and secretion. Results of this study and future experiments will further define the function of ACLP as well as its relation to connective tissue disease.

## Use of Electron Microscopy to Characterize Aβ-PrPC Assembly's Structures

**Student Presenter:** Timothy Liu
**Faculty Mentor:** David Harris (MED Biochemistry)
UROP Award

Alzheimer's disease (AD) is associated with aggregation of the amyloid-β (Aβ) peptide. There is strong evidence that small Aβ oligomers (Aβo), rather than fibrils, represent the main source of damage to neurons in AD. It is presumed that the disease process starts by the binding of Aβo to receptor proteins on the surface of neurons. A recent study showed that cellular prion protein (PrPC), one documented Aβ receptor, specifically inhibits Aβ polymerization by binding to the rapidly growing end of each fibril, thereby contributing to the neurotoxic effect of Aβ aggregates. Moreover, electron microscopy (EM) data show that the structure of fibrils that are formed in the presence of PrPC are different from those of control fibrils. In this project, we tried to define the structural features of Aβ fibrils formed in the presence of different concentrations of recombinant PrPC. In a technique known as single particle analysis, the SPHIRE software package was used to detect thousands of particles from the EM micrographs. These particles were then classified into multiple class averages, and a 3D structure at 22.5 Å resolution was then constructed from the 2D class averages. The Relion software package was also used to verify the results. The 2D class averages demonstrate sub-structural details consistent with the literature. A near-atomic resolution structure using cryo-EM is currently being determined using the same method. This may lead directly to effective AD treatments.

**Creation of a Conditional hnRNPUL1 Knock-out in Human Cell Culture Using CRISPR/Cas9**

**Student Presenter:** Max Lohse
**Faculty Mentor:** Michael Blower (MED Biochemistry)
UROP Award

Loss of function mutations are a key tool to understand protein functions. hnRNPUL1 is part of a family of proteins containing RNA and DNA binding domains, however, its specific function is unknown. By inactivating this protein, we can determine its importance and function. To achieve this, a conditional gene knock-out was created to eliminate the production of the hnRNPUL1 protein via the addition of auxin. This was done by using CRISPR/Cas9 to introduce a cut in the genome. A plasmid was inserted to have the cell use it as a template to repair the cut. This would lead to the insertion of a sequence that would trigger the degradation of the protein. Via the use of genomic DNA and PCR techniques, I have been able to create the sgRNA which will be used to create the cut in the genome. Using these same techniques, I have been able to put together two of the three pieces needed to create the template which the cell will use to fix the cut. The results from this experiment can be used to fully knock out this protein, allowing us to understand its role in the cell cycle and possibly genetic diseases.

**The Effect of the Hippo Pathway on Multiciliated Cells in the Airway Epithelium**

**Student Presenter:** James Lu
**Faculty Mentor:** Xaralabos Varelas (MED Biochemistry)
Loren E. Wold Research Award

Multiciliated cells are required in the airway to facilitate expulsion of foreign particles and maintain lung health. Despite numerous lung diseases that exhibit cilia defects, molecular events controlling multicilia homeostasis and function are poorly understood. In this study, we examine the cilia through the lens of the Hippo pathway, a signaling pathway that plays essential roles in lung epithelial development and homeostasis. Data from our lab has suggested distinct functions for Hippo signaling in multiciliated cells, and to study these functions, we generated genetic models that enabled us to conditionally delete genes encoding key mediators of Hippo signaling. For this, we targeted the transcriptional effectors of Hippo signaling, Yap and Wwtr1/TAZ, as well as the upstream regulatory kinases Lats1 and Lats2 in multiciliated cells and phenotypes resulting from deletion were observed through confocal microscopy and live cell imaging techniques, or by immunohistochemistry of fixed tissues. Cultured cells in vitro were comparatively analyzed to their in vivo counterparts. Our observations indicated defects in the structure and beating patterns of the cilia upon Hippo pathway perturbation. We further observed distinct localization patterns for Hippo pathway effectors at the apical domain of ciliated cells and in the nucleus, suggesting direct cilia regulatory roles and indirect transcriptional roles. Notably, ciliary defects observed following Hippo pathway perturbation are reminiscent of those observed in patients with COPD, asthma, and other airway-related conditions, raising the possibility that defective Hippo signaling contributes to cilia defects observed in lung disease.

**Microbial and Somatic Mutation Biomarkers in Male Prostate Cancer Inflammation**

**Student Presenter:** Miguel Mazumder
**Faculty Mentor:** William Johnson (MED Medicine: Computational Biomedicine)
UROP Award

Prostate cancer is one of the most prevalent cancer types amongst men. However, very little is known how bacteria impacts the inflammation and progression of prostate cancer. This project utilizes a computational framework (Pathoscope 2.0) and the Boston University Shared Computing Cluster to process and analyze whole-genome-sequence data for the identification of microbes in men with different stages of prostate cancer. The data also was processed for somatic mutations on a different computational platform (TERRA), to target PTEN, SPOP, FOXA1, IDH1 which are already known somatic mutations associated with prostate inflammation. Microbes such as S. justesenii appeared to be common throughout most of the patients as well as a higher prevalence of Varicellovirus in older patients that had a prostate specific antigen (PSA) of 4.7 or higher. The goal of this research is to discover prognostic or predictive biomarkers associated with prostate tumor inflammation/progression. With potential somatic mutation or microbial biomarkers, the risk of prostate cancer may be reduced through improved diagnosis and prognosis in the medical field. Potential progression of this research could include applying the same steps and procedures to a different dataset to ensure validity of the results.

**Exploring the Effect of a Chemokine on MYCN Amplification Neuroblastoma**

**Student Presenter:** Grace Meara
**Faculty Mentor:** Hui Feng (MED Pharmacology & Experimental Therapeutics)
UROP Award

Neuroblastoma is the most common cancer in children younger than 1 year old. Aberrant MYCN activity is associated with over 50% of high-risk neuroblastoma and is a reliable predictor of disease aggression. MYCN-driven neuroblastoma is an immunologically "cold" tumor and its mechanism of immune evasion remains poorly understood. Understanding the mechanisms by which MYCN induces the suppressive tumor microenvironment (TME) is important to improve treatment of this cancer. In the Feng lab, it has been discovered that MCYN, an oncogene, transcriptionally upregulates a specific chemokine but not others in neuroblastoma cells. To understand the role of this not well studied chemokine on neuroblastoma pathogenesis, we utilized a zebrafish model of neuroblastoma, MYCN; EGFP which the tumor cells are labeled with EGFP and compare tumor onset and progression in MYCN zebrafish with and without overexpression of the chemokine-of-interest. Specifically, we overexpressed the chemokine-of-interest in zebrafish neural crest cells and monitored the fish tumor by fluorescence microscopy based on the EGFP intensity and quantified to evaluate the effect of increased amount of this chemokine on MYCN-driven neuroblastoma. We found that overexpression of this specific chemokine had earlier tumor onset and more aggressive tumor progression compared to fish without the chemokine overexpression. For future research, understanding the mechanisms by which this chemokine causes increased tumor growth and targeting it for future neuroblastoma therapy should be researched. Our goal is to fully elucidate the function of this chemokine in the TME and understand how it affects tumor onset and progression for future research.

**Determining The Effects of Chronic Intermittent Alcohol Drinking on the Levels of the Neuropeptide PACAP in the BNST**

**Student Presenter:** Gianna Medeiros
**Faculty Mentor:** Valentina Sabino (MED Pharmacology)
UROP Award

Alcohol use disorder (AUD) is a chronic relapsing condition characterized by compulsive, uncontrolled consumption of alcohol. Chronic exposure to ethanol produces neuroadaptations in specific brain regions, including the bed nucleus of the stria terminalis (BNST). The goal of this research is to determine the effects of chronic alcohol drinking on the pituitary adenylate cyclase activating polypeptide (PACAP) system in the BNST of mice. In our studies, we exposed mice to repeated cycles of voluntary access to ethanol and withdrawal through an intermittent access two bottle choice, where mice are allowed to drink water and 20% alcohol for 24h on Monday, Wednesday, and Friday. We have found that PACAP levels in the BNST, as measured by densitometry, are increased in mice exposed to chronic alcohol, compared to water controls. We are currently performing additional experiments to determine whether the source of this increase of PACAP is local (i.e. within the BNST) or an afferent brain region. For this purpose, we are using a line of mice that expresses a red fluorescent protein in PACAP neurons together with a retrograde tracer approach. The immunohistochemistry and microscopy counting phases of these experiments are currently underway. We expect to find that the elevated levels of PACAP in the BNST are due to an activation of PACAP neurons in the lateral parabrachial nucleus (LPBn), based on the observation that the LPBn contains PACAP neurons and heavily projects to the BNST. This research may highlight a key role for the PACAP system in AUD.

**Facilitators and Barriers of Youth Advisory Boards in Healthcare**

**Student Presenter:** Homar Murillo
**Faculty Mentor:** Astraea Augsberger (MED Clinical Practice)
UROP Award

Youth Advisory Boards (YAB) have been utilized by organizations to include youth voice in decision making as a mechanism to address inequities and increase youth access. Specifically in healthcare, YABs can improve health outcomes and increase youth agency. However, there is limited research on implementing YABs in healthcare settings, and no studies specific to BIYOC. This research examines the facilitators and barriers to implementing a YAB with 8 youth of color in a safety net hospital in Boston. From August of 2020 to August 2021, we conducted a project evaluation including semi-structured interviews at three distinct time points with board youth and one-time interviews with adult stakeholders from the partnering hospital. The data were coded using thematic analysis. One facilitator described by youth was having space for community building among team members and adult supporters to establish meaningful/collaborative partnerships. A barrier discussed by the youth was the power and racial dynamics that existed throughout the project with the partnering hospital and identified 'higher ups' of the team. As a result, youth at times felt tokenized and described inconsistent communication and a lack of support. Among the interviewed adult stakeholders, a facilitator was an authentic interest in involving youth in their community engaged practices and research. However, findings demonstrate that there is a need for resources, including staff, time, money, and training in youth-adult partnerships and anti-oppressive practice, to promote authentic youth engagement. Findings from this research can aid the successful formation and implementation of YABs in health care settings.

**Optimal Concentrations of Deoxycytidine Analog Decitabine that Maximize Fetal Hemoglobin Expression and Cell Vitality**

**Student Presenter:** Nicole Nguyen
**Faculty Mentor:** Shuaiying Cui (MED Medicine)
UROP Award

Increased fetal hemoglobin (HbF) expression prevents sickling and, in turn, alleviates sickle cell disease (SCD) symptoms, motivating the development of novel HbF inducers, such as deoxycytidine analog decitabine (DAC). DAC is capable of inducing HbF, but the potential cytotoxicity hinders its approval as an SCD treatment. This research aims to determine the concentrations of DAC in vitro that maximize HbF induction and cell viability and whether or not combining DAC and hydroxyurea (HU) - the standard treatment for SCD - induces HbF expression more effectively. Determining a safe but effective dosage of DAC could benefit SCD patients unresponsive to HU.

The effectiveness and cytotoxicity of DAC are initially examined in human umbilical cord blood-derived erythroid progenitor-2 (HUDEP2) cells. After 2 days of treatment with various concentrations of DAC, cell viability and differentiation are analyzed using a manual hemocytometer and flow cytometric assays; both mRNA and protein abundance of globin genes are determined by RT-qPCR and western blots. Lower concentrations, especially 0.0625 μM DAC, maximized HbF expression and cell viability. Similarly, concentrations of 0.05 μM or 0.01 μM DAC along with 25 μM HU demonstrated greater HbF expression but lower cell viability when compared to only DAC treatment. These results illustrate DAC's potential as an alternative treatment for SCD patients who do not benefit from HU treatment. Further validating the efficacy of DAC in primary erythroid progenitor CD34+ cells from normal subjects and sickle patients would provide more support for future preclinical studies.

**The Efficiency of ERG in Lymphatic Endothelial Cells that Induces Lung and Heart Fibrosis**

**Student Presenter:** Ashna Panchmatia
**Faculty Mentor:** Maria Trojanowska (MED Rheumatology)
UROP Award

Scleroderma is an autoimmune disease affecting the skin, connective tissue, and internal organs, which can cause fibrosis and inflammation. ERG, a transcription factor that is a key regulator of endothelial cell function, is downregulated in scleroderma patients, but its role in lymphatic endothelial cells is not known. A bleomycin-induced fibrosis model was used to assess the effects of conditional Erg depletion in lymphatic endothelial cells on the lungs, skin, and heart of 14 mice after 7 days. Wild type and ErgCKO mice were injected intradermally with phosphate-buffered saline (PBS) or bleomycin for 7 days. Collagen deposition was assessed using trichrome staining in the lungs and skin and Picrosirius staining in the heart. Quantitative polymerase chain reaction (qPCR) was used to measure the gene expression of eight profibrotic genes for each mouse. Interestingly, mice with ERG depletion in lymphatic endothelial cells had higher levels of profibrotic gene expression in the lungs and the heart at the baseline; however, this trend was not observed in the skin. Consistent with the mRNA expression, it can be seen that mice with ERG depletion exhibit a moderate increase of collagen deposition in the heart and lungs but not in the skin. Future experiments will include more mice per group and the quantification of a wider range of profibrotic and proinflammatory genes; significant findings would be confirmed in human tissues. This research provides new insights into the role of ERG in the lymphatic vasculature.

## Reconstitution of RNAi in Zebrafish

**Student Presenter:** Elaine Park
**Faculty Mentor:** Daniel Cifuentes (MED Biochemistry)
UROP Award

The Argonaute protein family plays roles in gene silencing through pathways like RNA interference. Unlike other animals, zebrafish have an Argonaute 2 protein that is unable to efficiently slice their target mRNA, and thus lack efficient RNAi. The reason being that the first aspartate of the DEDH catalytic tetrad is mutated to alanine. However, Ago3 in humans and fish have the fully functional catalytic tetrad that is necessary for RNA slicing. And that the slicing activity of human Ago3 can be increased to levels more comparable to human Ago2 with a 14 nucleotide microRNA instead of the canonical 22-23 nucleotide miRNA that Ago2 is optimized with. Thus, we sought to restore RNAi in zebrafish using siRNAs optimized for Ago3 activity. We designed 14 nt ss small RNAs to target locations in GFP mRNA and injected them into zebrafish embryos, along with GFP and RFP mRNAs. Injecting RFP mRNA also provided an injection control to ensure any lack of GFP expression was not due to faulty embryo injection. At 6 hours post injection, we compared GFP and RFP expression to see if Ago3 and our injected miRNAs were successful in silencing GFP gene expression, while RFP was left unaffected. We found that there was no significant decrease in GFP expression for any of the miRNAs we injected. Thus, we were unable to restore RNAi in zebrafish through the use of Ago3. In the future, we may explore more how to do so through using a humanized version of Ago2 in zebrafish.

## The Interactions of Eukaryotic Translation Initiation Factor eIF5 with eIF1A and eIF2's beta Subunit

**Student Presenter:** Eleanor Paul
**Faculty Mentor:** Assen Marintchev (MED Physiology & Biophysics)
UROP Award

Initiation of translation (protein synthesis) involves the assembly of the ribosome with the help of eukaryotic translation initiation factors (eIFs). We examined the interactions of eIF5 with eIF1A and eIF2β. eIF2 is a heterotrimeric GTPase that hydrolyzes GTP upon start codonselection. eIF5 is the GTPase activating protein (GAP) for eIF2. eIF5 binds eIF1A until startcodon selection, when it binds eIF2-GDP. eIF5's C-terminal region includes a folded C-terminal domain (CTD), surrounded by a linker, the DWEAR motif, and a C-terminal tail (CTT), which both dynamically contact the CTD. The interactions of eIF5 with eIF1A and eIF2β were studied using NMR chemical shift perturbation (CSP) and Microscale thermophoresis (MST). Using eIF1A deletion mutants in NMR, we determined that the eIF1A N-terminal tailand its folded domain contact eIF5-CTD while the eIF1A-CTT interferes with binding. Toelucidate the effects of the DWEAR and the CTT of eIF5 on its affinity for eIF2β and eIF1A, we tested three eIF5 deletion mutants: eIF5-CTD, eIF5-CTD with the CTT, and eIF5-CTD with both the DWEAR and CTT. We observed stronger interaction with eIF1A without the DWEAR and the CTT but stronger interaction with eIF2β in their presence. Using CSP, multiple binding sites on eIF2β for eIF5 are observed. The opposing effects of the DWEAR and the CTT of eIF5 on its interactions with eIF1A and eIF2β indicates that rearrangement of the intramolecular interactions within eIF5 can mediate the transfer of eIF5 from eIF1A to eIF2-GDP upon start codon selection.

**Plasma Exosomes Drive Prostate Cancer Progression in Men with Co-morbid Metabolic Disease**

**Student Presenter:** Isabella Pompa
**Faculty Mentor:** Gerald Denis (MED Hematology/Oncology)
UROP Award

Prostate cancer is the second leading cause of cancer mortality among American men with 34,000 deaths reported annually. Patients with Type-2 diabetes (T2D) have worse prognoses and higher mortality rates than non-diabetics (ND). 31 million people in the United States have T2D, and T2D prevalence is especially high in safety-net clinics, as much as 25%. The biological mechanisms linking T2D to prostate cancer progression are unknown, and safety-net patient populations are understudied and underserved. We hypothesized that exosomes, extracellular vesicles key to intercellular communication, mediate cancer progression. Exosomes were purified by size fractionation from blood plasma of patients of differing metabolic status, and characterized by NanoSight NS300. DU145 human prostate cancer cells were treated with 10^9 exosomes for 2 days. PCR, gene array, and RNA sequencing were performed to reveal critical signal transduction networks. We report exosomes from T2D patient plasma drive epithelial-to-mesenchymal transition (EMT), a characteristic of cancer progression, as well as immune exhaustion, in prostate cancer models. Exosomes from ND plasma fail to induce EMT and immune checkpoint expression. The Bromodomain and ExtraTerminal (BET) proteins are effectors for exosome-driven EMT, and BET inhibitors block the effects of T2D plasma exosomes. Plasma exosome profiling could be used to improve the standard of care and outcomes, as a diagnostic tool to predict the progression risk of prostate cancer patients with metabolic comorbidities. New therapeutics could be developed to lower the risk of progression in men with T2D and early-stage prostate cancer, which disproportionately impacts low income communities.

**The Clinical Application of Digital Technology in Alzheimer's Disease Dementia**

**Student Presenter:** Meha Prabhu
**Faculty Mentor:** Rhoda Au (MED Anatomy & Neurobiology)
UROP Award

There is growing evidence for the use of smartphone applications to study the progression of Alzheimer's disease (AD) dementia. However, this has yet to be investigated on a large-scale basis. This study examined the utility and feasibility of using a smartphone application to conduct remote-based cognitive assessments in 80 participants from the Boston University Alzheimer's Disease Center [40 controls, 40 Mild Cognitive Impairment (MCI)]. Data was collected using the neurocognitive battery, DANA (Defense Automated Neurobehavioral Assessment). Participants performed three tasks: Simple Reaction Time (SRT), Procedural Reaction Time (PRT) and Go/No-Go (GNG), which generated a cognitive efficiency score based on accuracy and speed. The tasks were repeated over segments spread across 12 months. It was observed that 100% of participants completed the tasks as per schedule. A lower average cognitive efficiency score for all tasks over time was found among MCI participants as compared to controls. These differences however were only significant for SRT. Task performance appeared to improve in the control group with time while performance in the MCI group fluctuated with no clear pattern across tasks. Overall, this study indicates the feasibility of using smartphone applications to measure cognitive function in older adults, with and without cognitive impairment. Findings suggest that performance on remote-based cognitive tests administered via smartphone may help to differentiate individuals with MCI from those who are cognitively normal, facilitating the potential for detection of cognitive decline. Data collection across a longer period of time and larger sample size could yield more significant results.

**A Mouse model for Neonatal Opioid Withdrawal Syndrome (NOWS) induces Brain Region-specific Changes in Proteins Associated with Microglial Activation (IBA1) and Myelin Protein Expression (MBP)**

**Student Presenter:** Katherine Sena
**Faculty Mentor:** Camron Bryant (MED Pharmacology)
UROP Award

Due to an ongoing public health crisis, the prevalence of both Opioid Use Disorder and Neonatal Opioid Withdrawal Syndrome(NOWS) has increased. Opioid exposure can affect the expression and function of glial cells in the adult brain, however, effects of opioid exposure and withdrawal on neonatal glial function is unknown. We used a mouse model of NOWS to determine the effect of perinatal opioid exposure on glial activation and myelination patterns in brain regions known to be affected by opioids. Outbred Swiss Webster Cartworth Farms White pups were administered morphine (15 mg/kg, s.c.) or saline once daily from postnatal day 1-14, roughly corresponding to the third trimester of human gestation. 3 hours prior to tissue collection on day 15, pups were administered naloxone (2 mg/kg, s.c.) or saline to compare the effects of naloxone-precipitated and spontaneous withdrawal. Immunohistochemistry was used to stain tissue from the hippocampus, habenula, and the nucleus accumbens for markers of active microglia (IBA1) and myelination (MBP). Indications of elevated microglial activation following neonatal morphine and naloxone were found in the nucleus accumbens and a near-significant increase in the hippocampus(CA1), relative to mice treated with saline and naloxone. Additionally, significantly lower fluorescence of MBP in the dentate gyrus was found in mice that received morphine treatment, implicating a decrease in myelination as a consequence of perinatal morphine exposure. Habenula staining did not exhibit significant differences between treatments. Future research will examine the impact of perinatal opioid exposure and withdrawal within other brain areas and cell types.

**Leveraging the Framingham Study to Investigate Relationships between Traumatic Brain Injury, Alzheimer's Disease and Related Dementias**

**Student Presenter:** Kristin Shanabrook
**Faculty Mentor:** Jesse Mez (MED Neurology)
UROP Award

Traumatic brain injuries (TBI) are common in organized sports and daily life and can have lasting health effects. The study will characterize the currently unclear relationship between traumatic brain injuries and Alzheimer's Disease/Alzheimer's Disease-related Dementias (AD/ADRD) outcomes. Since dementia is a slowly progressive disease and contributory TBI can occur many years before dementia onset, the relationship between the two takes a lot of resources to assess. Past studies often relied on highly selected samples which introduced many potential confounding factors.The study is leveraging data collected by the Framingham Heart Study (FHS) through comprehensive retrospective chart review. FHS is a large community-based cohort study that began in 1948 and has since followed multiple generations of the same families. Data collection for the TBI study involves the systematic tracking of head injuries, their symptoms, and potential confounding factors throughout the participant's life. This information is found in the extensive medical and exam records retained by FHS.The traumatic brain injury data for FHS Generation 1 (n=5209) has been collected, while the review for FHS Generation 2 data (n=5124) is still ongoing. Preliminary analyses are beginning on Generation 1 data, including estimating the incidence of TBI and how it varies by age and decade, and estimating the relationship between TBI, dementia and dementia subtypes. The information gleaned from this study will inform the planning of service needs for long-term population health; in the setting of organized sports, it will allow people to make more informed health decisions.

**Attitudes and Practice Patterns in Breastfeeding Counseling in Women with Epilepsy among Neurologists and Obstetricians**

**Student Presenter:** Rebecca Summit
**Faculty Mentor:** Abrar Al-Faraj (MED Neurology)
UROP Award

It is widely accepted that breastfeeding is the ideal nutrition for the healthy growth and development of infants and holds additional long-term benefits to both child and mother. Breastfeeding rates are lower in women with epilepsy than in women without epilepsy. In the past it was unclear if it was safe for mothers using anti-epileptic drugs (AEDs) to breastfeed, but current data is supportive of the safety of many commonly used AEDs. Still, the breastfeeding rates among women with epilepsy remain low. Previous research has shown that breastfeeding counseling increases the rates of breastfeeding in women with epilepsy. However, counseling is lacking for women with epilepsy in clinical practice. The first stage of our research consisted of extensive literature review and revisions to develop an online survey on the REDCap platform and distribute it to obstetricians and neurologists. Our objective is to assess attitudes, practices and barriers to breastfeeding counseling practices, and to identify gaps within current breastfeeding counseling for women with epilepsy. The data we collect in this stage will be analyzed to create a more detailed series of questions for a focus group. From the survey and focus group data, our published paper will create suggestions and recommendations for physicians as they counsel women with epilepsy before birth and postpartum. With the assistance of these recommendations, we hope to increase the understanding of breastfeeding safety in women with epilepsy and ultimately increase the rates of breastfeeding.

**Effects of Fli 1 Downregulation on THP1 Migration**

**Student Presenter:** Yashasvi Tharani
**Faculty Mentor:** Andreea Bujor (MED Rheumatology)
UROP Award

Systemic sclerosis (SSc) is an autoimmune connective tissue disease characterized by endothelial injury and fibrosis. Immune cells including monocytes are recruited to the site of injury where they differentiate into pro-fibrotic and pro-inflammatory macrophages. Increased macrophage infiltration has been observed in SSc patients. Furthermore, monocytes from SSc patients show a downregulation in Fli1, a member of the Ets family of transcription factors. Microarray analysis of monocytes with depleted Fli1 show increased pro-migratory genes, suggesting that Fli1 downregulation contributes to enhanced tissue infiltration and fibrosis in SSc. This study investigates the effects of Fli1 downregulation on the migration of monocytes. THP1 cells were transfected using si-RNA to achieve post-transcriptional Fli1 gene silencing. Transwell assays were then used to set up co-cultures of Human Pulmonary Artery Endothelial Cells (HPAECs) and the transfected THP1 cells to allow cell migration under +/- MCP1 conditions. MCP1 is a chemoattractant protein secreted by resident fibroblasts that contributes to the cell migration. There was a significant increase in the migration rate of si-Fli1 treated THP1 cells in response to MCP1 compared to cells treated with non-targeting si-RNAs. These results suggest that decreased Fli1 in monocytes may contribute to enhanced macrophage infiltration seen in SSc. Future studies will be done in mice with conditional Fli1 deletion in myeloid cells (LysMCreFli1loxP/loxP mice) to confirm the in vitro results. Additionally, the molecular mechanisms involved in the pro-migratory effects of myeloid Fli1 downregulation will be investigated. This research provides new insights into monocyte migration in disease.

**VEGFA Promotes Cholangiocyte-driven Liver Regeneration in a Chronic Liver Injury Mouse Model**

**Student Presenter:** Emily Truong
**Faculty Mentor:** Valerie Gouon-Evans (MED Medicine)
UROP Award

End stage liver disease (ESLD) is a common cause of death in the United States and the only prevailing treatment is liver transplantation, but this procedure is critically challenged by the shortage of organ donors. The liver is known for a remarkable regenerative ability through hepatocyte-driven regeneration, the proliferation of the main functional cell type of the liver, the hepatocyte. However, in ESLD, hepatocyte proliferation is exhausted due to the escalating progression of steatosis, inflammation, fibrosis and irreversible cirrhosis. Here we investigateda new strategy to promote regeneration through an alternative endogenous mechanism, specifically through a cholangiocyte-mediated repair. For this purpose, a lineage tracing mouse model was generated to test whether the transient delivery of vascular endothelial growth factor A (VEGFA) via injections of non-integrative VEGFA mRNA encapsulated in lipid nanoparticles (VEGFA mRNA LNPs) can promote the differentiation of cholangiocytes expressing its receptor vascular endothelial growth factor receptor 2 (VEGFR2/KDR) into hepatocytes. The mice were chronically injured with a choline deficient ethionine supplemented diet and hepatocyte proliferation was exhausted in order to mimic conditions seen in human chronic liver diseases developing steatosis. We found that VEGFA significantly promotes the differentiation of cholangiocytes into hepatocytes as well as virtually resolves steatosis. Thus, administration of clinically non-integrative and safe VEGFA mRNA LNPs could potentially serve as an exciting novel therapy for the human chronically injured livers by forcing cholangiocyte-to-hepatocyte conversion.

**In silico and Behavioral Analyses of CSNK2A1 Variants related to Okur-Chung Neurodevelopmental Syndrome**

**Student Presenter:** Prasida Unni
**Faculty Mentor:** Maria Isabel Dominguez (MED Hematology/Oncology)
UROP Award

Okur-Chung Neurodevelopmental Syndrome (OCNDS) is a recently identified rare disease associated with autism, global developmental delay, and intellectual disability for which there is no cure. OCNDS results from a heterozygous mutation in the CSNK2A1 gene which encodes CK2α, a serine/threonine protein kinase necessary for embryonic development. The function of the various CK2α mutations which lead to OCNDS must be determined, in order to develop therapies for patients with OCNDS. This study investigates CK2α missense mutations in OCNDS through (1) an in silico exploration of mutations and (2) the expression of select mutations in the Xenopus laevis animal model.First, missense mutations which lead to OCNDS were compiled from literature and several data repositories. In silico tools were used to predict the severity of the mutations based on evolutionary conservation, potential functional impact, and potential impact on protein stability. Then, the mutants R47Q, N161S, and R191Q were expressed in Xenopus laevis embryos. Behavioral touch assays were performed to compare the differences in behavior between control and CK2α mutant-expressing tadpoles.The CK2a mutants that were in top ⅓ of most affected mutants across all prediction programs were R312W, D156Y, D156H and P231R. In the behavior assays, R47Q and N161S injected tadpoles displayed a response pattern which differed from control.These results indicate that there may be a biochemical rationale for the damaging effects of certain OCNDS mutations, but further experimental data is necessary to determine the impact of each mutation in embryonic development and their molecular mechanisms.

**The Relationship Between Perceived Social Discrimination and Amygdala to Hippocampus Ratio Volume in Older Adults**

**Student Presenter:** Cheyenne Watts
**Faculty Mentor:** Karin Schon (MED Anatomy & Neurobiology)
UROP Award

The focus of the current research project is to investigate the relationship between stress related to interpersonal discrimination, cognition, subjective and objective memory, and neurocognitive Alzheimer's disease (AD) risk factors in Black American adults. The goal of this study is to examine whether greater stress related to social discrimination is associated with memory function and structural integrity of brain areas associated with memory and emotion processing. Data analysis was conducted using R-Studio on existing neuroimaging data from a previous related study, which was pre-processed using FreeSurfer 6.0, an automatic brain segmentation software. Covariates included age, sex, and education (n = 36). Our brain regions of interest, the hippocampus and amygdala, are both associated with responses to stress and underlie memory function. The posterior hippocampus is important for episodic memories. Along with the amygdala, the anterior hippocampus is also implicated in emotion processing. The amygdala processes emotional experiences such as aggression, anxiety, and fear, and modulates episodic memory. These brain structures are highly plastic regions that allow us to investigate the relationship between negative social experiences and brain structure. The primary hypothesis of this study is that greater social discrimination related stress is associated with a greater ratio of anterior to posterior hippocampal volume and greater ratio of amygdala to hippocampal volume. We compared both amygdala to hippocampal ratio, and anterior to posterior hippocampal ratio. This research provides background knowledge that will be essential in understanding how race-related stress is related to brain function and structure in the aging brain.

**Effect of Antibiotics Use in Outcomes in Subarachnoid Hemorrhage (SAH) Patients**

**Student Presenter:** Joanna Yang
**Faculty Mentor:** Anna Cervantes-Arslanian (MED Neurology)
UROP Award

Subarachnoid hemorrhage (SAH) is a life-threatening form of stroke. Approximately 72% of SAH patients develop fever, non-infectious and infectious, contributing to irreversible cognitive and functional impairments. Due to a lack of guidance regarding antibiotic use in the Neuro ICU in the setting of positive versus negative cultures, a retrospective review of 123 patients with non-traumatic SAH admitted to Boston Medical Center from 2014 to 2020 was completed. 80 patients (59 ± 15 years) received a course of antibiotics while 43 patients (52 ± 13 years) did not ($p = 0.01$). Patients with low-grade Hunt & Hess (HH) scores were less likely to receive antibiotics than those with high-grade HH scores (45.7% vs. 90.6%, OR: 11.4, $p < 0.001$). Receiving a course of antibiotics also leads to longer ICU (5.3 days) and hospital stays (7.5 days) and higher discharge modified Rankin Scale (mRS) ($p < 0.001$, $p < 0.001$, $p < 0.001$). Among the 80 patients, five had their stay complicated by C. difficile (6.25%). Among patients who started antibiotics while waiting or after culture results (n = 54), stopping antibiotics before the planned completion date leads to greater ICU and hospital days, antibiotics usage, and higher discharge mRS ($p = 0.004$, $p = 0.008$, $p < 0.001$, $p < 0.001$). These findings help support the hypothesis that patients who complete a full initial course have a shorter stay and better clinical outcomes due to prompt treatment. This points towards a possible discussion into changing antibiotics usage protocols for SAH patients.

## Improving the Accuracy of Glycan Structural Assignments with Stable Isotope Labeling

**Student Presenter:** Xiaoyu Zhang
**Faculty Mentor:** Catherine E Costello (MED Biochemistry)
UROP Award

Subtle glycan structural variation can have profound effects on their biological functions. For example, difference in the sialic acid linkage specificity of the virus receptors presents a major cross-species barrier preventing the avian influenza virus from easily infecting the human population. Electronic excitation dissociation (EED) tandem mass spectrometry (MS/MS) can provide structural details to define the glycan topology and linkages, although spectral interpretation may be complicated by the presence of isomeric fragments. Here, we employed stable isotope labeling to improve the accuracy in fragment assignments. Deuterium labels were introduced either to the glycan reducing end via reduction by sodium borodeuteride or in the form of per-deutero-methylation using iodomethane-d3. Derivatized glycans were analyzed by EED MS/MS. Deutero-reduction facilitates differentiation of reducing- and non-reducing-end fragments, whereas per-deutero-methylation leads to different mass changes among fragments providing information on the number of methylation sites. For native glycans, preferential loss of CH2OH over OH loss from Z-ions at 4-linkage sites is a reliable indicator for differentiation of 3- and 4-linkages. However, parallel reduction in the abundance ratio of Z-CH2OCH3 to Z-OCH3 ions at 3-linkage sites was not observed for permethylated glycans. Per-deutero-methylation revealed that 3-linked sites produced primarily Z-CD2OCD3 and 4-linked sites generated predominantly Z-CH2OCD3, thus affording their utility for determining the abundance ratio of Z-CH2OCD3 to Z-OCD3 ions for linkage differentiation in permethylated glycans. Our results showed that stable isotope labeling is an effective way to improve the accuracy of glycan structural assignments.

## The Effect of SARS-CoV-2 on Heart Muscle Cells: Comparison of Cultured Cardiomyocytes and Serum of COVID-19 Patients

**Student Presenter:** Allyson Zheng
**Faculty Mentor:** James Hamilton (MED Physiology and Biophysics)
UROP Award

Diagnosis of COVID-19 is based on the detection of the SARS-CoV-2 virus and often by the severe pulmonary manifestations in patients. However, many COVID-19 patients have often developed cardiovascular symptoms which can lead to prolonged hospitalization and heart failure, suggesting the need for further investigation on SARS-CoV-2's effect on the heart. We aimed to identify an optimal selection of proteins (biomarkers) in the blood for recognizing underlying cardiovascular comorbidities. We hypothesized that the heart-specific biomarkers Heart Fatty Acid Binding Protein (H-FABP) and cardiac Troponin-T are released from heart muscle cells (cardiomyocytes) after membrane damage by SARS-CoV-2. We quantified these biomarkers in samples from SARS-CoV-2-infected patients' blood and from cultured cardiomyocytes after exposure to lipopolysaccharide (LPS), a molecule that contributes in COVID-19 infection with SARS-CoV-2. We will perform the same assay on cardiomyocytes infected with SARS-CoV-2, and expect it to further confirm our hypothesis. We observed increased H-FABP and Troponin-T concentrations from cells cultured with higher LPS doses and longer incubation times. Biomarker concentrations in the serum were significantly higher in the SARS-CoV-2-infected samples than the controls, consistent with our predictions of higher leakage of these proteins from damaged cells. By acting as an initial screening for overlooked cardiovascular conditions, these quantitative measurements of heart-specific biomarkers have the potential to create a rapid standardized test that provides patients with optimal and individualized treatment upon hospitalization. With new SARS-CoV-2 variants that challenge the efficacies of current vaccines, this test will prove to be an essential tool for the most reliable medical care.

# *Computational and Mathematical Sciences*

### Transverse Modulational Dynamics of Patterns

**Student Presenter:** Sierra Dunn
**Faculty Mentor:** Ryan Goh (CAS Mathematics)
Symposium Volunteer

We study transverse modulational dynamics of striped pattern formation in the wake of a directional quenching mechanism. Such mechanisms have been proposed to control pattern-forming systems and suppress defect formation in many different physical settings, such as light-sensing reaction-diffusion equations, solidification of alloys, and eutectic lamellar crystal growth. Furthermore, they are a simple model of a growth process in a patterned biological system. In the context of the complex Ginzburg-Landau and Swift-Hohenberg equations, two prototypical models of pattern formation, we show that long-wavelength and slowly varying modulations of striped patterns are governed by a one-dimensional viscous Burgers equation, with viscous and nonlinear coefficients determined by the quenched stripe selection mechanism. This reduced model allows for accurate description of defect dynamics as shock/rarefaction dynamics.

### Extreme heat: Wet-Bulb Temperature Hot Spots in East Oklahoma & Implications for Heat Vulnerability & Policy

**Student Presenter:** Harrison Friedman
**Faculty Mentor:** Daniel Sussman (CAS Mathematics)
UROP Award

Climate change has exacerbated heat stress in many areas, and heat stress is most deadly when paired with high humidity. According to a recent study, the wet-bulb temperature (which takes humidity and air pressure into account) of 35 degrees Celsius is the limit for human survival when one is exposed for over six hours. To analyze which places in the world are approaching this threshold, this study used RStudio to analyze 43 years of NOAA data and determine where the most dangerous spots can be found. By mapping both extreme temperature as well as frequency, we were able to find both the most extreme temperatures in the world as well as in the United States. Eastern Oklahoma is home to the worst spots in the United States, as it is the only place in the US in which weather stations recorded wet-bulb temperatures of 30 degrees Celsius. We also created a heat vulnerability index, which was based on previous studies that had also created one, and found that these locations were statistically more likely than other parts of Oklahoma to be vulnerable to rising temperatures. Finally, using time-series methods, we projected the near-future wet-bulb temperatures in the area to predict how much closer the temperatures will come to the threshold.

### A Topological and Non-Euclidean Dynamic Model of Biological Membranes and Viral Infection

**Student Presenter:** Alexander Novakovic
**Faculty Mentor:** Emma Previato (CAS Mathematics)
UROP Award

Membranes organize reactions and form the boundary passageway of the most fundamental unit of life, the cell. This research presents novel mathematical models to evaluate the dynamic structure of cell and viral membranes, and describes their deformation and pinching during a variety of processes, such as cytokinesis, fertilization envelope formation, and viral endocytosis. The membrane shape is determined by a variational principle, and the properties of the life cycle and viral infection mechanism are evaluated and compared from a geometric and physical perspective. The topological model of this work unveils the dependence on the permeability and structural stability of portions of the membrane. Differential geometry is used to characterize the cell-level fusion and splitting characteristic of fertilization and cytokinesis, respectively, using curvature. Bulk transport processes, understood using the fluid mosaic model of continuous membrane deformation, are examined in terms of geometric properties which remain invariant (ie topologically) under continuous changes. Laboratory digital media of cytokinesis, fertilization, and bulk transport are analyzed computationally using Open Source Physics Tracker Software to extract dynamic geometrical properties of membranes and compare with the theoretical modeling, based on the number of membrane layers, chemical composition and distribution characteristic to each of these biological processes. Applications to mature neuron and myocyte quiescence, and sperm alignment with oocyte microvilli, are discussed along with a case study of the novel coronavirus. A proposal that unifies the deformation and differential geometry models is presented for the detectability of the exit of the prevalent virus from the host cell membrane

### Clinical Validation of a Deep-Learning Based Model To Predict Lung Cancer Risk from Chest X-Rays

**Student Presenter:** Anika Walia
**Faculty Mentor:** Vineet Raghu (MET Computer Science)
UROP Award

Lung cancer is the most common cause of cancer death. Eligibility for lung cancer screening is determined by Centers for Medicare and Medicaid Services (CMS) criteria which rely on smoking status, pack-years (packs smoked per day * years of smoking), and years since quitting, information that may not be available in the electronic medical record (EMR). Chest X-rays (CXRs) are the most common diagnostic imaging tests in medicine, and currently unused information in CXRs may inform lung cancer risk. Our lab has shown that a deep learning-model CXR-LC can estimate 12-year lung cancer risk using data readily available in the EMR. We hypothesize that CXR-LC can be applied to more patients than CMS criteria and better predicts 12-year lung cancer incidence. In a cohort of 13,722 patients not diagnosed with lung cancer, who had at least one CXR between 1/1/2013 and 12/31/2014, 32.5% of patients had enough information documented to determine CMS screening eligibility. A cox regression showed CMS eligible patients, according to EMR data, had a 2.7 times greater risk of lung cancer than ineligible patients, similar to previous reports. Next, we will input these patients' CXRs and data into CXR-LC and test if CXR-LC better predicts incident lung cancer than current CMS criteria. Additionally, we have developed a webserver to host our models and plan to add CXR-LC for public use. These results suggest that CXR-LC may be easier to calculate using available EMR data

**Fractal Analysis of the Urbanization Development in Boston: 2000-2020**

**Student Presenter:** Junze Yin
**Faculty Mentor:** Emma Previato (CAS Mathematics)
UROP Award

The existing research about fractal analysis focuses on analyzing urbanization via the contour of cities based on their satellite images. The cities' contour (or boundary) resembles a coastline, which does not have a regular shape. Fractal analysis is an indicator of urbanization because it measures the urban sprawl, which is the degree of fragmentation and transition from monocentric to polycentric structures. The fractal dimension is an index that describes the complexity of a geometric object: if when measuring the object we scale the unit by $\epsilon$ and the measure gets scaled by $N$, then the fractal dimension $D$ is defined by$${\displaystyle {\log_{\epsilon }{N}={-D}={ {\log {N}}\over{\log {\epsilon }}}}}. $$Our goal is to create a visual representation for the changes of Boston's metropolitan area and its growth rate, and to do so we analyze its fractal dimension. Two methods, box-counting and radial analysis are utilized to estimate Boston's fractal dimension, based on census data. A longitudinal study is lacking. We estimate the fractal dimension of Boston over the past 37 years by a time series, and by non-linear regression we project the future extent of Boston's urbanization. By an exclusion algorithm, we also analyze the fractal dimension of Boston boroughs, to bring out the fractal (self-similar) nature of the city.We compare planimetric maps with satellite images and comment on superior features of one or the other. Lastly, the logistic equation is postulated as a model to fit the data of the change of fractal dimension throughout these years.

# *Engineering*

### Measuring Lyman-Alpha Emissions with GISSMO

**Student Presenter:** Adam Bahlous-Boldi
**Faculty Mentor:** Brian Walsh (ENG Mechanical Engineeering)
UROP Award

Our current knowledge of the Earth's exosphere is quite limited, especially considering its importance and impact on space flight and space weather close to the earth. To analyze its behavior, the GLIDE (Global Lyman-alpha Imagers of the Dynamic Exosphere) mission will analyze its interaction with Lyman-alpha, a spectral emission from hydrogen in the sun. GLIDE is a part of NASA's RideShare project and will be launching alongside the IMAP mission in 2025.

Our project, GISSMO (GLIDE solar spectral monitor) is a part of the greater GLIDE mission, aiding by providing it with Lyman-alpha and soft X-ray emissions to act as a control variable. 2 Lyman-alpha filters are stacked, filtering out undesired wavelengths of light. After the filters, the target light is incident on a sensitive photodiode, which converts the photons into a very small electrical current. Finally, this current is fed through a transimpedance amplifier and read into an ADC. I worked on tackling the challenge that is the technical aspect of the design of the photodiode current detection board and transimpedance amplifier, while also mitigating electrical noise. This was made difficult by the fact that the output currents are in the Nano Ampere (10^-9) range, making it difficult to reliably detect. My initial board and amplifier design made great strides towards being able to measure Lyman-Alpha emissions for GLIDE. Additionally, work was done on mathematically modeling the transmission of light through the filters, to predict exactly how
small the photodiode output will be.

### Engineering Protein Signal Peptides for More Effective WNT Ligand Secretion from Endothelial Cells

**Student Presenter:** Shirin Bakre
**Faculty Mentor:** Christoper Chen (ENG Biomedical Engineering)
UROP Award

Scientists often synthetically overexpress secreted proteins in order to study the drivers of various biological processes, such as regeneration and vascularization. Unfortunately, these studies are frequently hindered by the insufficient secretion of these proteins of interest. One such poorly secreted protein, WNT2, is being studied in our lab for its role in liver regeneration. This project seeks to enable these studies by engineering a more effectively secreted WNT2 protein. To do this, the signal peptide sequence, a primary determinant of secretion efficacy, can be engineered to improve protein secretion. A literature search was performed to identify three high-affinity signal peptide sequences, Azucridin, Human Albumin, and Tissue-Type Plasminogen Activator. Using Gibson Assembly, the identified signal peptide sequences were incorporated into a doxycycline-inducible (TET) backbone. Human endothelial cells were engineered to express the modified WNT2 proteins, via virus infection. qPCR was used to confirm the genetic expression of WNT2 at similar levels across all experimental conditions. Western Blot was used to determine the ratio between intercellular and extracellular WNT2 protein, and a WNT reporter assay was leveraged to validate the functionality of our engineered WNT2 proteins. This data will allow us to nominate the optimal signal peptide for improved WNT2 secretion for further studies in the lab. Although the results of this project focus on the optimization of WNT2 secretion, we expect that they will be generalizable to other secreted proteins of interest, thereby enabling ongoing investigations of various biological mechanisms within our laboratory and beyond.

## Modeling Elastogranular Interactions via Simulation

**Student Presenter:** Joshua Bender
**Faculty Mentor:** Douglas Holmes (ENG Mechanical Engineering)
UROP Award

Elastogranular interaction is the interaction between elastic materials and granular matter. There are many examples of this interaction in nature, most notably being the interactions between plant roots and soil. The interplay between the mechanics of a slender structure such as a root and the surrounding medium provide a fascinating example of the nonlinear behaviors of the structure such as bending and buckling. This research focused on developing simulations using the molecular dynamics simulator LAMMPS (Large-scale Atomic/Molecular Massively Parallel Simulator). We were able to create a model that accurately simulated the force required to pull an elastic material (string) out of granular matter (beads). The simulation output was compared with data from experiments performed in the lab over 10 trials to verify results. After the LAMMPS model was verified, more experimental simulations were attempted (and are still in progress). This involved vibrating a particle at the end of the elastica to allow it to actively dig. We concurrently performed tests in the lab by vibrating a string in multiple different types of granular matter to explore what regimes of density and diameter are feasible to dig in. Our current findings show that the active root works best in low density, large diameter grains. Once the simulation model is complete we can sweep through a greater range of variables for the granular matter and test more advanced root formations that would be difficult to create in the lab.

## Conditioning Neural Progenitor Cells for Transplantation into Injury Environments in the Central Nervous System

**Student Presenter:** Gabriela Berniac
**Faculty Mentor:** Timothy O'Shea (ENG Biomedical Engineering)
UROP Award

Central nervous system (CNS) injuries such as stroke, traumatic brain injury, and spinal cord injury often result in long term disabilities for patients such as speech and language impairment, memory loss, and paralysis. Both the body's natural wound-healing response and current clinical treatments do not enable sufficient neural tissue repair necessary for functional recovery. Cell transplantation has emerged as a promising strategy for promoting repair of CNS injuries. However, injury environments contain molecular cues from blood and serum proteins that can harm transplants, limiting repair outcomes. This project aims to condition mouse neural progenitor cells (NPCs) prior to transplantation using fetal bovine serum (FBS). Using this conditioning approach, we hypothesize that cells will be triggered to differentiate into immature astrocytes that may help repair lesion cores more effectively than host cells or non-conditioned NPC transplants. To condition NPCs, we applied different concentrations and durations of FBS exposure before returning cells to serum free maintenance media conditions. Using RT-qPCR and immunocytochemistry, we analyzed gene and protein expression changes for neural stem cell and astrocyte markers. Data showed that cells receiving cyclic exposure to a low concentration of FBS differentiated into cells that had elevated expression of astrocytic markers compared to unconditioned NPCs. Our results suggest that these conditioned NPCs represent a promising candidate for transplantation into mouse CNS injury lesion cores. Further studies will focus on optimizing the conditioning regime applied to NPCs prior to transplantation as well as analyzing repair outcomes in stroke mouse models using the conditioned NPCs.

### Fisheye Re-ID: Reliably Counting People in Large Indoor Spaces

**Student Presenter:** John Bolognino
**Faculty Mentor:** Prakash Ishwar (ENG Electrical & Computer Engineering)
UROP Award

Person re-identification is the task of matching images of the same person captured at different times or by different cameras. Many methods utilizing convolutional neural networks (CNNs) have been formulated for person re-identification in images captured by standard cameras, but their performance on overhead fisheye images is unknown. This research evaluates the performance of eight popular re-identification methods on a hand-labeled dataset of overhead fisheye images. The selected methods have been reported to achieve over 75% mean Average Precision (mAP) on Market-1501, a public re-identification dataset of standard images. Their performance on our fisheye-image dataset was evaluated as follows. First, each image was fed into the CNN of a given method and a feature vector was extracted from the last layer. Then, cosine similarities of all pairs of query and gallery image feature vectors was computed. Finally, a greedy algorithm was used to match query-gallery image pairs using their cosine similarities. Performance was assessed using the so-called query matching score (QMS). The tested methods produced 48-62% QMS with ResNet50 giving the highest score. This result is surprising since ResNet50 is the backbone of several other methods, most of them outperforming ResNet50 on Market-1501. It is unclear whether this is due to using QMS instead of mAP as the performance metric or using fisheye instead of standard images. Therefore, in my future research, I am planning to reevaluate these methods on Market-1501 using QMS. This should reveal the impact of fisheye distortions on re-identification performance.

### Print Path Routine for Multimaterial 4D Printing Applications

**Student Presenter:** Sophie Caplan
**Faculty Mentor:** J. William Boley (ENG Mechanical Engineering)
UROP Award - Clare Boothe Luce Summer Undergraduate Scholar

Four dimensional printing is a form of additive manufacturing that 3D prints objects using custom inks which cause the object to shape shift over time in response to programmed stimuli. Suitable inks for Direct Ink Writing (DIW) are developed at the Additive Assembly Laboratory (AAL) and printed through a customized Computerized Numerical Control (CNC) machine. The alignment of an ink's print path is pivotal to studying its properties at the material level, however creating such print commands was previously tedious and largely uncustomizable. This research focused on enhancing the print path routine of the machine by developing a slicer in order to provide AAL with a means to design an object using Computer Aided Design (CAD) software and print it with either a longitudinal or tangential infill alignment. This slicer was developed in stages, starting with a study of Standard Tessellation Language (STL) files, triangulated surface representations of CAD models. Several algorithms were then written for varying levels of shape complexity to sort through the file and define an object's boundary lines. Infill print paths are determined by defining either longitudinal or tangential pathways to consecutive boundary lines throughout the object. The slicer code was written directly into a Python subclass of the CNC machine's language and is therefore easily shared across the lab. With a means to print a CAD model with custom infill alignment, greater focus can be placed on studying novel inks' properties and achieving more complex 4D prints.

## HappyCell - Your Genetic Design Helper

**Student Presenter:** Roy Chen
**Faculty Mentor:** Radhakrishna Sanka (ENG Computer Engineering)
LCP - Stem Pathways

The genetic design had always been complicated and time-consuming, that's why we created HappyCell. HappyCell is a web helper that is more fit to our Lab, where its functionality includes: Visualize plasmid and genetic circuit, error checking the genetic design assembly, and a built-in database.

But since there are a lot of genetic design helpers that create plasmids from a Fasta file around, people should choose HappyCell compared to others for the following reasons. First, it reduces reliance on lab personnel since everything is done on the website. Second, since it's done by a machine, it increases the reliability of genetic assembly, reducing the cost of failed experiments. And third, it has an assembly kick-off and monitoring service, for example, you can monitor the progress of the experiment on your laptop at home.

HappyCell has a lot of potential for more purposes, where in the future we could maybe integrate other parts of the lab into HappyCell and make it into a bigger website.

## High-throughput Finite Temperature Properties of 2D Materials from First Principles

**Student Presenter:** Quentin Clark
**Faculty Mentor:** Sahar Sharifzadeh (ENG Electrical & Computer Engineering)
UROP Award

The automated resource-efficient simulation of atomistic properties of crystals at finite temperatures has potential in the guiding the development of future materials. This project builds an automated workflow to run a set of density functional theory (DFT)-based calculations, combined with a novel formalism relating the phonon dispersion to changes in material properties at finite temperature. The goal is to find statistical relationships between DFT-predicted zero-temperature properties and finite-temperature observables for a database of two dimensional materials. My role in this project was to develop a full Python framework to connect the various components of the calculation pipeline together, to enable full automation of the calculation workflow, significantly saving researcher oversight time and reducing points of possible human error. The DFT and density functional perturbation theory (DFPT) calculations were both run using the Quantum ESPRESSO (QE) software suite. Parsers and data manipulation objects were written and tested for the QE phonon calculator. Automating the handling of the data between the various calculators and data sets/materials taken from other research were done by simpler Python scripts largely utilizing the numerical library Numpy and Atomic Simulation library ASE. The project is currently in progress. As of now, the framework has been set up and completed up until the Zacharias-Giustino formalism (the equations connecting DFPT to material properties at higher temperatures). Future work on the project will complete the setup of the overall automation script and run the script over a large set of materials before identifying phenomenological relationships between calculation parameters and temperature.

### Classifying States of Anesthesia in Mice using Electrical and Optical Activity

**Student Presenter:** Elisa Cordeiro Lopes
**Faculty Mentor:** John White (ENG Biomedical Engineering)
UROP Award

Anesthetics have been well-characterized in neuroscience research at the molecular and system levels, however, they are not well understood at the mesoscale level. It is important to understand how anesthetics affect the brain since they impact neural development in infants and surgical recovery in the elderly. Therefore, this research used multimodal optical and electrical recordings at different stages of the anesthesia to explore its effects in mice. In addition to the clinical benefits, the project also provides a relationship between the electrical activity, which is better understood, and the optical fluorescence activity. The approach was to develop an algorithm to preprocess, filter, and extract relevant features of the data. First, the data was filtered to remove noise. Then the algorithm would identify mice movement and different features related to the different stages of anesthesia. With the corrected and labeled data, the spectral content of signals were analysed, showing how the frequencies and power change over time. The emergence of oscillations depending on anesthesia state was analyzed and, the coherence between the electrical and optical activity was established, informing how similar they are. The results show an increase in lower frequency power in deeper stages of anesthesia. Finally, in addition to identifying features of anesthesia signals with the algorithm, these results can be used for training and testing of an anesthesia-state classifier, which can be used to monitor the depth of anesthesia in patients during surgical procedures.

### Increasing the Throughput of an Autonomous Experimentation System for Mechanics

**Student Presenter:** Sebastian Diaz
**Faculty Mentor:** Keith Brown (ENG Mechanical Engineering)
UROP Award

Additive manufacturing, commonly known as 3D printing, can produce a wide range of complex structures. While this is useful for creating complex structures, it also emphasizes the challenge of identifying the best structure for a given application. We are addressing this challenge through an autonomous experimentation (AE) system that can decide the best designs to test and then test a large number of samples with little to no human interaction. When compared to humans testing these samples manually, this AE system is faster, more consistent, and more effective in identifying useful experiments. Specifically, the AE system consists of five 3D printers that consistently print designs, a robotic arm that moves the printed samples, a scale to weigh the samples, and a universal testing machine to evaluate the mechanical properties of the samples. The main goal was to increase the throughput, namely the rate at which samples were tested. This involved programming the robotic arm to make effective movements and incorporating new design features to increase the effectiveness of the system, such as a scraper system to clean the printers. Initially, only 50 samples were being tested per week; however, towards the end of summer, the system produced and tested over 350 samples in a single week. Our future target is to analyze 500 samples a week, which will allow us to rapidly find structures with highly optimized mechanical properties. This approach represents a paradigm shift in the way that mechanical components are designed for high performance and safety critical applications.

**Characterizing eLightOn for E. coli; a Single-Component, Highly Tunable, Optogenetic System**

**Student Presenter:** Alexandra Dolynuk
**Faculty Mentor:** Mary Dunlop (ENG Biomedical Engineering)
LCP - Stem Pathways

Optogenetics allow light to control gene expression as a fast, precise, and reversible alternative to chemical triggers. One particular system, eLightOn, is a simple and robust mechanism that switches expression "on" when exposed to blue light. Compared to other optogenetic systems, eLightOn has a high induction fold, fast activation kinetics, and high adaptability. This system employs LexRO, which dimerizes and binds to its cognate operator sequence, repressing gene expression, in the dark. Upon blue light exposure, the LexRO dimer dissociates and initiates expression. Activation time and leaky expression can be tuned by LexRO content.

This research characterizes eLightOn in E. coli by modeling its activation kinetics based on time and intensity of exposure and by examining this system at the single-cell level. Activation kinetics were tested using a Light Plate Apparatus and an Optoplate, which illuminated wells at different timepoints or intensities. We examined single cell behavior of darkened cells and their reaction to blue light through a microscope by measuring expression of red fluorescent protein. We found that eLightOn has an activation time of 150 minutes and that the activation kinetics fit a Hill function. Also, light at different intensities induces variable gene expression, even after long exposures. These results highlight the effectiveness and tunability of this optogenetic system. As a future application, it will be interesting to switch out the fluorescent reporter gene for an antibiotic resistance gene to determine whether leaky expression is reduced enough for eLightOn to serve as an effective system to control antibiotic resistance.

**Improving CT-based Lung Cancer Diagnosis Via In Silico Deformation Mapping Biophysical Characteristics of the Lungs**

**Student Presenter:** Delaney Dow
**Faculty Mentor:** Hadi Nia (ENG BME)
UROP Award

Lung cancer is commonly diagnosed with CT scans and continues to have low survival rates. Finding a means to diagnose tumors as malignant earlier minimizes the possibility of misdiagnosis and could improve the survival rate for patients. Deformation mapping takes consecutive CT scans and overlays them to produce a heat map whose magnitude represents the change between the two scans at any particular point. This project analyzed those differences and created metrics that could improve the detection of malignant tumors
The study generated deformation maps from CT scans between a control group and experimental group. Both groups had a lung abnormality detected in their initial and second screenings; in the second year, the experimental group received a malignant diagnosis whereas the control group did not. A MATLAB program generated several metrics from each patient's deformation map to obtain information such as the maximum magnitude of deformation in the area of the tumor. Those metrics were averaged among the two groups (experimental vs. control) to determine any significant differences between the two groups for a particular metric.
While the study is still ongoing and no conclusive results have yet been determined, the goal of the study will be to continue to analyze particular metrics to determine if there is a statistical significance between the two groups or not. Once this significance can be determined, the implications of this study could lead to decreased levels of misdiagnosis for lung cancer tumors to ultimately increase the survival rate of patients with lung cancer.

### Small Scale COVID-19 WasteWater Surveillance at Boston University

**Student Presenter:** Soumaya Fayie
**Faculty Mentor:** Catherine Klapperich (ENG Biomedical Engineering)
UROP Award

During the COVID-19 pandemic, municipalities and institutions are using environmental surveillance to detect the SARS-CoV-2 virus through wastewater. Studies have shown the virus is detected in mucus through nasopharyngeal, anterior nare, and saliva swabs but is also detectable through fecal viral shedding. Due to how infectious SARS-CoV-2 is and the new presence of the Delta variant of the virus, another form of detection will help Boston University (BU) keep track of cases this upcoming fall semester. This study targets the patient's fecal matter through wastewater to detect SARS-CoV-2 RNA and Pepper Mild Mottle Virus (PMMoV), a human fecal extraction control, by concentrating wastewater samples, extracting nucleic acid, and testing the samples using an RT-qPCR assay.Wastewater samples are collected from a BU dormitory and taken to our laboratory to concentrate, filter, and store. The purpose is to isolate the RNA of the virus from concentrated samples. The samples are 24 hours composites and are divided into composites for each day. All samples are tested using an RT-qPCR assay for SARS-CoV-2 or PMMOV. During the study, PPMOV has been positively detected in the samples collected, confirming that fecal samples are detected in wastewater. Additional studies are being done to determine if SARS-CoV-2 is detectable in the samples. For future works, the aim is to continue collecting samples and optimizing the concentration and filtering processes to detect the SARS-CoV-2 virus in the RT-qPCR assays.

### Using Computational Modeling to Optimize Carbon Capture Systems

**Student Presenter:** Sofiya Filippova
**Faculty Mentor:** Emily Ryan (ENG Mechanical Engineering)
UROP Award

Computational modeling is used to run simulations of experiments on computers, rather than completing the physical experiment which can be very costly. Carbon capture is the process of filtering out carbon dioxide from flue gas, also known as exhaust gas, in order to prevent them from entering the atmosphere. In our research, we want to understand the relationship of temperature and velocity of flue gas in an enclosed carbon capture device developed by a private company. Since running many iterations of the physical experiment is costly in terms of both time and materials, we run high fidelity simulations of the carbon capture instrument instead. We run simulations of the model of the carbon capture device with different values for the initial velocity of the flue gas and measure the CO2 concentration at the outlet in each simulation. In doing so, we are able to find the optimal velocity of the flue gas at which the majority of the carbon dioxide is captured, while protecting the filter from being damaged by high temperature resulting from reaction heat.

**Testing of Short-Wave Infrared Probe for Tissue Water and Lipid Monitoring during Hemodialysis.**

**Student Presenter:** Jodee Frias
**Faculty Mentor:** Darren Roblyer (ENG Biomedical Engineering)
UROP Award

Hemodialysis is a treatment option for patients with end-stage kidney renal disease with a purpose of removing excess amounts of waste and fluids. An unmet clinical need is the ability to properly quantify the amount of fluid to be removed. With the goal of quantifying the tissue water and lipid content of patients undergoing hemodialysis, we have developed a wearable probe utilizing short-wave infrared (SWIR) light (900-1300 nm), characterized the system performance through both simulated and in vitro measurements, and validated its ability to quantify water and lipid content through in vitro and in vivo measurements. Solid tissue-mimicking phantoms of different lipid concentrations (5%, 10%, 15%, 20%), which were fabricated using heavy cream and water, were utilized to characterize performance and determine the probe's ability to measure water-lipid content within tissue. Measurements conducted demonstrated high precision (0.08% coefficient of variation for 980 nm at 5mm), low drift (0.1%/hour), and high signal-to-noise ratio at the 5 mm source-detector separation (40 dB). Contrast was observed between the different concentrations of phantoms measured. In vivo measurements were taken on a subject's forearm using lotion (hydrating) and acetone (dehydrating) to demonstrate the ability to monitor hydration over time. Skin hydration via lotion created a greater change in voltage than applying no treatment. These results suggest that this technique is clinically relevant for the quantification of water and lipid in tissue. In the future, our device may represent a new clinical tool for more quantitative assessment of volume status in hemodialysis patients.

**Connected Vehicles in Vehicular Network Simulations**

**Student Presenter:** Arturo Garcia
**Faculty Mentor:** David Starobinski (ENG Electrical & Computer Engineering)
UROP Award

Connected vehicles will be a major innovation to transportation services in society. If vehicles can communicate with their surroundings, transportation can be more efficient in terms of cost, safety, and speed. In our research, we originally intended to study one of the existing technologies for vehicular communications, namely Cellular Vehicle-to-Everything (C-V2X). As defined in the 3GPP Release 14 Mode 4, C-V2X is a distributed network where vehicles self-manage the resource blocks available. Particularly in Mode 4 that lacks a cellular infrastructure to monitor the network, there are several adversarial attacks that can have significant consequences on the network. Specifically, we planned to simulate Denial-of-Service (DoS) attacks on the network using Vehicles in Network Simulation (Veins), a high-fidelity framework for vehicular simulations, to showcase their effectiveness. However, due to Veins' complexity and our limited time, we were not able to build our desired simulator. As a result, we changed our plans to build a simpler network only using one of the components of Veins: Omnet++. We are currently working on creating a network of nodes based on the IEEE802.11 protocol. Once we accomplish this task, we will add complexity approaching our desired vehicular network and will analyze it.

**Development and Characterization of Soft Robotic Arm for Minimally Invasive Intracardiac Surgery**

**Student Presenter:** Kiran Gomatam
**Faculty Mentor:** Tommaso Ranzani (ENG Mechanical Engineering)
UROP Award - Clare Boothe Luce Summer Undergraduate Scholar

Soft surgical robotics utilizes flexible material in order to interact safely with the human body. This project focused on designing, fabricating and characterizing a soft robotic arm with applications in minimally invasive intracardiac surgery. The developed soft robotic arm, in comparison to conventional minimally invasive surgical tools, has improved maneuverability by allowing for three degrees of freedom of movement in addition to vertical expansion and contraction. Fabrication of the arm consisted of alternating layers of thermoplastic elastomer and teflon. Thermoplastic elastomer bonds to itself under heat and pressure, and teflon acts as a non-stick mask. In series, these polymers create a stacked, three-column, multi-balloon structure that moves when fluid is pumped into it. A channel, located centrally between the three balloon-columns, enables surgeons to guide small tools in the heart by controlling the soft robotic arm. This arm design required modifications in order to satisfy size constraints made by the clinical collaborator. Updating the design and optimizing the fabrication process led to a successful, miniaturized arm and characterization of this miniaturized arm proved that size constraints were close to being met. With minor design modifications, these requirements will be satisfied, enabling surgeons to have improved dexterity during minimally invasive procedures.

**Exploring the Role of Akt Isoforms on the Morphologic and Migratory Behavior of Breast Cancer Mutants**

**Student Presenter:** Veronica Hui
**Faculty Mentor:** Christopher Chen (ENG Biomedical Engineering)
UROP Award

Over 70% of patients with breast cancer, the most common non-skin cancer in American women, harbor some dysfunction in the PI3K-Akt-mTOR signaling axis, a pathway that regulates cell proliferation, growth, and migration. Interestingly, recent work suggests that not all PI3K pathway mutations are functionally redundant. It is known that different Akt isoforms drive distinct changes in cell behavior, but the mutation-specific Akt isoform dependencies are unknown. This study investigates the role of Akt isoforms on two of the most common breast cancer mutations, ErbB2 amplification and PIK3CA H1047R, to investigate if either isoform is necessary for mutant-specific migratory and morphological differences. Cells were grown in a 2D confluent monolayer and stained with E-cadherin and Edu to quantify cell shape, size and proliferation, or scratched and imaged over time to analyze scratch wound closure. FIJI and CellProfiler image analysis softwares were used to analyze the time-lapse and immunofluorescence images for migration and morphology. Initial analysis suggests that different Akt isoforms foster distinct behaviors in the shape, proliferation, and migration of each mutant, but further experiments will need to be conducted for a higher statistical power. Ongoing work will focus on the relationship between Akt isoform and breast cancer mutant in 3D, which can be elaborated using our lab's 3D mammary duct-on-a-chip to investigate similar behaviors. This research will provide a deeper understanding on the role of Akt isoforms on mutation specific tumor progression, potentially enhancing therapeutic options for patients harboring these mutations.

### A Statistical Study on Fast Plasma Streams in the Inner Magnetosphere

**Student Presenter:** Abdelaziz Hussein
**Faculty Mentor:** Toshi Nishimura (ENG Electrical & Computer Engineering)
UROP Award

Recently, a new type of optical emission in the Earth's upper atmosphere (>100 km altitude) called Strong Thermal Emission Velocity Enhancement (STEVE), has been observed as a narrow glowing ribbon of purple light that extends east-west in the night sky. STEVE is associated with a fast, narrow stream (1°-2° in latitude) of hot ionized gas, called Subauroral Ion Drifts (SAID). The objective of my research was to determine the difference between the inner magnetospheric conditions during SAID and wider (3°-5° in latitude) fast ion flows called Subauroral Polarization Streams (SAPS). This research was completed through a statistical study using NASA's THEMIS spacecraft as well as NASA's Van Allen Probes (VAP) data, finding 360 SAID events and 420 SAPS events. We found that the separation between the ion and electron boundaries is larger for SAPS compared to SAID. Moreover, we found an excitation in electric and magnetic waves within the flow channel for SAID, which could be a source of heating for STEVE. Understanding the mechanism by which STEVE is generated goes beyond the scientific advancement of knowing what causes a glow in the night sky. STEVE is associated with steep plasma density gradients, which scatter radio waves propagating through the upper atmosphere, causing disruptions in the transfer of signals that we rely on in our daily lives; such as GPS signals and communication with commercial satellites in space. Thus, understanding STEVE and SAIDs is crucial for enhancing mitigation efforts of space hazards which affect our daily lives.

### Developing an Origami Soft Robotic Needle Deployment Mechanism for Endoscopic Procedures

**Student Presenter:** Taylor Janke
**Faculty Mentor:** Sheila Russo (ENG Mechanical Engineeering)
UROP Award - Clare Boothe Luce Summer Undergraduate Scholar

In the past few years, lung cancer has caused millions of deaths worldwide due to difficulties obtaining tissue samples. The purpose of this research is to create a device that simplifies the lung biopsy process in an inexpensive way. The end goal is to have the procedure conducted more safely and decrease the overall cost so that more people will be able to get the testing they need. The origami needle deployment mechanism that I manufactured is small enough to fit on more stable devices, while also being able to expand steadily with inflation. The doctor would be able to look through a camera and remotely control exactly where the needle should be deployed allowing for the desired piece of tissue to be obtained; this cannot currently be done. In designing this prototype, I originally used paper and a silicone elastomer, but quickly realized that I could not fold it small enough to achieve the desired dimensions. I then changed methods and used a laser cutter and heat press to combine layers of differing shapes of thermoplastic elastomer (TPE) and Teflon, which allowed the prototype to be significantly smaller. The end goal is to have the diameter be around 2mm which could attach to a bronchoscope or a catheter that someone else in my lab is working on. The next steps would be to attach a needle to the top of the prototype and measure the forces the device is able to achieve, completing the device.

## Microfluidics Reimplemented

**Student Presenter:** Jude Kamoona
**Faculty Mentor:** Radhakrishna Sanka (ENG Engineering)
LCP - Stem Pathways

3DuF is a microfluidic CAD web application, developed in conjunction with CIDAR lab, which provides researchers with standard microfluidic design tools and library that makes it easy, replicable, and more hassle-free than ever before to create microfluidic chips. The research conducted investigated the frontend software of 3DuF and implemented a rehaul of the plain Javascript code to the robust framework, Vuejs. The latter was chosen over Javascript due to its increased responsiveness and decreased bugs, due to the decoupling of components. To investigate the current UX issues, usability interviews were conducted with microfluidic researchers, as well as, understanding Vuejs and the abilities and limitations of its UI library. The following guided the steps to redesign the components which users were encountering problems with, along with, porting the whole web application to the new framework.The implementation of 3DuF in Vuejs provided smoother transitions between the interactions of different components such as how the components are called through the menu, and improved features like the Import Border function. Furthermore, the porting of the UI to Vue allowed for more researchers and community members to contribute to the open source code without the need to understand the vast intricacies of the large code base. Now, the new and refined look enables users to understand the full functionality of all 3DuF has to offer due to the new design and added simplicity.

## The Role of Glucose in Tendon Explant Health

**Student Presenter:** Brandon Kao
**Faculty Mentor:** Brianne Connizzo (ENG Biomedical Engineering)
UROP Award

For athletes and aging adults alike, tendon and ligament injuries are a common and debilitating problem, accounting for 20-30% of all musculoskeletal injuries. Studies have shown that individuals with type II diabetes are 4 times more likely to experience tendinopathy than non-diabetics. However, the pathogenesis of diabetic tendinopathy has yet to be understood. Therefore, I studied the role of glucose in tendon explant health in order to gain insight into how glucose levels may lead to tendinopathy. Our hypothesis was that high glucose levels would reduce metabolic activity and collagen synthesis. Mouse flexor digitorum longus tendon explants were harvested and cultured in a stress deprived environment for 7 days in media of varying glucose concentrations: 0g/L, 1g/L, 4.5g/L. After 7 days, the tendons were assessed for differences in viability and metabolism as well as the synthesis and total content of collagen, glycosaminoglycans (GAGs), and DNA. There were no statistically significant differences between the 3 groups for any of the assays, failing to support my hypotheses. This in itself is an interesting finding, as I expected to see much less tendon activity across all assays for the no glucose group. While we normally use low glucose media for tendon culture, a trend in my results show that a higher glucose concentration may be more beneficial for certain aspects of tendon health, including collagen and GAG synthesis. I plan to look deeper into these differences by focusing on protein turnover and tendon mechanical function in future studies.

## Machine Learning Based Hot Spot Prediction on Processor Chips

**Student Presenter:** Carlton Knox
**Faculty Mentor:** Ayse Coskun (ENG Electrical & Computer Engineering)
UROP Award

Emerging methods of heat management for high-power computer chips often rely on measuring the temperatures across the full surface of the chip and throttling or cooling specific areas accordingly. However, it is usually not possible to directly measure the full heatmap of a chip. This is because the placement of temperature sensors on a chip is limited by the size and power costs of the sensors. As a result, the temperatures reported by the on-chip sensors may not reflect the true hot spots. This project seeks to explore the viability of using simulation data from PACT (PArallel Compact Thermal simulator designed by PeacLab) to train a machine learning algorithm to generate the heatmap for a given chip with the sensor information available at runtime. Similar methods of using machine learning often involve measuring the heatmap with a thermal camera; however, using simulation data may allow for faster, practical, and more accurate model training. Additionally, being able to use a simulator like PACT would allow for testing in earlier stages of chip design where a physical prototype has yet to be made. In the first part of the project, I worked on implementing VisualPACT, a visualizer for PACT simulations that allows for easier analysis of transient simulations. The next step for the project would be to use machine learning to analyze PACT data. If successful, this project would propose a method to train a model for accurate hot spot detection that could be used for efficient heat management.

## Development of Molten Salt Flux for Solar-grade Silicon Production

**Student Presenter:** Rashid Kolaghassi
**Faculty Mentor:** Uday Pal (ENG Mechanical Engineering)
UROP Award

The novel method, Solid Oxide Membrane Electrolysis, is used to produce solar silicon from silica without any greenhouse emissions, at a reduced cost and involving one unit operation. The efficiency and reliability of the cell relies on an appropriate molten salt flux electrolyte. The flux is designed to have high-ionic, low-electronic conductivity, low volatility, moderate operating temperature, and chemical stability with electrodes and solid oxide membrane. In this project, FactSage 8.0 was used to determine the eutectic composition. Other thermo-physical and-chemical properties were obtained from CES EDU. The flux, with predetermined amounts of CaF2, MgF2, CaO, YF3 and SiO2 is then prepared through baking, ball milling, melting and re-melting processes. The ball milling media was specifically selected to avoid the possibility of inducing any ceramic impurities. The flux was quenched, and its compositions was analyzed using SEM/EDS. The results confirmed the theoretical properties mentioned above. A series of SOM electrolysis trial runs were then conducted to test the flux. It was found that the salt is primarily ionic before and after electrolysis. The flux did not attack the YSZ membrane, and the silicon wafer serving as the cathode remained intact which demonstrated that the salt worked optimally and according to our theoretical predictions.

### Soft-Robotic Fiber Jamming Mechanism for Variable Stiffness in Catheter Applications

**Student Presenter:** Harin Lee
**Faculty Mentor:** Sheila Russo (ENG Mechanical Engineeering)
UROP Award

Flexible catheters, rope-like medical devices used to look deep inside the human body and perform operations, are highly effective for minimally invasive, diagnostic procedures. However, when there is a need to manipulate tissue with the tip of the catheter, there is a problem: the catheter's flexibility and small size, which are needed to navigate through delicate, hard-to-reach areas, such as the peripheral lung or the pituitary gland, hinder its ability to provide sufficient forces to extract tissue at the surgical region. A possible solution to this difficulty is to use a soft robotic fiber jamming mechanism to vary the stiffness of the catheter when needed. Fiber jamming is a phenomenon that occurs when a vacuum is pulled on a collection of thin fibers inside an airtight, elastic membrane, causing the fiber elements to experience frictional coupling, thereby stiffening the entire structure. Upon releasing the vacuum to atmospheric pressure, the fibers flow freely and the structure becomes flexible. In this study, novel fiber jamming techniques were explored at the millimeter scale and compression tests were run on various prototypes to observe their mechanical properties. By varying the number of fibers inside each prototype, variable stiffness was successfully achieved. Once implemented into a catheter, fiber jamming will help to maintain low stiffness when steering through tubular structures but also high stiffness when applying forces to tissue. In the future, testing different fibers and applying differing vacuum pressures will help to achieve the greatest differential stiffness between unjammed and jammed states.

### Screening of Genomic Loci in Natural Isolates of D. discoideum for Targeted Integration Sites

**Student Presenter:** Yuke Li
**Faculty Mentor:** Allyson Sgro (ENG Biomedical Engineering)
UROP Award

Many recent studies of the model organism Dictyostelium discoideum exploit the diversity of its naturally-isolated strains to explore biological processes such as kin recognition and altruistic cellular behavior. However, while a well-annotated genome and mature techniques exist for lab-domesticated ("axenic") strains, genetic tools and data for natural isolates are limited. To extend our tools for axenic strains to natural isolates, this project aims to develop a targeted gene knock-in system for natural isolates by screening genomic loci where genes of interest could be integrated without disrupting the normal physiology of D. discoideum. To be a candidate, a locus needs to be redundant, highly expressed, and highly conserved. Based on genomic data from an axenic strain, actin genes stood out since there are 17 redundant actin genes that share the identical amino acid sequence. We hypothesized that actin genes are highly conserved not only within the axenic strains but also across natural isolates. This hypothesis was confirmed by Sanger sequencing of PCR-amplified actin genes from natural isolates genomes, which we found to have high similarity to actin genes from the axenic genome. We therefore constructed knock-in vectors which contain genes of interest flanked by homology arms that would replace actin genes during homologous recombination. These vectors will be tested in multiple natural strains to check for neutral and stable expression. The actin-based knock-in system is promising because it could potentially allow neutral genetic manipulations in many natural strains, thus enabling researchers to study biological processes with minimal off-target effects.

**Development of Fully Soft Robot Stabilization System for Minimally Invasive Intracardiac Surgery**

**Student Presenter:** Zi Heng Lim
**Faculty Mentor:** Tommaso Ranzani (ENG Mechanical Engineering)
UROP Award

While minimally invasive surgery has many benefits over conventional surgical procedures, one difficulty surgeons face while performing minimally invasive surgery is the lack of stabilization of the surgical tool when inside the body. This project focused on the development of a fully soft robot with the function of being able to stabilize both itself and the surgical tool at localized areas in the heart. With a fully soft robot, the stabilization system is then able to manipulate its size and shape for both initial insertion followed by deployment when at the target area. Adhering layers of a thermoplastic elastomer to each other at specific locations using heat and pressure creates a balloon-like mechanism that is able to inflate to provide stability or deflate to allow for flexibility when needed. In combination with this, semi flexible material (FR-4) is also used to create a flexure system that adds additional support to the stabilization system when deployed. The completed design shows that the system fits the dimensional requirements when compacted for insertion while also providing a large outward expansion ratio for deployment inside the heart. Testing also indicates that there is insufficient inner area for blood to flow through due to the inward bulging of the stabilizing thermoplastic elastomer balloons when expanded. With minor modifications and design improvements, the stabilization system has the potential to allow for better control of the surgical tool closer to the surgery area, thus making the procedure easier for the surgeon and safer for the patient.

**Automatic Inter-Person Distance Measurement using Overhead Fisheye Cameras**

**Student Presenter:** Zhangchi Lu
**Faculty Mentor:** Janusz Konrad (ENG Electrical & Computer Engineering)
UROP Award

Social distancing is an effective tool for fighting pandemics, however verifying compliance is difficult. In this project, I am developing a method to automate verification of compliance by estimating the distance between people using an overhead fisheye camera. Fisheye cameras have a much wider field of view than traditional cameras so a single camera can monitor a large room. However, such cameras introduce geometric distortions that must be accounted for when estimating distances between people in 3-D space. I developed several machine-learning algorithms to predict the 3-D distance between two 3-D points at the same height above the floor given their positions in an overhead fisheye image. To train these algorithms, I collected images of a very large chess mat placed on tables of a classroom and labeled the corner points of individual squares. Among these algorithms, the multi-layer perceptron produced the most accurate results. Using 75% of the collected point-pairs for training and the remaining 25% for testing, this algorithm produces 1% relative mean-absolute 3-D distance error. That is, two points located on a table that are 6 feet apart can be estimated to be at that distance with an average error below 1 inch. Therefore, an accurate distance estimation between standing people should be possible if their locations in a fisheye image are known. To validate this algorithm on real-life data, in future research I plan to collect images of people, automatically find their locations in these images and estimate 3-D distances between them.

**Modeling the Effect of Pulse Plating Protocols on Dendrite Growth in Li Metal Batteries**

**Student Presenter:** Trevor Melsheimer
**Faculty Mentor:** Emily Ryan (ENG Mechanical Engineering)
UROP Award

The formation of dendritic microstructures on lithium electrodes presents safety and cycling challenges for the development of high-performance, rechargeable Li metal batteries. Shifting charging from the standard constant current (CC) protocol to a pulse plating (PP) or reverse pulse plating (RPP) protocol has been shown to inhibit dendrite growth and improve cycle life, in both experimental studies and coarse-grain computational models. In this study, a reactive transport SPH model is used to simulate dendrite growth at the electrode-electrolyte interface under multiple cycles of CC, PP and RPP charging protocols. This model enables computational studies to support experimental work with greater predictive capability. The PP and CC simulations agree with experimental results, while the RPP simulations predict what future RPP experimental results could look like.

**Increasing 3DuF Microfluidics Design Potential**

**Student Presenter:** Liam Murray
**Faculty Mentor:** Radhakrishna Sanka (ENG Electrical & Computer Engineering)
LCP - Stem Pathways

Microfluidic chips allow processes to be undertaken at minute scales, reducing waste and often increasing speed. 3DuF is a software tool for designing microfluidic devices in a graphical, parameterized environment. In order to facilitate the addition of new functionality, the representation of the physical features of the device and the representation of the render presented to the user need to be separated. In order to disjoin these representations, the visual representation was relocated from the existing object class to a new class. Modifications throughout the codebase were then made in order to account for this change in architecture. New functionality was then able to be incorporated. This includes the ability to add text to a 3DuF design without said text translating into physical aspects on the chip, allowing the input of notes and descriptive text. Additionally, an integration layer was enabled, making it possible to design devices with electrical and magnetic components. These additions allow for microfluidics designs with increased functionality and better cooperative potential, making 3DuF a more attractive tool for microfluidics designers.

**How Obesity Affects Human Breast Cancer Cell Invasion and Escape in a 3D Microfluidic Model**

**Student Presenter:** Mackenzie Obenreder
**Faculty Mentor:** Joe Tien (ENG Biomedical Engineering)
UROP Award

Breast cancer is the second leading cause of all cancer deaths and one of the most prevalent to women. Obesity is associated with increased incidences of metastasis and poor survival outcomes for breast cancer patients. The functional relationship between obesity and poor prognosis and how obesity affects breast cancer cell escape is unclear. For this project, I engineered a three-dimensional model of human breast cancer that enabled the study of early stages of metastasis, specifically the invasion of the tumor into surrounding tissues and escape into a cavity. I did this by using a needle-based approach to mold two aligned cavities in type I collagen within a chamber. One cavity was filled with MDA-MB-231 breast cancer cells to form a microtumor. Obesity was studied in the model using two methods: first, breast adipose-derived stem cells (ASCs) from obese and lean patients were embedded in the surrounding collagen to determine whether physical and chemical factors from adipose cells affect escape. Second, microtumors in cell-free collagen gels were treated with various fatty acids to determine how free fatty acids affect escape. Microtumors in lean or obese adipose cell-laden collagen escaped sooner than microtumors in adipose cell-free gels, though there was no significant difference in escape between lean and obese conditions. Preliminary data for the fatty acid experiment revealed that oleate hastened escape while palmitate and stearate delayed escape compared to control. These results suggest that obesity may play an important role in breast cancer metastasis.

**Engineering Peptides and Peptidomimetics to Interfere at the SARS-CoV-2 Spike Protein-ACE2 Interface**

**Student Presenter:** Nicole Ostrovsky
**Faculty Mentor:** Diane Joseph-McCarthy (ENG Biomedical Engineering)
UROP Award

The sudden rise of the COVID-19 pandemic has affected everyone in some capacity. Although vaccines have been deployed, their global reach is limited and the longevity of the induced immunity and potential vulnerability to immune evasion makes the need for complementary therapeutics critical. Most therapies that are currently in development are aimed at binding to the SARS-CoV-2 spike protein to prevent its binding to its human receptor, Angiotensin-converting enzyme 2 (ACE2). Our novel approach is focused on engineering peptides that bind to ACE2 and prohibit its interaction with the spike protein. We used computational mapping software and molecular visualization programs to identify binding hotspots on ACE2 at the spike-ACE2 interface to determine the best binding location for the peptides. We then began designing peptides predicted to bind to ACE2 at the interface. The designs were initially based on the structure of the spike protein receptor binding motif (RBM) and modified after an analysis of data for mutants in the RBM region that affect the ACE2 binding affinity. Each of the 8 peptide designs was evaluated for its potential energy when binding to ACE2 and the one with the best energy was selected as a candidate to take forward. This peptide design will serve as a foundation for further research into identifying the minimal determinants of binding of spike to ACE2, and in the future optimized peptides may be developed as intranasal therapeutics for the prevention of SARS-CoV-2 infection.

**Improving the user interface of 3DμF, an Interactive Design Environment for Continuous Flow Microfluidic Devices**

**Student Presenter:** Beining Ouyang
**Faculty Mentor:** Radhakrishna Sanka (ENG Electrical & Computer Engineering)
LCP - Stem Pathways

Microfluidic devices have the potential to address challenges in biological computation and synthetic biology. There is a need for specialized tools to automate the design process of microfluidic devices. Previously, an open-source interactive web-based tool named 3DμF was created to automate the process. It demonstrated the idea of automating the designing of microfluidic devices for "Lab on a Chip" systems. Currently, the codebase of 3DμF is in JavaScript. However, this system could face difficulties in changing existing components and adding new features since it involves numerous modifications on different code files. To solve this problem, the 3DμF codebase is integrated to Vue.js, which is a popular modern JavaScript framework. It enables single file components, therefore, it's easy to scale up the project by simply adding single new files instead of modifying a large number of existing files. It also separates views, data, and components which makes it easy to make changes and maintain. For this project, the graphics and user interface elements including zoom sliders, file uploading interface, and tooltips are optimized and updated in Vue.js. In the future, more components and features will be added and optimized to expand 3DμF's capabilities and further enable users to automate designs. Overall, the project not only provides an interactive tool for the design of microfluidic devices but also benefits other researchers who are developing design automation algorithms in the same field by sharing advances in microfluidic design techniques.

**MicroFaaS: Bare Metal Serverless on Single-board Computers**

**Student Presenter:** Yanni Pang
**Faculty Mentor:** Ayse Coskun (ENG Electrical & Computer Engineering)
UROP Award

The current cloud computing model is based on clusters of virtualized machines running on expensive, energy-inefficient style rack servers. The MicroFaaS project proposes a new cloud computing model that runs on clusters of low-cost single-board computer "workers." Each worker runs a single function to completion without virtualization, providing a more isolated, efficient, low-overhead cloud environment.Multiple BeagleBone Black single-board computers running a Linux kernel optimized for fast startup acted as the workers for the project. The orchestrator BeagleBone sends out pre-written MicroPython (a lightweight Python alternative) functions to the workers to perform. After execution, the worker will reset its environment in preparation for another workload, or shutdown to conserve power if there is no work to be done.Through several experiments, we found that MicroFaaS used 80% less energy per function than a comparable traditional virtualized cluster. MicroFaaS was able to perform 168 functions per minute compared to 118 functions per minute on the virtualized cluster. We believe MicroFaaS can achieve even greater throughput with custom built hardware. The results show a promising reduction in energy and throughput comparable to traditional cloud platforms. With continuing development, MicroFaaS could lead to a more sustainable, efficient, and scalable cloud computing future.

## The Role of Glutamine Supplementation in Protein Synthesis of Murine Tendon Explants

**Student Presenter:** Felicia Pinto
**Faculty Mentor:** Brianne Connizzo (ENG Biomedical Engineering)
UROP Award

Supplementing culture medium with a moderate level of the amino acid glutamine stimulates production of the amino acid proline and increases collagen synthesis in fibroblasts, liver tissue, and bone. The purpose of this experiment was to determine the effect of glutamine levels on tendon explant health, which has not been done before. Understanding the mechanism behind collagen synthesis can help further our understanding of tendon healing. We hypothesized that metabolic function and protein (collagen, proteoglycans) synthesis would be suppressed with higher concentrations of glutamine. In this study, mouse digitorum longus tendon explants were cultured for seven days at three different concentrations of glutamine (0 mM, 0.2 mM, and 4 mM) with medium changes every 48 hours. We measured collagen and glycosaminoglycan (GAG) synthesis, explant metabolism, and GAG, DNA, and collagen content at days three and seven, as well as cell viability at the beginning and end of the culture period. Both GAG and collagen synthesis were highest in the low glutamine group and lowest in the high glutamine group, which supports our hypothesis. Interestingly, the high glutamine group also had lower metabolic activity than both the no glutamine and low glutamine groups. In the future, we would like to find the switchpoint between normal and suppressed collagen synthesis and also investigate the role of glucose levels in this process.

## 3DuF Feature and Algorithm Implementation

**Student Presenter:** Xiangzhe Ruan
**Faculty Mentor:** Radhakrishna Sanka (ENG Electrical & Computer Engineering)
LCP - Stem Pathways

3DuF is an interactive web designing tool for biologists and researchers to create microfluidics chip designs. The use of microfluidics chips in research has grown tremendously, but the designing process is long and tedious since there is no microfluidics specific designing tool other than general purpose CAD tool. My mentor Krishna has been researching the different places a microfluidics specific designing tool would help researchers to save time and energy. He and his previous team has created a simple web designing tool already. The purpose for this summer is refactoring the entire website in Vue framework and adding different features users requested. This summer, I would work on mainly two parts of the project: Implementing new features and two routing algorithms or 3DuF. I implemented a popular demand center function to place the entire design to the center of the grid and other features regarding to the connection component. I also implemented A* and Hightower's algorithms to find the best path between two points while avoiding all components already placed on the grid. In summary, I was able to learn the old codebase and refactor some of the core classes to the new codebase and implemented two different routing algorithms to find a path between two points on the microfluidics chip.

**Improvement of the Power Supply unit for Electrodynamic Screen (EDS) film and Development of Electric Field Monitoring Methods for monitoring the EDS film's Performance for Self-cleaning Solar Panels**

**Student Presenter:** Anthony Saab
**Faculty Mentor:** Malay Mazumder (ENG Electrical and Computer Engineering)
UROP Award

The Electrodynamic Screen (EDS) a transparent film, designed for laminating solar panels, that create a traveling electric field on the surface of the panel for automated removal of dust by electrostatic repulsion forces. My work this summer was to analyze and understand the functioning of the Power supply that activates the EDS films as well as investigate methods for electric field measurements.I studied Power electronics, with the help of a previous UROP participant, to understand some fundamental circuit topologies and their operations so that I could modify and improve the current design of the power supply. I focused on DC-DC converters, inverters, and energy storage systems. I also performed literature search on the methods for electric field measurements to evaluate and possibly improve the electric field monitor for detecting malfunctions of the EDS film. I wrote a report about relevant electric field measurement methods that compares different measurement devices such as the microelectromechanical sensors (MEMS), the rotating electric field mill, and the integrated optical E-field sensor, to test these devices and select the best option for our application.Overall, it was a learning experience that was necessary for me to move forward with the project. This summer, I gained an in-depth understanding of power electronics, and learned electric field measurement methods and I am looking forward to continuing working during the fall so I can perform some testing of these electric field measurement methods and conclude my work.

**Pythia: An Sutomated, Cross-Layer Instrumentation Framework for Diagnosing Performance Problems in Distributed Application**

**Student Presenter:** Justin Sadler
**Faculty Mentor:** Ayse Coskun (ENG Electrical & Computer Engineering)
UROP Award

Distributed applications are programs that run on multiple computers, servers, and databases to accomplish a task. Due to using many different devices, distributed applications can have many different sources of performance errors, so manually diagnosing problems becomes difficult. For this project, we implement Pythia, a framework that automatically debugs performance problems by detecting which components consistently slow the application.

Pythia narrows down the search for the problem source by collecting data on the application, identifying which areas of code perform problematically, and determining where more data should be collected for further analysis. To do this, Pythia utilizes tracepoints, which are placed on different sections of the software application and, when enabled, collect data on the performance. As a proof of concept, we used JavaScript Object Notation (JSON) to allow Pythia to interface with Jaeger, a distributed tracing platform, and select which tracepoints to enable and which to disable to remove irrelevant data. Jaeger monitors enabled tracepoints on distributed systems and reports that information to Pythia.

Using a JSON file was successful in disabling and enablingindividual tracepoints. This could be used as a basis for solidifying this feature into Jaeger and allowing Pythia to be widely used, and thus bringing Pythia closer to reality.

**Formulation of Trehalose Based Nanoparticles for Therapeutic Protein Delivery**

**Student Presenter:** Riya Sen
**Faculty Mentor:** Timothy O'Shea (ENG BME)
Symposium Volunteer

Traumatic spinal cord injury (SCI) results in devastating, permanent paralysis that represents a significant healthcare burden. Spontaneous repair of SCI fails because traumatically injured neural tissue is replaced by dense fibrotic non-neural lesions that lack intrinsic glia necessary for supporting regeneration. To promote neural repair, our goal is to repopulate injury environments with glia, but the dense fibrotic lesion core makes repopulating chronic injury lesions with glia challenging. To address this, we are developing an enzyme based strategy that can be used to debride the fibrotic tissue in the lesion prior to glia cell transplantation to improve grating outcomes in chronic injuries. Delivery of debriding enzymes to SCI lesions is challenging because the enzymes are readily degraded in vivo and have short therapeutic half lives. Therefore, strategies must be developed to improve the long term functional stability of the enzymes. My work focused on formulating nanoparticles capable of complexing with and stabilizing enzymes to improve their long term efficacy in lesion environments. The nanoparticles, composed of trehalose branched polymers end capped with charged monomers, use hydrogen bonding and ionic interactions to interact with the protein they are encapsulating, creating a nanoparticle in which the branched polymers complex with, and surround, proteins. Using FTIR, DLS, and GPC, I characterized the nanoparticles' chemical composition, charge, and size in order to formulate and optimize nanoparticles for this application. The next steps of my research will be to test the effectiveness of the nanoparticles I made in vitro and in vivo.

**Development of a Behavioral Task Measuring Functional Activation Post-Stroke to Track Behavioral Recovery**

**Student Presenter:** Shashwat Shah
**Faculty Mentor:** David Boas (ENG Biomedical Engineering)
UROP Award

Ischemic stroke is a complex neurovascular injury that results from an occlusion of the blood supply to neuronal tissue resulting in the damage of neurons and can cause a severe loss of function. The damage caused by a stroke triggers a complex repair and recovery process that is influenced by behavior post-stroke. While there exist some behavioral tasks which monitor behavioral recovery, these tasks fail to provide a measure of the functional activity of the brain while engaging in the behavioral task. Our goal was to create a motor task which allows us to observe and track functional activity during the behavioral task so we can understand how that activity relates to the behavioral outcomes after recovery. We created a modified lever push task which can be performed by a head fixed mouse under an imaging set up as they recover from the stroke. Here we report how we implemented our behavioral task and used intrinsic optical signal imaging (IOSI) along with laser speckle contrast imaging (LSCI) to measure and record the changes in functional activity as the behavior was performed by the mouse during post-stroke recovery. This created a behavioral task not only passively monitors behavioral recovery, but also provides us with the underlying functional activity changes associated with that recovery. Moving forward, this task will provide better insights into the complex mechanisms of stroke recovery and how long-term behavioral outcomes are shaped by post-stroke behavior.

## Characterization of Cell Death in Injured Heart Tissues

**Student Presenter:** Medha Shekhar
**Faculty Mentor:** Christopher Chen (ENG Biomedical Engineering)
UROP Award

After a myocardial infarction, the damaged heart undergoes a fibrotic response that leads to an increase in the production of collagen, creating an excess of stiff scar tissue that causes the heart to pump less efficiently over time. Current studies modeling cardiac injury are limited to expensive in vivo models or animal models that do not fully capture human biology. Thus, the objective of this project was to create a human 2D in vitro system to model cardiac injury to study changes in the extracellular matrix (ECM) after cell death. After developing a co-culture of human induced pluripotent stem cell cardiomyocytes (iPSC-CMs) and primary cardiac fibroblasts (CFs), the cardiac monolayer was injured with a high power pulsed laser and stained for markers of apoptosis and necrosis. Results showed that as we increased the laser power from 0.35 mJ to 0.75 mJ, the average intensity of apoptosis increased, all significantly higher than the non-injured condition, validating the injury model. The average intensity of necrosis followed a similar trend, but only showed significance to the control at 0.75 mJ. Further characterization of the injury process will be done using quantitative PCR to look at fibrotic gene expression between the non-injured and injured tissues. Once the fibrotic process is well characterized, we aim to develop methods to reduce the fibrotic response and activate regenerative pathways to promote more robust healing.

## Anomaly Detection and Diagnosis in High Performance Computing Systems via Semi-Supervised Machine Learning

**Student Presenter:** Joshua Shterenberg
**Faculty Mentor:** Ayse Coskun (ENG ECE)
Symposium Volunteer

Supercomputers and High Performance Computing (HPC) systems are being used today for everything from discovering new drugs to quantum mechanics and molecular modeling. Application performance variation in these systems leads to premature termination of jobs, wasted computing resources, and more critical system problems. Therefore, the collection and interpretation of the system telemetry data for this anomaly detection/diagnosis is significant because of the performance variations anomalies therein may cause. Solving this problem manually (with a human) is not feasible because of the sheer size of the data to be analyzed. Recent proposed methods make use of supervised machine learning models to diagnose previously encountered performance anomalies. However, supervised machine learning models require large labeled data sets for training, which requires significant human intervention, which is not as feasible. This spring and summer, I have been investigating semi-supervised solutions, in hopes of minimizing this problem of human intervention even further. Specifically, I have been working on a framework based on Label Propagation, a type of semi-supervised machine learning model making use of the fact that elements of a dataset that are "closer" (comparably smaller distances) are more likely to share the same label. I have prototyped methods using Label Propagation, to compare its performance with existing models based on Autoencoders, random forest algorithms, and more. My research thus far has shown Label Propagation, alongside these existing models, to be a powerful intermediary step that further limits labeled data required in these pipelines, without compensating performance and accuracy of the models themselves.

## In Silico Prototyping for Intranasally-Administered Agents for COVID-19 and Other Respiratory Pathogens

**Student Presenter:** Zachary Silfen
**Faculty Mentor:** Diane Joseph-McCarthy (ENG Biomedical Engineering)
Global Challenge Research Award

The COVID-19 pandemic has demonstrated the need for rapidly deployable biomedical interventions for respiratory pandemics. A therapeutic for prophylaxis or early treatment complement COVID-19 vaccines and help reduce the rate of viral evolution by limiting the infection pool. The research described herein aims to develop a rapid in silico prototyping platform for optimization of the formulation and development of antiviral drugs for SARS-CoV-2 and other respiratory pathogens. We are utilizing computational fluid dynamics (CFD) to measure the droplet deposition as a function of particle size at the nasopharynx, the initial site of infection with COVID-19. This parameter is essential for determining effective drug transport in varying nasal geometries. Next, a statistical model linking demographics and variations in nasal geometry will be created. This will create a model-based framework to study how the nasal anatomy affects targeted delivery of drugs to the nasopharynx across a range of diverse anatomies. Initial CFD simulations and measurements on a set of actual nasal geometries will pave the way for additional research. As a Global Challenge Research Award recipient, work beyond this will involve expanding the number of CT-scan based models and running CFD simulations on new models, further refining the protocol for generating synthetic geometries based on the initial validation results, possibly 3D printing one of the actual nasal geometries and its corresponding synthetic clone for use in vitro testing, and finally utilize the geometries to select device and formulation pairs for an antiviral drug combination of interest for development as a COVID-19 therapeutic.

## Developing a Biologic AND Gate

**Student Presenter:** Blaire Smith
**Faculty Mentor:** Ahmad Khalil (ENG Biomedical Engineering)
LCP - Stem Pathways

The AND logic gate is useful in synthetic cell-based therapy due to its aptitude for specificity. In this work, it involves two drug-inducible switches. The first switch controls a zinc-finger (ZF) which binds to DNA upstream of the effector gene, while the other drives expression of a transcription activator (TA). They are each fused to a counterpart in an interacting heterodimer pair to constitute a transcription factor (TF). When both switches are "turned on", this TF drives expression of an effector gene. My goal is to identify the optimal heterodimer pair, defined as the pair that produces the strongest effector gene output. To achieve this, I screened 5 heterodimer pairs with Switch 1 regulated by the doxycycline-inducible system and Switch 2 regulated by the cumate-inducible system. Corresponding ZF and TA pairs were transduced into Jurkat cells with an mCherry fluorescent reporter as readout. Cell fluorescence was measured using flow cytometry to determine the pair with the strongest mCherry expression. Overall, all pairs produce fluorescence when the circuit is turned on. The BW11A ZF and BW11B TA pair demonstrate the strongest fluorescence, similar to the constitutive ZF-TA pair (positive control), suggesting its potential use for further therapeutic applications. One such example is to apply this AND gate to a synthetic Notch (synNotch) system, where a cancer effector protein is expressed when two different synNotch receptors that drive the ZF and TA, respectively, are triggered by a specific cancer cell. This prevents cytotoxicity against non-cancer cells.

### Evaluating the Use of Homomorphic Encryption for CNN-based Inference on MNIST Dataset

**Student Presenter:** Darya Smolina
**Faculty Mentor:** Ajay Joshi (ENG Electrical & Computer Engineering)
UROP Award

In today's data-driven world, maintaining data privacy is a critical requirement. Homomorphic Encryption (HE) has emerged as one of the leading technologies to accomplish privacy-preserving computing. In this project, we implement a convolutional neural network-based image classification task by leveraging the Microsoft SEAL library for HE-based computing. Our custom neural network consists of three different layers performing inference on the encrypted images from the Modified National Institute of Standards and Technology (MNIST) dataset. As we need to operate on floating-point data, we utilize the Cheon, Kim, Kim, and Song (CKKS) scheme-based homomorphic addition and multiplication to perform various linear and nonlinear operations in the neural network. Amongst the linear operations in a neural network, convolution is the most expensive operation. In HE-based computing, thousands of rotations are required while computing inner products on encrypted data within the convolution layer, which is computationally expensive. Therefore, we modify the convolution operation to a matrix-vector multiplication to better suit the HE-computing model. We also modify the nonlinear operation like ReLU to a square function. We train our custom neural network (with modified nonlinear functions) on unencrypted images from the MNIST dataset and we observe a classification accuracy of 98.3%. We evaluate the performance of our HE-based image classification model on an Intel Xeon CPU running at 2.40 GHz. The parameter set selected to implement the privacy-preserving image classification task ensures at least 128 bits security. We observe that we can perform an image classification task on encrypted images in 955 milliseconds.

### Creating an Anatomical Atlas of Brainstem Cell Types

**Student Presenter:** Sandya Subramanian
**Faculty Mentor:** Michael Economo (ENG Biomedical Engineering)
UROP Award

Different cell types connect throughout the brain to form the circuits that carry out diverse behaviors. Cells in the brainstem participate in many of these functions, from maintaining heart rate to coordinating movement of head and neck muscles. However, determining which cell types are found across different parts of the brainstem and how they are connected has been difficult. Using single cell RNA-sequencing (scRNA-Seq) data, the gene expression of brainstem cells is becoming better understood, allowing for the discovery of "marker genes" that are specifically expressed by unique subtypes of cells. Leveraging these scRNA-Seq data, we selected 15 marker genes and designed probes to label these gene transcripts in brainstem tissue. Using multiplexed fluorescence in situ hybridization (mFISH) and confocal microscopy, I was able to visualize and localize the unique cell types that express these genes through the brainstem. To understand which of these cell types participate in movement circuits, I additionally used anterograde transsynaptic tracers to label cells that receive synaptic input from cells in the motor cortex. I then employed mFISH to determine the molecular identities of these connected brainstem cells. By using these methods, I am now able to construct a first-of-its-kind atlas of the distinct cell types found across the brainstem. These data will be highly useful to any future studies of brainstem cell types and circuits and their contributions to brainstem-associated behaviors.

**Developing a Minimally-Invasive Device that Quantifies Fibrosis and Assesses Chronic Kidney Disease Using Optical Spectroscopy**

**Student Presenter:** Ksenija Tasich
**Faculty Mentor:** Ousama Aamar (ENG Biomedical Engineering)
UROP Award

Pathological assessments of kidney biopsies are slow, labor-intensive and susceptible to variability and sampling error. There is a need for a new standardized, minimally invasive, rapid, and quantitatively reliable method for routine clinical prognosis of Chronic Kidney Disease (CKD). Interstitial fibrosis and tubular atrophy are proven indicators of CKD and can be identified by specific features of spectral signatures obtained with Elastic Scattering Spectroscopy. In the study, a CKD induced rat model was used to analyze the optical scattering of fibrotic tissue samples. Spectral measurements were obtained in-vivo during a surgical procedure using a fiber-optic probe that delivers pulses of light from a xenon arc lamp and collects the backscattered light from the renal tissue via two adjacent optical fibers. The resulting data indicated dramatic spectral distinctions due to changes in the scattering properties of fibrotic kidney tissue. Fibrosis induced an increase in light scattering in the UV-Visible region. Variations in spectral properties between fibrotic kidney samples and controls were observed throughout the study, specifically notable between 300 and 450nm. By analyzing these variations from measured spectral signatures, our goal is to effectively model and quantify the progression of kidney fibrosis using ESS. Using machine learning techniques and statistical analysis in MATLAB and Excel, we were able to compare different biomarkers. Optimal biomarkers were selected and plotted based on the largest r-squared value. Future work will include conducting similar studies of taking in-vivo, transcutaneous measurements at a more frequent interval in order to increase the data pool.

**Two-Temperature Model for Femtosecond Laser Ablation of Graphene**

**Student Presenter:** Benyamin Trachtenberg
**Faculty Mentor:** Michelle Sander (ENG Electrical & Computer Engineering)
UROP Award

Graphene has been sought out for use in electrical devices such as transistors, sensors, and high-efficiency solar cells due to its extraordinary two-dimensional thinness, flexibility, strength, and thermal and electrical conductivity. However, to utilize these technologies, precise micro-level patterning is needed which provides little to no changes in undesired locations. Unlike current mechanical and chemical techniques, femtosecond lasers provide localized heating and cutting while retaining graphene's properties outside the heated area.

To predict the heat transfer from the laser to the graphene sample, a simulation was built using the two-temperature model to calculate the increase of temperature in the electrons and lattice. Solving numerically using the finite difference method, the effects of the pulse fluence, duration, and beam radius on the size of the ablated region and the surrounding heated regions were studied to optimize the laser parameters for experimental work. Additionally, the simulation was used to show that the size of the ablation can be calculated directly by a much simpler model which assumes direct transfer of energy to the lattice. Finally, the electron temperatures attained were used to predict the regions where defects may arise in the graphene. Results for a single laser pulse as well as for five pulses were obtained and compared to better understand the role of accumulating heat when many pulses are used.

### Mitigating Current Variation in Particle Beam Microscopy

**Student Presenter:** Luisa Watkins
**Faculty Mentor:** Vivek Goyal (ENG Electrical & Computer Engineering)
UROP Award

Particle beam microscopy is a technique for imaging at near-atomic resolution, which uses a scanning beam of charged particles, causing secondary electrons to be emitted in response. These secondary electrons are detected and are used, along with the knowledge of beam current, to reconstruct an image of the sample. Unfortunately, the scanning beam of charged particles varies in time, and conventional reconstruction methods do not acknowledge this fact, causing performance degradation; with conventional methods, expensive and precise particle beam generators are required to maintain constant beam current and achieve good performance. My project demonstrates that when the beam current variation is appreciable, a novel approach of time-resolved sensing is significantly more accurate than conventional methods. To more actively combat this unknown varying beam current's effects, my project further focuses on designing algorithms that use time-resolved sensing for even better image reconstruction quality by simultaneously estimating the unknown beam current variation and the underlying image, offering an alternative to methods that exploit statistical assumptions on the image content without explicitly estimating the beam current. I demonstrate both causal and non-causal algorithms on synthetic data and offer them as comparison methods which could lead to less expensive equipment in the future. Beyond improving the image estimation, the introduction of effective beam current estimation potentially provides improved control of manufacturing and fabrication processes.

### Engineering Small Molecules and Peptides that Bind to SARS-CoV-2 Spike Protein in Closed Form

**Student Presenter:** Ziwen Xie
**Faculty Mentor:** Diane Joseph-McCarthy (ENG Biomedical Engineering)
UROP Award

The high transmissibility, lethality, and frequent mutation of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), the virus that responsible for COVID-19, has brought severe challenges to the world in the past two years. With the knowledge that SARS-CoV-2 spike protein undergoes a conformational change prior to binding to its human receptor, the goal of this research is to design small molecules and peptides that bind to the closed form of the spike protein, thereby preventing host cell entry. Such spike binders are envisioned as a complementary approach to vaccines for people who cannot access the vaccine, and may be useful for prophylaxis and early treatment. This project involved first carrying out a structure analysis comparing the open state and closed state of SARS-CoV-2 spike protein to define regions of interest that may play a role to the conformational change. Then a hot spot analysis was performed to define putative binding sites using FTMap. Furthermore, by further analyzing the structural and hot spot data by implementing a new scoring scheme, the more promising putative binding sites for future virtual screening are identified. Test runs using Autodock Vina to screen a small set of potential ligands have been done to setup the system. Together these results provide a basis for screening for candidate binders and should ultimately enable the design of a new class of agents that bind to the closed form of the SARS-CoV-2 spike protein.

**Developing a Pneumatic Soft Robotic Haptic Feedback Glove to Assist Minimally Invasive Surgery**

**Student Presenter:** Jonathan Ye
**Faculty Mentor:** Sheila Russo (ENG Mechanical Engineering)
UROP Award

Minimally invasive surgeries, such as laparoscopies and endoscopies, are commonly used to aid in diagnosis and therapeutic interventions for many diseases, such as colorectal cancer, severe gastroesophageal reflux disease (GERD), and pancreatic cancer. However, the main concern with minimally invasive surgery is that, as the surgeon is guiding the tool through the patient, the surgeon can accidentally damage biological tissue through uncontrolled forces pressing onto the tissue. Though rare, these accidents can cause bleeding and damage which can lead to additional surgery, adding complication to the surgical procedure. We propose to develop a haptic feedback glove that is pneumatically actuated with wearable soft robotics to aid the surgeon to more precisely and safely guide the surgical tool during minimally invasive surgery. Three main objectives were completed with the project: the glove design and manufacturing, the actuator design and manufacturing, and the control circuit design and coding. Ultimately, the haptic feedback glove was successfully designed and manufactured to include a glove made out of spandex and neoprene, actuators made out of heat weldable fabric, and a fully functional control board. Validation testing will be done with block force testing of the actuators and in-vitro testing of the glove during an endoscopy simulation. If proven to be effective, this novel approach to use wearable soft robotics as haptic feedback for surgical purposes will allow minimally invasive surgery to be safer, giving the surgeon more precise control of the surgical tool.

**Investigating Machine Learning-Based Optical Flow Algorithms on a Simulated Beating Heart**

**Student Presenter:** Tao Zhang
**Faculty Mentor:** Emma Lejeune (ENG Mechanical Engineering)
UROP Award

Optical Flow algorithms compute the apparent motion of objects between two consecutive frames. Optical Flow algorithms, as the name suggests, are computational methods that can be used to predict and analyze the motion characteristics of a moving or deforming object. In this research, Sparse and Dense Optical Flow Algorithms have been applied and tested on a self-made beating heart on a simulation 3-D platform named Blender. The project is beneficial since the Optical Flow Technique could be used to help doctors predict the motion status of the beating heart, and then the doctors can pre-judge which part of the heart does not work normally.During the project, a realistic heart was built in Blender. In order to create a video to make the heart “alive” (i.e., “beat”), the animation functions in the platform, such as scaling its size constantly, have been used. The heart was then applied and tested with Sparse and Dense Optical Flow Algorithms from OpenCV to predict the motion status between frames of the video. The results were promising, indicating those two algorithms were valid and worked successfully on the heart; when the simulated heart was “beating”, both sparse and dense algorithms illustrate the correct directions. In the future, this process could be improved by comparing the velocities resulting from the algorithms and those from the simulation platform.

### X-World: Accessibility, Vision, and Autonomy Meet

**Student Presenter:** Minglan Zheng
**Faculty Mentor:** Eshed Ohn-Bar (END Electrical & Computer Engineering)
UROP Award

An important issue facing the development of vision-based intelligent systems today is the critical lack of accessibility-awareness. A main reason for this issue is the lack of any large-scale, standardized vision benchmarks that incorporate relevant tasks and scenarios related to people with disabilities. This lack of representation hinders even preliminary analysis with respect to underlying pose, appearance, and occlusion characteristics of diverse pedestrians. What is the impact of significant occlusion from a wheelchair on instance segmentation quality? How can interaction with mobility aids, e.g., a long and narrow walking cane, be recognized robustly? To begin addressing such questions, we introduce X-World, an accessibility-centered development environment for vision-based autonomous systems. We tackle inherent data scarcity issues by leveraging a simulation environment which enables spawning dynamic agents with various mobility aids. The simulation supports generation of ample amounts of finely annotated, multi-modal data in a safe, cheap, and privacy-preserving manner. In our analysis, we highlight novel difficulties introduced by our benchmark and tasks, as well as opportunities for future developments. We further validate and extend our analysis by introducing a complementary real-world evaluation benchmark of in-situ navigation by pedestrians with disabilities. Thus, our contributions provide an initial step towards principled development and widespread deployment of vision-based agents that can perceive and model the interaction needs of diverse people with disabilities.

### Measurement of Thin SiO2 Films on IRIS Chips Using Color Images

**Student Presenter:** Hui Cong (Kreiver) Zhou Peng
**Faculty Mentor:** Selim Unlu (ENG Electrical & Computer Engineering)
UROP Award

The Interferometric Reflectance Imaging Sensor (IRIS) is a widefield imaging system that uses spectral reflectance information to quantify biomass accumulation on sensor chips that have a thin layer of silicon dioxide (SiO2). Mass accumulation information can be extracted by the thin-film interference phenomenon commonly found in soap bubbles, where variances in the thickness of the bubble produce different observable colors and shifts in spectral reflectance curves. Measuring the initial thickness of the SiO2 layer plays a big role for quantification. However, due to manufacturing tolerances, the thickness of SiO2 fluctuates 5% from the desired 110 nm and having the right thickness is crucial for sensitive experiments. To find a cost-effective solution to measure the thickness of the SiO2 layers and filter the chips, a reflectance-based interferometric microscope was built to capture images of the sensor chips and test out the custom software program used to generate the thickness lookup table based on the reflectance data obtained. Once tested, a consumer color scanner will be modified to image the chips and the same software will be used to quantify the thickness of SiO2.

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