2023

The 26th Annual Boston University Undergraduate Research (UROP) Abstracts

The 26th Annual

Undergraduate Research Symposium

Friday, October 20, 2023
GSU Metcalf Ballroom

Poster Presentations
11am-1pm

BU

Boston University Office of the Provost
Undergraduate Research Opportunities Program

UROP
Funding curiosity

The Twenty Sixth Annual

Undergraduate Research Symposium

Friday, October 20, 2023

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

Cover and logo design by Morgan Danna
Booklet compiled by Molly Powers

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Welcome to UROP

The Undergraduate Research Opportunities Program (UROP) connects BU undergraduate students with funded, faculty-mentored research experiences across all disciplines. The program's goal is to cultivate relationships between faculty and students beyond the classroom to shape independent, innovative, and collaborative research leaders. UROP research help students hone critical skills while learning the language of their chosen discipline.

Types of UROP Funding

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, Arts, and Preprofessional Scholars Awards (HAP): (summer only) HAP Scholars Awards provide students with a stipend to conduct research in the arts, humanities, and certain non-STEM preprofessional fields.

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 Summer 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 2023 awardees are Kennedy Harwood (CFA Painting), Virginia Jansen (CFA Music), and Anna Paradise (CFA Art, CAS English).

The **Clare Boothe Luce Scholar Award** supports undergraduate summer research projects undertaken by females in select STEM fields. The summer 2023 awardees are Isabelle Boegholm (CAS Physics), Kelsey Mangis (CAS Astrophysics), Camille Mauceri (CAS Physics), Suhani Mitra (ENG Computer Engineering), Joscie Palen (ENG Biomedical Engineering), Hanna Schlegel (ENG Mechanical Engineering).

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 2023 awardees are Luciano Forancoe (CAS Biology & Molecular Biology), Clifton Johnson (CAS Biology), Jason Shi (CAS Biology), Nicole Zakskorn (CAS Biochemistry).

The **Nelson Undergraduate Research Award** was established in 2023 and supports research in communications. The inaugural awardee is Emma Longo (COM Media Science).

The **New England BioLabs Scholar Award** is supported by New England BioLabs and is part of UROP's corporate sponsorship program. The summer 2023 awardee is Erika Meagher (CAS Biology).

The **Newbury Center Award** is provided by Boston University's Newbury Center to support first-generation college students conducting summer research through UROP. The summer 2023 awardees are Lenny Adonteng (CAS Sociology), Taelor Anderson (CAS Psychology), Brenden Blakley (CAS Marine Science), Luciano Forancoe (CAS Biology & Molecular Biology), Maxine Hsiung (CAS Neuroscience), Kelvin Kuang (CAS Neuroscience), Sofia Marin (CAS Sociology), Angel Morales (CAS Astronomy), Hawa Ndiaye (CAS Biology & Molecular Biology), Jake Purinton (CAS Biology & Molecular Biology), Renzo Quintero (CAS Biology).

The **Mary Erksine Undergraduate Research Award** was established in memory of former UROP Director and CAS Biology Professor, Dr. Mary Erskine. The summer 2023 awardee is John Lee (CAS Biology & Molecular Biology).

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 2023 awardee is Pareesha Haresh (CAS Biology & Molecular Biology).

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.*
- *Tip: You only need to apply to UROP if you want funding for your research. You can also conduct research for credit or volunteer on a research project. Research for credit is handled by individual departments and volunteering can be arranged directly with your faculty mentor.*

Step 4: **Have Your Mentor Submit a Letter of Recommendation.** Part of your UROP application is a letter of recommendation written by the faculty mentor with whom you are working. 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. Stipend awards are paid directly to students as income through Student Payroll.

Acknowledgments

UROP is supported primarily by Boston University's Office of the Provost. We extend our warmest thanks to Associate Provost for Undergraduate Affairs, Amie Grills, for her continued enthusiasm, support, and encouragement of undergraduate research at BU. We also thank our faculty advisory committee for their efforts in reviewing applications and guiding UROP to achieve its mission. We sincerely 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
Boston University Newbury Center
National Science Foundation
Clare Boothe Luce Program of the Henry Luce Foundation
Mark and Ruth Nelson
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

Investigating Mitochondrial Activity in Mutant Muscle Cells

Student Presenter: Jasmine Akinpelu
Faculty Mentor: Frank Naya (CAS Biology)
UROP Award - SURF

The muscular dystrophies are a debilitating group of skeletal muscle diseases characterized by widespread muscle degeneration, loss of muscle mass, and perturbations in metabolic activity. Widespread changes in gene expression are a common pathophysiological feature. Noncoding RNAs (ncRNAs) including miRNAs, lncRNAs, and snoRNAs, expressed from the imprinted Dlk1-Dio3 locus are dysregulated in muscular dystrophy in humans and mouse models of the disease. The Dlk1-Dio3 ncRNAs have been shown to be involved in skeletal muscle differentiation and regeneration, and their expression correlates with changes in muscle metabolism. Therefore, Dlk1-Dio3 ncRNAs represent an ideal locus to investigate the regulatory connection between muscle differentiation and metabolism, and how this process goes awry in disease. CRISPR/Cas9 gene editing was used to genetically engineer two distinct deletions – 300 and 900 base pairs - in the promoter region of the Dlk1-Dio3 ncRNA locus in a mouse myoblast cell line. The 300 and 900 bp promoter deletions resulted in the upregulation and downregulation, respectively, of all ncRNAs in the Dlk1-Dio3 locus, respectively. Both mutant myoblasts cell lines displayed defective myotube formation, a key indicator of differentiation, compared to control myoblasts. Further characterization of the mutant myoblasts cell lines revealed changes in mitochondrial properties as determined by MitoTracker assays. In addition, bioinformatic analysis of potential Dlk1-Dio3 miRNA targets identified transcripts encoding proteins that may function in mitochondrial metabolism. Further molecular characterization of these ncRNA mutant myoblasts will lead to novel pathways in coordinating metabolism and muscle differentiation and aid in the development of targeted muscular dystrophy therapeutics.

Investigating gut-ovary tissue crosstalk using Drosophila melanogaster

Student Presenter: Ethan Anderson
Faculty Mentor: Kim McCall (CAS Biology)
UROP Award

The goal of this project was to investigate the mechanisms by which traumatic injury causes ovary dysfunction in Drosophila melanogaster. Intestinal dysfunction and reproductive issues are known peripheral effects of traumatic injury, which we hypothesize are caused by disarray in the insulin signaling pathway, leading to issues in gut-ovary tissue crosstalk. Drosophila is a good model since many pathways, including the insulin signaling pathway, are highly conserved. Female flies that undergo trauma show mature egg retention in the ovaries, which is also seen when Insulin peptide 8(Ilp8) is knocked down in the gut. I used the Gal4-UAS system to create tissue-specific knockdowns of the three main Ilp8 receptors; Lgr3, Sdr, and InR. I dissected the gut and ovaries from these knockdowns, used Dapi staining to visualize mature eggs in the ovaries, and used the antibody stain Dcp1 to visualize cell death in the gut and ovaries. Knockdowns of InR showed a mature egg retention similar to the Ilp8 knockdowns. Since InR is a receptor for all 8 insulin-like peptides, Ilp8 may not be the only important signaling molecule involved in gut-ovary tissue crosstalk. The three knockdowns for the Ilp8 receptors showed limited Dcp1 expression in the gut and ovaries, indicating that receptor knockdowns do not lead to increased cell death. InR has not been investigated within the context of gut-ovary crosstalk; however, these findings suggest that it plays a significant role in ovary function, and future research will need to be conducted to determine which Insulin peptides are involved.

Assessing Heat Resilience and Energy Allocation of Cryptic Coral Lineages in Palau

Student Presenter: Shantelle Bartley
Faculty Mentor: Sarah Davies (CAS Biology)
UROP Award - SURF

Anthropogenic activities are the primary drivers of climate change and are causing increased rates of coral bleaching. If prolonged, coral bleaching can lead to starvation due to the loss of carbon sugars from the photosynthetic algal symbionts. Yet, some corals living in naturally high-temperature environments exhibit adaptations including increased energy stores that can facilitate survival during the nutritionally challenging conditions associated with bleaching. Semi-enclosed lagoon habitats in Palau's rock islands experience temperatures similar to those expected under future climate change; however, corals of the species Porites lobata that live in these lagoonal habitats experience less bleaching than adjacent colonies on cooler outer reef sites. Here, we identified three genetic distinct lineages (L1-L3) within these Palauan reefs and thermal challenge experiments revealed that the two lineages mainly inhabiting the warmer lagoonal reefs (L2 and L3) are more thermally tolerant than the lineage largely restricted to the cooler outer reefs (L1). We conducted a reciprocal transplant experiment and quantified host and symbiont energy reserves after 1 year to test if L2 and L3 exhibited increased energy stores. We found that transplantation did not significantly affect these energetic traits, and instead constitutive differences between the lineages was observed. Specifically, L2, but not L3, had higher energy stores than L1. These data suggest that these lineages are likely adapted to higher temperatures in distinct ways: increased energy reserves facilitate L2 survival in high-temperature environments, but L3 likely employs a different, yet undetermined, adaptive strategy.

Developmental spatial gene expression patterning and candidate shRNA targets for understudied schizophrenia risk genes

Student Presenter: Matthew Boberg
Faculty Mentor: Ali Brack (CAS Biology)
UROP Award - SURF

Multiple studies have identified ten new understudied genes which confer substantial risk for schizophrenia. The cell type specificity and developmental timing of expression of these genes remains unknown. This project utilized multicolor fluorescent in situ hybridization (MFISH) to localize risk genes to brain regions relevant for disease pathology. In addition, we focused on the SetD1A gene as it was identified as having the highest odds risk ratio within the Schizophrenia Exome Sequencing Meta-Analysis (SCHEMA) consortium. En route to producing an optimal knockdown mouse model to explore behavioral deficits with SetD1A, HEK cell transfections were carried out utilizing 4 SetD1A shRNA, and western blots were used to analyze the efficacy of knockdown. Our results concluded with identifying the optimal shRNA for knockdown of SetD1A in vitro, as well as successfully stained brain slices for MFISH with analysis still ongoing. This work helps elucidate the developmental gene expression pattern of multiple recently identified schizophrenia risk genes, and identifies a candidate shRNA sequence for targeted expression knockdown in further studies.

Defining the Relationship between VEGF and Wnt5 signals to PMCs and Jun expression and function in PMCs

Student Presenter: Sophie Bodine
Faculty Mentor: Cynthia Bradham (CAS Biology)
Martin Research Award

Pattern formation is vital for embryonic development. Our lab uses the larval skeleton of the sea urchin L. variegatus as a model for developmental patterning. The larval skeleton is secreted by the PMCs, which migrate to form the pattern in response to ectodermal cues. Our previous work showed that expression of the PMC cluster marker Jun, is increased and expanded by the VEGFR inhibitor Axitinib. This suggests that the patterning cue VEGF is required to inhibit Jun expression. Complementary findings implicate the patterning cue Wnt5 as a positive regulator of Jun. To ascertain these relationships, we perturbed either VEGF or Wnt5, then performed HCR-FISH to measure Jun expression. Our previous findings suggest that Jun is required for PMC cluster formation. We tested the requirement of Jun for PMC cluster formation by performing whole mount PMC immunolabeling on Jun MO-injected embryos. Our preliminary results indicate that both WntMO- and JunMO-injected embryos display a loss of PMC cluster identity, consistent with our hypothesis. In addition, WntMO-injected embryos displayed knocked down Jun gene expression, further confirming our hypothesis that Wnt5 is required for Jun expression, while Jun is required in turn for PMC cluster formation. These findings provide a preliminary mechanism for the first steps in skeletal patterning that define the PMC clusters where skeletal development initiates.

Impact of Holobiont on Cnidarian Immunity and Transcription Factor NF-kB

Student Presenter: Caoimhe Bodnar
Faculty Mentor: Thomas Gilmore (CAS Biology)
UROP Award - SURF

Anthropogenic climate change is a problem of increasing concern, with particular attention paid to its effects on marine life. Corals belong to the phylum Cnidaria, and the coral reef holobiont - made up of the host coral, intracellular photosynthetic algal symbionts, and a complex microbiome - fosters large amounts of biodiversity. Coral bleaching (the loss of algal symbionts) and death due to environmental stressors threaten the complex reef ecosystem that many people around the world depend on. To study cnidarian health under changing conditions, we have focused on the effects of the microbiome on cnidarian immune processes. We have studied how alterations to the microbiome impact levels of NF-κB, a transcription factor involved in immunity in many organisms. As a model for the cnidarian holobiont, the sea anemone Exaiptasia pallida (Aiptasia) was depleted of its microbiome by treatment with antibiotics. Loss of the bacterial microbiome was verified by quantification of bacteria colony growth and amplification of the 16S region of the bacterial genome. By Western blotting, we found that NF-κB protein levels are higher in microbiome-depleted Aiptasia as compared to control (full microbiome) anemones. Furthermore, NF-kB levels were decreased when the microbiome repopulated depleted anemones. This observation suggests that the microbiome is involved in affecting immune pathways that may influence the anemone's capacity to form interactions with both algal and bacterial colonizers. Further studies will be directed at characterizing Aiptasia genes affected by the microbiome and how these effects affect cnidarian biology, especially immunity and sensitivity to environmental perturbations.

Big Cat Endocasts Reveal Hunting Behaviors

Student Presenter: Luke Buza
Faculty Mentor: Eva Garrett (CAS Anthropology)
UROP Award

African felids are a well known and charismatic group, and therefore have the potential to illustrate how morphometric data can be used to broaden scientific understanding of feline cognition. This study utilizes this clade to support that scans of cranial material can be applicable in discerning physiological and behavioral differences. To do so, endocasts were created from open-source CT scans of felid crania to measure the visual cortex and other centers of the brain. These data are compared with other factors such as body weight, sociality, and activity cycle to contextualize interspecific differences. CT scans of cranial samples from Acinonyx jubatus (cheetah), Panthera leo (lion), Panthera pardus (leopard), and Caracal caracal (caracal) were downloaded from Morphosource.org, and loaded into Avizo 2022.2 for manipulation. Endocasts were virtually created via filling the endocranial cavity and exported as polygon files. These models will then be measured using a geometric morphometrics method, using biological and pseudo-landmarks to mark the visual centers of the brain. These morphometric ratios will be compared statistically in a one-way analysis of variance (ANOVA), and correlated against external data on felid bodyweight, prey weight, and sociality. Results will reveal potential interspecific physiological variation and indicate the degree of correlation between the felids' brain regions, sociality, and prey-type. These correlations can provide useful insight into how visual information is used in hunting behavior. Along with increasing the sample size for more robust statistical results, future studies will conduct internal data collection methods on the species' behaviors via ethograms to clarify correlations.

Validation and Characterization of Viral Peptides Affecting Cellular Proliferation and Apoptosis

Student Presenter: Jordyn Choe
Faculty Mentor: Juan Fuxman Bass (CAS Biology)
UROP Award

Viruses are nonliving and depend on host cell machinery to fulfill their life cycles. Virus-host protein-protein interactions dysregulate many host cell pathways including those which regulate cell growth and death to form suitable environments for replication. While many proteins which regulate these processes are known, many remain uncharacterized. To identify all viral proteins capable of modulating cell growth and death, we conducted proliferation and apoptosis screens in U2OS cells transduced with an expression library of viral peptides derived from the protein coding sequences of ~200 human infecting viruses. We now aim to characterize significant hits from our primary screening to uncover the molecular mechanisms of action. Using MTT-based viability assays, we determined that 11 of the 20 peptides enriched or depleted in our primary screen significantly alter resistance to cell death. To further validate our hits effects on proliferation, we conducted focused secondary screens using cell lines stably transduced with each of our 20 peptide hits. In our aim to characterize the molecular mechanisms of our validated hits, we will perform DNA content assays to assess and understand how our peptide/protein hits affect cell cycle state and proliferation. To understand if these hits specifically alter apoptosis, we will perform flow cytometry Annexin assays. This endeavor will broaden our understanding of viral interface with host signaling pathways, and potentially aid in the development of novel therapeutics for treatment of viral infection.

Translating an Oceanographic Book from Spanish to English: Caribbean Basin and Marine Protected Areas of Nicaragua

Student Presenter: Hannah Connell
Faculty Mentor: Ethan Deyle (CAS Biology)
UROP Award

Nicaragua Azul provides a comprehensive understanding of the ecology, oceanography, and biodiversity found in Nicaragua and throughout Central America. The goal of translating this text is to bridge language barriers and provide the international community with a decade's worth of oceanographic research. Nicaragua is home to incredible biodiversity and safeguards this natural resource with 78 protected areas that cover nearly one-quarter of the country's landmass. During this project, we successfully translated 64 pages and over 26,000 words from Spanish to English. The English translation of Nicaragua Azul will be a valuable resource for students, educators, and researchers around the world. This translation and publication will encourage new ecological research in Central America and improve the representation of Nicaragua in scientific scholarship. The main anthropogenic threats in Nicaragua include the exploitation of natural resources, pollution, and infrastructure development. These threats highlight the importance of improving environmental literacy to promote the ecological richness of this region. The success of this project will lead to the publication of Nicaragua Azul in both the Spanish and English languages. This publication has the potential to facilitate research collaborations while advancing knowledge about Nicaragua's rich natural heritage.

Recapitulation of the Arabidopsis alf3 Mutant by Transformation with the Mutant Allele

Student Presenter: Luciano Foranoce
Faculty Mentor: John Celenza (CAS Biology)
Loren E. Wold Research Award, Newbury Center Award

In the model plant species Arabidopsis thaliana, induction of innate immunity defense responses causes a decline in root development. The phenotype of the aberrant lateral root formation 3 (alf3) mutant displays an autoimmune phenotype, leading to a dying root system, even without a pathogen present. Previously, the Celenza lab has produced seed lines that show similar phenotypes to alf3 when exposed to exogenous salicylic acid (SA), a key signaling molecule in plant innate immunity. In addition, the lab has created transgenic lines that contain an estradiol-inducible variant of the alf3 mutation designed to recapitulate the original alf3 mutant phenotype. Using recapitulation lines that showed the strongest phenotype relative to their non-induced counterparts, RT-qPCR was used to determine the relative induction of PR1, a key marker gene for an active plant innate immune response. Each targeted line showed a large increased fold expression of the PR1 gene when compared to the control gene PP2AA3. Future work will focus on additional RT-qPCR analysis of these lines as well as in the mutants with an altered SA response. These results are promising for future analysis of the ALF3 gene's function and for studying plant innate immunity as a whole. Better understanding of plant defense pathways likely will yield more efficient methods for plant growth agriculture.

Strain-Dependent Rates of Wolbachia Accumulation in Drosophila Oocytes

Student Presenter: Isabella Hirt
Faculty Mentor: Horacio Frydman (CAS Biology)
UROP Award

Viruses and intracellular bacteria localise to specific regions of the cells they colonise. Wolbachia are intracellular bacteria that are transmitted down generations via the egg cytoplasm in a similar manner to mitochondrial transmission. We are studying the transmission of these bacteria in fruit flies (Drosophila melanogaster). The Drosophila egg develops as a cyst of 16 interconnected cells. The posterior-most cell becomes the oocyte, whilst the remaining 15 develop into nurse cells whose primary function is to synthesise and transport nutrients into the developing egg. For successful transmission, Wolbachia must colonise the egg. Wolbachia accumulates in the oocyte surprisingly early in egg formation, before nutrient transport into the egg begins. Previous work shows that Wolbachia utilises the host transport system to migrate to the egg, the mechanisms of which are not completely understood. Wolbachia levels become enriched in the oocyte in comparison to the nurse cells almost as soon as an egg chamber forms. Using confocal microscopy we measured the density of different Wolbachia strains in nurse cells and the oocyte. Preliminary observations indicate that the enrichment is strain-dependent, where the pathogenic strain (wMelPopcorn) does not enrich the oocyte to the same level as the non-pathogenic strains (wMelCS in the preliminary data). This investigation will reveal novel aspects of how microorganisms utilise host transport systems.

Does clutch size reduction influence male-female interactions and levels of parental care in the clown anemonefish Amphiprion percula?

Student Presenter: Flora Kerner
Faculty Mentor: Peter Buston (CAS Biology)
UROP Award

A major goal of behavioral ecology research is to understand the causes of variation in levels of parental care within and among species. One specific question is, how do parents respond to the partial loss of a clutch of eggs? Parents could perceive offspring needs and increase care for the remaining eggs, decrease care for the remaining offspring perceiving their lowered reproductive value, and/or increase aggression toward each other in response to perceived failures of parental care. We investigate these ideas using the clown anemonefish (Amphiprion percula) – a social coral reef fish displaying biparental (primarily male-driven) care and potentially aggressive behavior (primarily from females to males). Here, we tested the specific predictions that experimental clutch reduction will result in an increase in female aggression toward the male and an increase in male parental care in response to the female's behavior. We conducted a clutch reduction by removing half of the 5-day-old egg clutch of 15 breeding pairs. We recorded videos pre- and post-manipulation and collected behavioral data from these videos with the help of the program, BORIS. Preliminary results show varying levels of female aggression towards males and variations in male parental care among breeding pairs. Further analysis will help us determine whether this variation can be attributed to clutch reduction. These results could increase our understanding on the differing responses parents may have to the loss of their offspring.

Deciphering NEXMIF Gene Consequences: Neuronal Activity, Social Interaction, Potential Interventions in an ASD Mouse Model

Student Presenter: John Lee
Faculty Mentor: Hengye Man (CAS Biology)
UROP Award

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by three core behavioral traits: impaired social interactions, communication deficits, and repetitive behaviors. With ASD being on the rise annually, mutations in numerous genes have been linked to ASD development. One such gene is NEXMIF, whose loss of function has been associated with intellectual disability and ASD behaviors. To understand the role that the loss of NEXMIF plays in the development of seizures and hyperactivity in KO and HET mice, I will be using c-Fos, which is a proto-oncogene expressed within neurons after depolarization and is often used as an indicator of neuronal activity. The c-fos protein can be identified by immunohistochemistry techniques. c-Fos will allow me to measure neuronal activity throughout various brain regions in 1 mo. WT socially-naive female mice and WT female mice exposed to a social experience (three-chamber sociability test). Following the sociability test, perfusion and IHC of the brain slices were conducted to measure cFos expression through cell counting. Comparing cFos expression between socially-naive and socially active WT mice, the study uncovers increased expression in the striatum and amygdala for the socially active WT mice. This information can be utilized as a foundation for future experiments once cFos expression is measured in KO and HET mice. If we find brain areas that show significantly upregulated or downregulated cFos activity compared to WT mice, we can aim to rescue hyperactivity and seizures in KO and HET mice by manipulating neuronal activities in these specific brain regions.

Combined Effects of Warming Temperatures and Reduced Snowpack on Nutrient Cycling in a Northern Hardwood Forest

Student Presenter: Evelyn Liew
Faculty Mentor: Pamela Templer (CAS Biology)
UROP Award

Anthropogenic activity over the past several decades has led to a steady increase in global temperatures, largely due to the buildup of carbon dioxide and other greenhouse gases in the atmosphere. The consequences of the changing climate are observable in the forests of the Northeastern United States, such as rising growing season temperatures and decreasing snow cover. My project examines the impacts of this changing seasonality, e.g. the increase in growing season soil temperatures and the decrease in winter snowpack depth and duration, on the functioning of northern hardwood trees. I examined samples from the Climate Change Across Seasons Experiment (CCASE) at the Hubbard Brook Experimental Forest. CCASE consists of two reference plots and two plots that are warmed five degrees Celsius during the snow-free season using heating cables. Another two plots are warmed in the growing season and have snow removed in winter to induce soil freeze/thaw cycles. I collected litterfall samples that fell from individual American beech (Fagus grandifolia) and red maple (Acer rubrum) trees in each plot to understand how changes in soil temperature affect nutrient cycling in the northern hardwood forest. I processed the litterfall by sorting, homogenizing, and weighing each sample, then analyzing them through flash combustion for nitrogen and carbon content. As global temperatures continue to rise, studies show that nitrogen is declining in availability for uptake by terrestrial ecosystems. Results of my study will contribute to our understanding of how the continued rise in global temperatures is affecting potential shifts in nutrient cycling.

Tissue specific and environmental regulation of glucosinolate biosynthesis in Arabidopsis

Student Presenter: Erika Meagher
Faculty Mentor: John Celenza (CAS Biology)
New England Biolabs Award

When exposed to environmental stressors such as herbivory, plants release chemical compounds that defend against the stress. In the model organism Arabidopsis thaliana, plants sense attack by invaders through chemical signals called elicitors. The goal of this research is to understand what role CYP79B2 and two of its activating transcription factors, MYB34 and MYB51, play in the defense response of Arabidopsis to the elicitors, ATP and chitin. WT, myb34 mutant, and myb51 mutant strains carrying a CYP79B2-GUS reporter were grown for 11 days and then exposed to ATP, chitin, or no elicitor for 48 hours and expression of the reporter gene was then observed in the first leaves and roots of the plants. It was found that both ATP and chitin induced greater reporter expression in WT, myb34, and myb51 plants compared to no elicitor. Indole glucosinolates, a class of defense compounds synthesized by CYP79B2 in Arabidopsis, are currently being quantified by HPLC to confirm that elicitor-induction of CYP79B2 expression actually results in more indole glucosinolate production. Related to this work, I have also found that elevated temperature increases indole glucosinolate production by inducing transcription of the MYB51 transcription factor. Taken together, these results will add to the growing body of knowledge about how plants defend themselves against biotic and abiotic stress.

TFBS prediction in early Drosophila melanogaster embryos

Student Presenter: Christian Mei
Faculty Mentor: Zeba Wunderlich (CAS Biology)
UROP Award

Numerous transcription factors (TFs) collaboratively shape cellular processes within gene regulatory networks by binding to specific sequences known as cis-regulatory modules (CRMs). Accurately predicting TF binding sites (TFBS) in the genomic landscape will uncover crucial protein-DNA interactions encoding these networks. Approaches like ChIP-seq are limited to assaying one TF at a time and yield false positives, an issue also common in the computational motif scanning approach. We use DNA accessibility data to simultaneously predict the TFBS of 14 TFs essential for developmental patterning in early Drosophila melanogaster embryos. Early embryonic DNA accessibility data and TF binding motifs undergo processing using TOBIAS, a tool which identifies genuine TF binding through TF "footprints," reducing false positives. Analysis using the genomics BEDTools suite reveals that most TFBS are outside of CRMs, with intergenic and intronic regions hosting the highest TFBS count. However, density of TFBS is highest in CRMs, followed unexpectedly by 5'UTRs. To understand the biological significance of the large number of TF binding sites outside of known CRMs, we propose two hypotheses: 1) Some belong to uncharacterized CRMs. 2) They indicate evidence of a dosage-based activation mechanism. To address the first question, we pinpoint high-density TFBS clusters within active enhancer histone mark regions as potential novel CRMs. Further validation requires computational sequence conservation analysis and reporter assays. Future research will investigate high TFBS density in 5'UTRs to explore the dosage-based activation mechanism. This study impacts CRM prediction algorithms and reveals more of the nature of the TFBS landscape.

Regulation of anti-herbivory compound in Arabidopsis thaliana

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

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 biotic and abiotic stresses that they are not adapted for. Because plants typically respond to stress by producing amino acid derived defense compounds, climate change will likely alter plant metabolism and impact plant growth. Understanding the molecular mechanisms regulating plant defense in relation to metabolism can inform methods for breeding or engineering more stress-tolerant plants. This project focused on eight different Arabidopsis mutant strains that have single or combined mutations that reduce tryptophan synthesis and/or reduce or increase catabolism. Each mutant changes levels of tryptophan and/or indolic glucosinolates and in many cases negatively impacts overall plant health. mRNA extraction followed by RT-qPCR analysis showed that the indolic glucosinolate biosynthetic gene CYP79B2 had significantly elevated gene expression in all of the mutants tested when compared to wild type suggesting that both increased and decreased tryptophan metabolism elevate defense gene expression. Alteration in Trp metabolism gene expression was confirmed using RNA-seq analysis. This analysis surprisingly also showed altered expression in photosynthesis genes in different Trp metabolism mutants compared to WT. This finding was supported by chlorophyll quantification which showed significantly suppressed levels of chlorophyll in tryptophan biosynthesis mutants compared to WT. Other assays for photosynthesis will be looked into to further corroborate these findings. Future work also involves further analysis of the RNA-seq data to identify additional pathways that may cross-talk with Trp metabolism.

Cell-type specific contributions to behavioral deficits in a model of complement 4 overexpression

Student Presenter: Nicole Padro-Luna
Faculty Mentor: Luke Fournier (CAS Biology, Neurobiology)
UROP Award - SURF

Parvalbumin-positive interneurons (PV-INs) are key players in regulating pyramidal neuron spiking and orchestrating brain oscillations subserving cognition. PV-INs form dense, non-specific inhibitory synapses with neighboring excitatory neurons, serving an indispensable role in cortical microcircuit function. PV-INs are particularly susceptible to developmental stressors, and PV-IN dysfunction underlies many brain diseases, including schizophrenia (SCZ). Despite findings of reduced density of inhibitory markers and excitatory inputs to PV-INs in the prefrontal cortex (PFC) of SCZ patients, very few studies exist linking manipulations of SCZ-associated genes to PV-IN dysfunction in the PFC. In humans, specific structural variants of the immune gene, C4A, increase its expression and confer greater risk for developing SCZ. Our group demonstrated that overexpression of mouse homolog C4 (mC4-OE) in medial PFC (mPFC) pyramidal neurons led to developmental miswiring and social behavioral deficits in mice. Using multiplex fluorescence in situ hybridization, we identified PV-INs as a cellular source of mC4 in the mPFC. Therefore, we hypothesize that specific mC4-OE in PV-INs reduces excitatory drive, leading to an imbalance between excitation and inhibition, causing long-term deficits of mPFC-associated behavior. To test this, we have developed a novel, conditional mC4-OE mouse line and have crossed this to PV-Cre driver mice. Our preliminary data suggest that mC4-OE in PV-INs is sufficient to cause sexually dimorphic excitatory hypoconnectivity to PV-INs and anxiety-related behavioral deficits. However, we identified no cognitive deficits in a low-demand memory task. Our results are important because they begin to elucidate how neuroinflammatory signaling pathways contribute to pathological behavior.

Neuropixel Experimental Framework Design

Student Presenter: Gabriela Porto Machado
Faculty Mentor: Jeff Gavornik (CAS Biology)
UROP Award

One of the great unanswered questions in neuroscience is how the brain represents time and uses temporal memories to make predictions. The Gavornik lab uses spatiotemporal sequence learning paradigms to address this question in the mouse visual cortex through imaging and electrophysiology. My UROP project involved developing the recording and analysis pipeline for the recording rig built around the Neuropixel probe. There are two main components of the engineering and design work. First, constructing a physical recording rig that allows precise probe placement within an awake mouse's brain while safeguarding against damage of the delicate device. This effort involves using CAD software to design and 3D-print specialized head caps that protect the brain while granting access to cortical tissue. Second, developing a front end for an existing data processing pipeline, including a user-friendly Graphical User Interface (GUI) based application to enable mouse-driven interactions. This will allow experimenters with minimal coding experience to extract raw data from binary data files, align external event signals and time stamps, and detect action potentials using advanced spike-sorting algorithms. Additionally, the pipeline provides the capability to graph experiment-specific physiological data, utilizing defined event parameters.Throughout the design process, we are implanting the probe in mice in an iterative manner to get hands-on experience and determine what still needs improvement. As the rig design stabilizes we will begin using it to record activity across cortical areas during spatiotemporal learning to determine how cells in different layers and brain regions represent temporal information and signal prediction errors.

Identification of viral cis regulatory elements and their regulation mechanisms

Student Presenter: Jacob Purinton
Faculty Mentor: Juan Fuxman Bass (CAS Biology)
Newbury Center Award

Viruses are obligate-intracellular pathogens which cause detriment to humans. Following infection some viruses enter latency, where their genetic material persists within the host. Latent viruses remain dormant for an extended time before resuming replication. How viruses ultimately decide when to emerge from latency is poorly understood. We hypothesize that viral cis-regulatory elements (vCREs) allow viruses to sense the host cellular environment and coordinate these decisions. vCREs contain specific DNA sequences upstream of gene transcription start sites which are recognized and bound by host transcription factors (hTFs). Because hTFs are downstream regulators of many host signaling pathways, their binding to vCREs allow the virus to detect and respond to highly specific environmental cues. To identify which hTFs bind to vCREs we performed enhanced Yeast-1-Hybrid (eY1H) to detect protein-DNA interactions between known vCREs and a collection of hTFs. We also performed paired Yeast-1-Hybrid (pY1H) to identity cooperativity or antagonism between hTF pairs interacting with vCREs. For example, in Epstein-Barr Virus we identified many nuclear hormone receptors (NHR) that bind vCREs; thus, we hypothesize that NHR ligands that modulate viral gene expression. To identify novel vCREs across viruses, we performed Massively Parallel Reporter Assays (MPRAs) with a library tiling the genomes of dsDNA viruses and retroviruses that we transfected into mammalian cells. Because different viruses preferentially infect different cell types, we conducted MPRAs in various cell lines including lymphoblasts and lung fibroblasts. We hope to provide a more complete picture of viruses integrating host signals to regulate themselves.

Investigating Defective Phagocytosis in Draper Deficient Drosophila Brain

Student Presenter: Cheng Yang (Jason) Shi
Faculty Mentor: Kim McCall (CAS Biology)
Loren E. Wold Research Award

Clearance of apoptotic cells via phagocytosis is important for maintaining homeostasis. In the central nervous system, glia are responsible for removing dead cells. Disruptions in the phagocytic process can lead to various pathological conditions, such as autoimmune and neurodegenerative diseases. Draper (Drpr) is an important receptor for glia-dependent phagocytosis in Drosophila. Knockdown of drpr leads to an accumulation of neuronal corpses, actively dying glia and age-dependent neurodegeneration. The corpses in adult drpr-deficient flies are primarily neurons that die during development. TUNEL staining also showed that the number of corpses remains constant throughout the flies' lifespan, even though the neurodegeneration phenotype indicates that neurons continue to die. This suggests that the corpses that arise during adulthood are cleared. My research investigates which cells participate in clearing these corpses. To this aim, we express Green Fluorescent Protein (GFP) in potential phagocytes (glia and hemocytes) using the Gal4/UAS gene expression system and introduce pHRed, a genetically engineered pH sensor, in neurons. pHRed fluoresces red under acidic conditions and therefore can be used as an indicator of engulfment. Currently, we are in the process of generating flies with the desired genotypes, and while our results are not yet conclusive, our approach holds promise in shedding light on the mechanisms underlying corpse clearance within the Drosophila central nervous system.

Genetic and neural sources of individual differences in goal-directed learning

Student Presenter: Rhea Singh
Faculty Mentor: Jerry Chen (CAS Biology)
UROP Award

Individuals are equipped with varied cognitive and behavioral capacities to adapt to their surroundings. These variations are a combination of both genetic as well as environmental factors. In this study, we investigate how individual differences in learning arise from genetic variations at the gene expression, neural property, and behavioral levels, allowing greater insight into how learning deficits manifest across individuals with diverse genetic backgrounds. We subjected Diversity Outbred (DO) mice to an automated, cognitively demanding, goal-directed learning task to observe learning abilities and behavior. Preliminary results comparing founder strains to the DO strains suggest a genetic component affecting learning abilities. We optimized an RNA extraction protocol on the hippocampus, cortex, thalamus, and striatum of the animals. We found that our samples were largely of high concentration (>20ng/ul), high purity with a 260/280 ratio of greater than 2, indicating strong nucleic acid purity. Our RIN scores were also largely greater than 5, indicating mostly intact RNA. This optimisation will allow for future bulk RNA sequencing that will enable us to perform Differential Gene Expression analysis (DGE). Our future goal is to perform DGE analysis to elucidate the relationship between genotype and RNA expression between learning associated brain regions, and assess how gene expression drives behaviour in learner and non-learner animals.

Does female removal influence male parental care in the clown anemonefish Amphiprion percula?

Student Presenter: Reid Thomson
Faculty Mentor: Peter Buston (CAS Biology)
UROP Award

A major goal of animal behavior research is to understand levels of parental care provided by parents to their offspring. Species with biparental care are particularly interesting because each parent should benefit from shifting the burden of care to the other parent. In some species, power imbalances may occur within pairs, which might enable the more powerful/dominant parent to shift the burden of care to the less powerful/subordinate parent. Such might be the case in the clown anemonefish (Amphiprion percula), where the larger, dominant females perform much less parental care than the smaller, subordinate males. Here, we experimentally test the hypothesis that the high level of care exhibited by males is the result of the threat of punishment by the female should the male underperform. To test this hypothesis, we temporarily removed female clownfish when eggs were present and examined the effect of the removal on the parental behaviors of the male. We filmed male parental behaviors pre- and post-female-removal, and videos were then processed using Behavioral Observation Research Interactive Software (BORIS) v.8.20. We compared experimental data to control data using an ANOVA. Preliminary results from an ANOVA indicate that temporary female removal has no effect on male tending, mouthing, or fanning of the eggs. These results advance our understanding of the ways in which males and females do and do not negotiate levels of parental care in species with biparental care.

Remote Measurement of Morphological Traits on Wild Critically Endangered Yellow-Tailed Woolly Monkeys (Lagothrix flavicauda) in Perú

Student Presenter: Sofia Weaver
Faculty Mentor: Christopher Schmitt (CAS Anthropology)
UROP Award

Morphological data can provide powerful insights into primate health and life history. Measuring these traits in wild primates is challenging, as it typically involves invasive techniques which local ecology and conservation strictures may prohibit. Advances in photogrammetry allow for non-invasive collection of morphological traits on wild animals. Although validated as a viable technique to obtain accurate morphological measurements for several primate species, the use of parallel-lasers has not been widely implemented for arboreal species or smaller-bodied juvenile primates. The Critically Endangered yellow-tailed woolly monkey (Lagothrix flavicauda) is endemic to the cloud forests of Andean Perú. Despite its conservation status, L. flavicauda is among the least studied non-human primates, and extremely limited morphological data is available on this species. We used parallel-laser photogrammetry to collect morphological data on a group of wild yellow-tailed woolly monkeys residing in montane cloud forests near the community of Beirut. We found this methodology to be viable for L. flavicauda, including juveniles and infants. Average CVs for repeated measurements collected on individuals ranged from 0.19-4.37%. The indices of sexual dimorphism in measured characteristics ranged from 1.01-1.28. Additionally, in comparing adult male body measurements of L. flavicauda to comparably collected measurements of wild male lowland woolly monkeys (L. lagotricha poeppigii), we found size for L. flavicauda to be within the range of L. l. poeppigii, contradicting previous claims that body size, on average, is larger in L. flavicauda. The validation of this methodology will allow for the future study of the growth and development of this species.

Characterizing the epithelial sheath as a barrier to professional phagocytes during apoptosis in the ovary

Student Presenter: Max Wertheimer
Faculty Mentor: Kim McCall (CAS Biology)
UROP Award

In Drosophila, when cells die they are typically removed by phagocytic hemocytes. However, the ovaries inhibit hemocyte infiltration even when signals are released during cell death events. The signals released typically attract phagocytic cells to break down developing egg chambers and recycle nutrients but while hemocytes have been seen on the periphery, they do not enter the ovaries. The epithelial sheath, which lines the surface of ovarioles, may be responsible for inhibiting hemocyte infiltration via septate junctions which control the diffusion of signals across tissues and may physically inhibit hemocytes themselves. Eleven septate junction genes were identified as candidates and, using RNAi, knocked down to determine if they play a role in barring hemocyte entry into the epithelial sheath. The ovaries were dissected, stained and imaged using a confocal microscope to visualize any potential phenotypes. Findings show that many of the selected genes have adverse effects on fecundity and suggest the possibility of increased cell death in the ovaries. Some genes show severe phenotypes ranging from large gaps between eggs, tight bunching of the epithelial sheath, bunching of early stage eggs,and stretched stalk cells between eggs. These atypical phenotypes suggest excessive cell death, improper relaxation of the epithelial sheath, and abnormal cell signaling. These phenotypes will be explored further to quantify hemocyte invasion rates. Discovering the gene(s) responsible for epithelial sheath permeability can be key for understanding the immune response in other immune privileged organs and potentially develop targets for therapy.

The effects of draper gene knockdown in different tissues on ovarian function in Drosophila melanogaster

Student Presenter: Pamela Yang
Faculty Mentor: Kim McCall (CAS Biology)
UROP Award - SURF

The gene draper (drpr) is critical in cell clearance through its role as a phagocytic receptor. Drpr plays a vital role in maintaining multiple tissues by clearing dead cells, bacteria and debris. Recent research has shown decreased fecundity and increased egg retention when it is knocked down. While drpr-/- mutants show defects in ovary maintenance, it is unclear which tissues are critical in this gene expression for whole body physiology. Using the GAL4-UAS system to drive the drprRNAi transgene in a tissue-specific manner, we knocked down drpr in major tissues: brain, gut, muscle and ovary. Dissection results showed a strong egg retention phenotype, nearly a 4 fold increase, in two of the drivers used: elavGal4 (neurons) and esgGal4 (gut). These preliminary results suggest that Drosophila with drpr deficient neurons and gut stem cells have severe egg retention. Though the biological mechanism is unknown, drpr plays a role in clearing neuronal debris; and this knockdown may lead to defects in development and communication to the ovary. Interestingly, another neuron driver tested, nSybGal4, did not have the same egg retention phenotype as elavGal4 even though they targeted the same tissue. We hypothesize that this may be because elav is expressed primarily in embryonic stages while nSyb is expressed in adulthood, which questions the role of drpr in developmental stages for proper ovarian function. To further investigate this hypothesis, we will conduct temperature sensitive Gal80 experiments to introduce conditional knockdowns of drpr expression at different developmental stages and analyze their respective phenotypes.

The Impact of Global Dlk1-Dio3 Knockdown on Cardiomyocyte Directed Stem Cell Differentiation

Student Presenter: Nicole Zakskorn
Faculty Mentor: Francisco Naya (CAS Biology)
Loren E. Wold Research Award

The gene regulatory networks involved in the differentiation of cardiomyocytes, cardiac muscle cells, from stem cells are poorly understood. Delineating these pathways can provide valuable insight into the causes of congenital heart disease. Noncoding RNAs (ncRNAs) expressed by the Dlk1-Dio3 locus, a large imprinted ncRNA cluster, have been previously found to regulate cardiomyocyte proliferation and skeletal muscle differentiation. In addition, disregulated expression of Dlk1-Dio3 ncRNAs has been demonstrated in numerous models of cardiovascular disease, suggesting implications in disease pathogenesis and potentially providing an opportunity for future targeted therapies (Fahed et al., 2013). To investigate the role of Dlk1-Dio3 ncRNAs in cardiomyocyte differentiation, an in vitro model of directed differentiation of cardiomyocytes from stem cells was used. A global knockdown of the locus was induced by generating a deletion in the promoter in mouse embryonic stem (ES) cells using CRISPR/Cas9 gene editing, followed by directed differentiation to cardiomyocytes. Deletions in the promoter of the locus in skeletal muscle cells were previously shown to alter the expression of all ncRNAs encoded by the locus and impair differentiation. Electroporation was used to transfect the respective CRISPR/Cas9 plasmids into ES cells. In order to ensure both plasmids were properly integrated, antibiotic selection was used to enrich for and isolate cells with these plasmids. PCR amplification of genomic DNA and analysis via gel electrophoresis was used to qualitatively confirm integration into the genome. Future studies will examine whether a promoter deletion was induced and the effects of locus disregulation on cardiomyocyte differentiation.

Using Neural Networks to Illuminate and Predict Nest Site Choices and Nest Success in the Saltmarsh Sparrow

Student Presenter: Nina Zhao
Faculty Mentor: Leslie Kaufman (CAS Biology)
Humanities, Arts, and Preprofessional Scholars Award

The saltmarsh sparrow (Ammospiza caudacuta), a native of US Atlantic coast salt marshes, is predicted to go extinct around 2050 due to a high rate of egg/chick mortality (nest failure). Previous studies have investigated characteristics of females' nest site selections as well as successful nests (i.e. those that produce at least one fledgling); however, these statistical models have had mixed success and produced somewhat mixed conclusions that vary by marsh/region, even when we do know the ultimate cause (flooding/drowning) of nest failure. Neural networks have not yet been used to characterize where saltmarsh sparrows choose to nest and which nests successfully produce fledglings; these machine learning algorithms provide an opportunity to use deep learning to investigate this question in a way that mimics how the human brain learns and applies knowledge, with the potential to discover previously unknown patterns in data using unsupervised machine learning. Using the current knowledge of this vulnerable species' nest characteristics, it is possible to build a human-taught ("supervised") neural network that may be able to successfully characterize potential relationships between habitat characteristics and nest site selection and success. Furthermore, using only-self-taught ("unsupervised") machine learning may uncover previously unknown patterns linking habitat characteristics to nest site and success. The findings from these two approaches have the potential to shape saltmarsh sparrow conservation, in addition to saltmarsh conservation priorities and planning in the face of present-day and future saltmarsh disappearance.

Physical Sciences

Detecting Exotic Particles Through Solar Radiation Pressure Measurement Via MEMS Resonators

Student Presenter: Axel Almaguer Gaona
Faculty Mentor: Pritiraj Mohanty (CAS Physics)
UROP Award

Chameleons are hypothetical particles that could explain dark energy, one of the main models for the accelerating expansion of the universe. It is believed that the sun can emit them and that is the basis of the project's long-term goal: to detect such exotic particles, or similar, with the use of micro-electromechanical system (MEMS) resonators. To accomplish this, the goal was broken down into main components. First, the behavior of the resonators and their different kinds were explored. Their q-factors, sensitivity, and resonant modes were all measured through Signal and waveform generators. With this, the most suitable resonators were selected. Then, the main focus of the program was to detect the radiation pressure of a laser. The laser was modulated at high frequency and pointed at the resonator on vacuum, with the goal of obtaining a signal through it by the impacts of photons. After measuring such a signal, a similar process would then be followed for the solar radiation pressure. It would require the use of external modulation, careful movement of the system to follow the sun, and the displacement of many apparatuses to an open area, among other challenges. With this, it would be possible to reach the main goal. Chameleons are expected to create a similar signal as that of momentum transfer from the photons, so it would be needed to analyze and discern the two. This could show their existence, and as such, the experiment could bring a clearer understanding of why the universe expands.

Synthesis, characterization and reactivity of a series of iron and molybdenum Perfluoropinacolate Complexes

Student Presenter: Parnian Asgari
Faculty Mentor: Linda Doerrer (CAS Chemistry)
UROP Award

The oxidation of C-H bonds is a naturally occurring phenomenon that has been happening since the beginning of photosynthesis on Earth. Even with the advances in synthetic chemistry, the oxidation of C-H bonds is still difficult to control and recreate. The use of catalytic processes becomes crucial for the lowering of the activation energy for the oxidation of C-H bonds. The Doerrer group has previously published much about Fluorinated Alkoxides with metal centers such as manganese, zinc, iron, copper, cobalt and iron. The research I have done this summer focuses on iron, molybdenum and chromium complexes affixed with perfluoropinacolate (pinF) ligands. This summer, the {HNEt3}2[FeIII(OH)(pinF)2] complex (1) was synthesized. Previous students had been able to identify a peach-colored species, which was hypothesized to be the targeted complex, but their synthetic procedure was not replicable. Complex (1) was characterized using SCXRD, Evans method, UV-Vis and elemental analysis. Future directions involve the protonation of complex (1) and synthesis of {HNEt3}[FeIII(OH2)(pinF)2]. Additionally, the ability of a Mo(V) pinF complex to perform sub-stoichiometric oxidation of benzylic alcohols was studied using a series of alcohols. These studies were monitored using 1H NMR and partial conversion of alcohols to aldehydes and ketones was observed. Future directions will include studying other alcohols with varying temperatures and solvents.

Silicon uptake kinetics vary by macroalgae genera

Student Presenter: Brenden Blakley
Faculty Mentor: Robinson Fulweiler (CAS Earth & Environment)
Newbury Center Award

While silicon (Si) is considered an essential nutrient for diatoms, the importance of Si for other marine photosynthetic organisms is an area of emerging interest. Previous research has shown that Si is found in the roots and foliage of salt marsh grasses and mangroves. Recently, appreciable Si concentrations were reported for a variety of temperate macroalgae genera. If this finding holds true, it has important implications for marine Si cycling, primary production rates, carbon sequestration, and higher trophic level production. To investigate the potential impact of macroalgae on coastal Si cycling I conducted a series of classic kinetic incubations where I exposed three genera of macroalgae (Ulva, Fucus, Porphyra) to varying concentrations of Si ranging from 20 µM to 100+ µM. Over the incubations I collected water samples for dissolved Si analyses. I analyzed these samples using standard colorimetric techniques and then calculated macroalgae genera specific Si uptake rates. Preliminary analysis suggests that Ulva shows no concentration driven correlation in uptake rate but exhibits a rapid uptake at the start of the incubation known as surge uptake. In contrast, Fucus demonstrates classic michaelis-menten kinetics indicating active Si uptake. The final macroalgae genera results are forthcoming. Together these data highlight that macroalgae Si uptake may vary by genera, and in some cases (e.g., Fucus) macroalgae may compete for Si with other Si requiring organisms (e.g., diatoms). This study is the first we can find in the published literature of Si kinetics in marine macroalgae.

Anisotropic Galaxy-Galaxy Lensing by IllustrisTNG Galaxies

Student Presenter: Yi-Ting Chen
Faculty Mentor: Tereasa Brainerd (CAS Astronomy)
UROP Award

Gravitational lensing causes deflections of light rays when they pass through massive objects, resulting in distorted images of distant galaxies. Galaxy images that have been gravitationally lensed can be used to map out the amount and distribution of dark matter within the "halos" of galaxies. The cold dark matter (CDM) model predicts that dark matter halos are "flattened", causing anisotropy in the weak lensing signal (more distortion along the major axis of the lens than along the minor axis). Some galaxies in the observed universe do not exhibit anisotropic lensing. One explanation is a misalignment between the major axis of the light (galaxies) and the major axis of the mass (their halos), as halos contribute most of the mass. Dark matter halos are invisible, so we cannot observe them directly. Fortunately, we can use simulations to measure any misalignment. Here, I determined the upper bound of the anisotropic signal using the halos of 30 galaxies in different mass ranges from the IllustrisTNG-100 simulation. I also found the minimum physical radius around a galaxy required for full coverage the anisotropic signal to reduce CPU time. The next steps are to increase the number of lens galaxies to 3000 and measure the weak lensing signal using the major axes of the halos, as well as the major axes of the luminous galaxies (which may be misaligned from the halos). From this, I will characterize the anisotropic lensing as a function of the stellar masses, colors, and luminosities of the lens galaxies.

Application of a PISA Assay for Detection of Rocaglate Binding to DEAD-box Helicases

Student Presenter: Alice Fan
Faculty Mentor: John Porco (CAS Chemistry)
UROP Award

Rocaglates are a family of plant-derived natural products with therapeutic relevance. Some rocaglates are known to inhibit translation by clamping RNA onto DEAD-box helicases such that the RNA cannot be unwound and ribosomes cannot bind. Dysregulated translation contributes to several varieties of cancer and viral infections; thus, rocaglates are closely studied for their potential anti-cancer and anti-viral effects. We expect that rocaglate derivatives can bind to different DEAD-box helicases due to structural similarity between helicases. Therefore, we have assessed binding of various rocaglate derivatives to DEAD-box helicases to elucidate rocaglate structure-activity relationships. This work could facilitate focused rocaglate drug development that could be tailored to address diseases in which DEAD-box helicases play roles. We assess binding using the proteome integral solubility alteration (PISA) assay. PISA detects drug-bound proteins by measuring protein solubility at increasing temperatures, as more protein become denatured and desolubilized. Since ligand-binding generally increases protein stability, we see that rocaglate binding targets are more soluble when drug is added, even when temperature increases. We have conducted PISA on three families of compounds including rocaglaic acids, rocaglate-diazapinones, and the aglain derivative ponapensin. We found that the rocaglate-diazapinones and ponapensin do not exhibit significant binding to DEAD-box helicases, but the rocaglaic acids bind significantly to common rocaglate protein targets as well as a new DEAD-box helicase target. Binding to this new target could be associated with novel biological effects which encourages further biological studies and drug discovery efforts.

Photoreduction reaction catalyzed by Rieske non-heme iron oxygenase VanA derived from thermophilic bacterial source

Student Presenter: Jennifer Flores
Faculty Mentor: Pinghua Liu (CAS Chemistry)
UROP Award

Within the past fifty years, there has been a recent interest taken in Rieske type non-heme iron oxygenases in scientific literature. These enzymatic systems normally have 2 or 3 primary components: a reductase for harnessing the reductive potential of NAD(P)H, often a ferredoxin component which transfers electrons, and, finally, the oxygenase portion. The most widely studied Rieske-type enzymes are from mesophilic bacteria; however, this study aims to elucidate the mechanisms of these enzymes from thermophilic sources, namely Vanillate-O-demethylase (VanA) derived from Meiothermus rufus. Rieske enzymes derived from thermophilic sources are desirable due to several reasons: 1) their enzymatic stability at high temperatures as well as their potential use in industrial bioremediation; 2) the possibility of preparing these enzymes at much higher concentrations; and 3) more importantly, the better chance of trapping transient reaction intermediates. Another limiting factor of Rieske enzymes is the expensive need of NAD(P)H as a reductant as well as a reductase. Therefore, another key component of my research is the use of a photosensitizer/ sacrificial reagent pair to conduct photocatalysis by bypassing the need of reductant/reductases. We have successfully established all catalytic systems using both regular substrate and 13C-labeled substrates. We then expanded to characterize several reactions catalyzed by Rieske enzymes, including VanA catalyzed oxidative O-demethylation reaction.

Synthesis of Bifunctional Salen Cobalt Catalyst for Ring Opening Polymerizations

Student Presenter: Daniel Gorham
Faculty Mentor: Aaron Beeler (CAS Chemistry)
UROP Award

The synthesis of the bifunctional Salen Cobalt catalyst is vital to the development of safe and cost-effective means to produce sustainable polymer-based materials. The main goal of the project was to optimize the procedure and to later use the catalyst for several polymerizations. To determine the ideal conditions for the hydrogenation step, which was previously low yielding and inefficient, several pressures and catalyst loadings were tested. Purification techniques were also optimized on numerous steps to determine when and what should be done to ensure a pure final product was made. With the successful optimization of the hydrogenation and purification, the catalyst was able to be synthesized with a 72% yield on the final step. The pure product will now be used for a variety of copolymerization utilizing glycidol derivatives and carbon dioxide. In future works we will be testing the results of this catalyst versus a previously used catalyst that required high pressures to produce desirable yields.

Defining the structure and function of GT-A fold enzymes in Bacteria

Student Presenter: Pareesha Haresh
Faculty Mentor: Karen Allen (CAS Chemistry)
Mark W. Riemen Summer Research Award

Bacterial glycosyltransferases (GTs) contribute to the diversification of glycoconjugates critical to infectivity and thus, are of particular interest to address antibiotic resistance. The protein prokaryotic glycosylation pathway is specifically of interest due to its high similarity in the mode of construction of glycoconjugates while the final glycoconjugates vary widely. We are interested in the penultimate enzyme in the pgl pathway in Campylobacter, the GT-A fold enzyme PglI, which appends a branching glucose to a hexaglycan chain. However, very little is known about the mechanism of Pg1I and the use of the GT-A fold for activity. The goal of this research is to study a wide variety of GT-A fold enzymes in order to decipher the connection between the structure and substrate specificity. Of the GT-A fold enzymes targeted for study, a GT-A/GT-B fusion protein, A0A7J0BXV5, was identified. This protein was successfully expressed and purified, and preliminary structural characterization is on-going. In the future, additional GT-A fold enzymes will be studied, with targets chosen from the seven most prevalent families in the GT-A fold out of the 114 GT families. This research can help create a roadmap for GT-A fold enzymes in bacteria, with the goal of understanding substrate specificity, and in the future, provide foundational information for the understanding of Pg1I structure and function.

Optimization of Expression and Purification of Yeast Primase

Student Presenter: Soyoon Kang
Faculty Mentor: Deborah Perlstein (CAS Chemistry)

The cytosolic iron-sulfur cluster assembly (CIA) pathway is essential for the biosynthesis of eukaryotic Fe/S proteins residing in the cytosol or the nucleus, which are significant in key cell processes, such as DNA replication, transcription, and translation. The Fe/S clusters are transferred by the CIA targeting complex (CTC) and through direct physical interaction with target proteins or mediated through the adaptor. For the transfer, CTC must identify more than 40 structurally and functionally diverse Fe/S cytosolic and nuclear proteins, but the interaction between CTC and all these substrates remains unclear. One of the CTC recipients requiring Fe/S cluster for its RNA polymerase activity is primase, consisting of a Pri1 and Pri2. Pri2 is a subunit coordinating Fe-S cluster, and Pri1 has an LDW motif that was recently shown in our lab to be recognized by the Cia1-Cia2 in the CTC. Although recent cryo-EM studies showed the docking mechanism of primase, the most important residues contributing to the protein-protein interaction remain unknown. Here, we developed and optimized methods for the expression and purification of individual subunits Pri1 and Pri2. Pri1 from the yeast S. cerevisiae was successfully expressed in E.coli and purified by adjusting the lysis buffer to increase the solubility and stability of the protein. Using a co-affinity purification assay, Pri1 was shown to interact with the Cia1-Cia2 subcomplex of the CTC. However, the purification of Pri2 could not be identified. The study will continue optimizing the induction and purification methods of Pri2, including anaerobic purification or co-purification with Pri1.

Estimating Carbon Flux and Implementation of Disturbance into the PEcAn Data Assimilation Model

Student Presenter: Dain Kim
Faculty Mentor: Michael Dietze (CAS Earth and Environment)
UROP Award

Understanding the carbon dynamics and quantifying carbon pools are critical in studying the terrestrial ecosystem. Carbon travels from the atmosphere and the ocean to the land through biogeochemical processes, making up building blocks of all organic matter on Earth as a result. The Predictive Ecosystem Analyzer (PEcAn) provides a novel data assimilation technique for estimating carbon pools and fluxes across the contiguous United States, effectively combining the carbon forecast from a process-based model and satellite observations. Although PEcAn addresses the nonlinearities in the relationship between climate and vegetation, successfully estimating carbon pools in the U.S., it discounts the presence of disturbance that may be present in the ecosystem. In this study, we incorporated the disturbance case into the model to properly represent complex dynamics and feedback existing in modern ecosystems. We implemented an observational operator to account for both the disturbance and non-disturbance scenarios, enabling users to test different disturbance case scenarios when running the model. Upon verifying the correctness of the model through testing it against the simulated data, the updated PEcAn model will help provide a more robust baseline for ecologists to investigate the terrestrial carbon pools.

Global survey of whistler mode waves in the Earth's magnetosheath using THEMIS observations

Student Presenter: Jingxuan Li
Faculty Mentor: Wen Li (CAS Astronomy)
UROP Award

In a plasma-rich universe where 99% of matter exists as plasma, wave-particle interaction is vital for changing energy and number of charged particles. Whistler mode waves, a type of electromagnetic wave, are commonly observed in the Earth's magnetosheath—a plasma region located >~10 Earth radii away from the Earth. This study aims to investigate the properties of whistler mode waves in the Earth's magnetosheath and their dependence on the upstream solar wind dynamic pressure, which is an important process for affecting dynamics of plasma waves and electrons in near-Earth space. I used a programming language named IDL to analyze data from NASA's THEMIS satellites during the period from 2007 to 2018. The measurements from THEMIS provide wave measurements, including wave spectra and wave amplitude. The OMNI data set was used to provide solar wind measurements. The result of statistical analysis indicates that statistically wave amplitude occur is larger on the noon side of the magnetosheath than that in dawn and dusk sides. About 50% had amplitudes above 5 pT, and 8% surpassed 100 pT. Solar wind dynamic pressure is found to be highly correlated with whistler mode wave amplitude, with stronger amplitudes for higher solar wind dynamic pressure. These results improve our understanding of the global distribution of whistler mode waves and their response to various solar wind conditions. This understanding is critical for unraveling the complex solar wind-magnetosphere interactions, extending its significance not only to the Earth's vicinity, but also encompassing the broader scope of solar system plasmas and beyond.

A Study of Spatial Distributions of Cluster Galaxies in a CDM Computer Simulation

Student Presenter: Kelsey Mangis
Faculty Mentor: Tereasa Brainerd (CAS Astronomy)
Clare Booth Luce Award

There is strong observational evidence that a large amount of dark matter exists in the universe and, based on the results of computer simulations, the Cold Dark Matter (CDM) model best represents observations of the universe.In this investigation, I studied the distribution of galaxies within massive galaxy clusters in the IllustrisTNG300 simulation, which follows the growth of structure within a CDM universe. Within the simulation, I found "lopsided" distributions of cluster galaxies, indicating that the clusters are not yet fully-virialized and are still in the process of forming. I analyzed a database of approximately 10,000 galaxies taken from approximately 300 galaxy clusters. I characterized the lopsidedness of the galaxy distributions using a pair-wise clustering statistic, the results of which show that pairs of galaxies are much more likely to be found on the same side of a cluster than on opposite sides. In addition, I found that the degree of lopsidedness depends on the number of galaxies in the cluster, the average color of the galaxies in the cluster, and the average luminosity of the galaxies in the cluster. Therefore, if we actually live in a CDM universe, we expect that large galaxy clusters in the observed universe will show similarly lopsided distributions of galaxies since they are still in the process of forming. My future work will include comparing the results of the simulated cluster galaxies to cluster galaxies in the observed universe to test the predictions of CDM against observations of the observed universe.

Probing Jupiter's Upper Atmosphere Through H3+ Emissions and Ganymede's Shadow

Student Presenter: Russell Mapaye
Faculty Mentor: Luke Moore (CAS Astronomy)
UROP Award

This project aims to enhance our understanding of Jupiter's upper atmosphere by investigating its response to the passage of Ganymede's shadow, offering a novel approach to unraveling planetary dynamics. Existing models of Jupiter's upper atmosphere, while continually improving, remain imperfect, restricting our comprehension of the planet. By analyzing H3+ emissions, a valuable indicator of electron density, we gain insights into planetary ionization and recombination timescales. Away from the auroral regions, H3+ ions originate solely from solar photons. To address this, studying H3+ emissions in the absence of solar photons (beneath Ganymede's shadow) can yield more accurate measurements of ion decay lifetimes, serving as a valuable constraint on presently uncertain reaction pathways in giant planet photochemistry. Moreover, deducing ion temperature from the emissions enables us to infer atmospheric temperature, thereby refining our understanding of energetics in Jupiter's upper atmosphere. Utilizing spectroscopic data collected during Ganymede's eclipse, we reduced and analyzed the data by cleaning, calibrating, and determining spectral slit locations on Jupiter. With calibrated data, H3+ density variations were assessed for locations on Jupiter, leading to insights into atmospheric variations. This research holds significance in presenting a new lens for assessing atmospheric age and temperature. The project also addresses the need to measure equatorial H3+ lifetime sans sunlight and to constrain unknown chemical reaction rates. By unraveling Jupiter's atmospheric complexities, this work contributes to a deeper understanding of giant planet chemistry and atmospheric dynamics.

4 Dimensional Tracking Studies in the ATLAS Experiment

Student Presenter: Camille Mauceri
Faculty Mentor: Zeynep Demiragli (CAS Physics)
Clare Booth Luce Award

The ATLAS detector will be upgraded in preparation for the upcoming High-Luminosity phase of the LHC, which invites us to consider the implementation of developing detector technology. Particles produced by proton-proton collisions in the LHC are identified by reconstructing the path they travelled through the detector from individual hits on different layers of sensors. The reconstructed trajectory – or track, is then associated to an approximated collision location – or vertex. My project focused on the case where the detector can measure the time of hits in addition to their position. Using simulated detector data, I investigated the impact a four-dimensional detector would have on the efficiency and performance of track and vertex reconstruction. I implemented studies on timing information within ACTS: a new software framework that will be used in ATLAS for the High-Luminosity phase but is ultimately designed to be detector and experiment independent. To study the impact of timing information, we first needed to verify the performance of position-based track and vertex reconstruction in ACTS, which led to the discovery of some issues in the track reconstruction process. With the simulated data validated, we were able to see improvements in identification of tracks that had been incorrectly associated to vertices with the inclusion of timing information. Future studies will investigate if timing also improves characterization of jets: cone-shaped sprays of particles produced by hadronization. We are beginning to investigate this by adapting a neural network to identify jet type using timing information within the ACTS framework.

Spectroscopy of Calcium Ferrite (CaFe2O4) for Use in Calcium-Ion Batteries

Student Presenter: Elliott Mendenhall
Faculty Mentor: Kevin Smith (CAS Physics)
UROP Award

Lithium-ion batteries power the modern consumer world, but this technology is ecologically problematic in its production and disposal. Calcium based batteries present a possible alternative which would have far less of an ecological impact, but currently the energy density of calcium batteries is not enough to compete with lithium-ion. This project examined one possible material for use in calcium batteries, calcium ferrite (CaFe2O4). This calcium ferrite powder was analyzed using XAS (X-ray absorption spectroscopy) to determine its electronic structure. Three different variants of the powder were analyzed, one pure calcium ferrite and two vanadium doped calcium ferrites (at 5% and 10% doping levels). Different X-ray energies were used to measure all elements in each sample—calcium, iron, oxygen, and vanadium—ranging from 250 - 1000 eV (soft X-ray range). These measurements show specific binding energies for certain electron orbitals in each sample. From this we can determine the chemical oxidation states, crystal site symmetry, and electronic structure of these different samples. This research establishes the start of a larger project by making basic characterizations about this material. Understanding these chemical and electronic properties is crucial to this material's potential application in battery technology.

Synthesis and Characterization of a Pt-Gd Tetramer

Student Presenter: Alaina Minarik
Faculty Mentor: Linda Doerrer (CAS Chemistry)
UROP Award

Lantern complexes are a topic of interest in the field of inorganic chemistry for their metal-metal bonding and novel intermolecular magnetic properties, while the lanthanides are notable for their single molecule magnet behavior, useful for molecular magnets and quantum information storage technologies. The purpose of this project was to develop a synthesis for a lanthanide-containing lantern complex of the form [(SOCR)4PtLn(mu2-X)2LnPt(SOCR)4], where SOCR is thioacetate or thiobenzoate; Ln is a lanthanide; and X is a bridging ligand. The synthesis was initially attempted with thioacetate as the bidentate ligand, gadolinium as the lanthanide, and chlorine as the bridging ligand. One equivalent of the reagent K2PtCl¬4 was first combined with four equivalents of potassium thioacetate to achieve K2Pt(SAc)4. This intermediate was then added slowly to an equivalent of GdCl3, and the product was recrystallized and characterized with single crystal X-Ray diffraction. The crystal structure revealed that, instead of achieving the expected product, the synthesis resulted in a tetramer containing a cubane core composed of gadolinium atoms, bridged by chlorine atoms. This unexpected complex featured a Gd-Gd interatomic distance of 3.844 Angstroms, which could accommodate the formation of Gd-Gd bonds if the bridging chlorines were removed. Repeating the synthesis with different lanthanide halides yielded structures with similar behavior. The next step in this research will be to form bonds between the lanthanide atoms in the tetramer, using Collman's reagent or Pd2(dba)3 to remove the bridging halogen, producing a rare complex containing lanthanide-lanthanide bonds.

Changes in the Jet of the Blazar 1510-089, Powered by a Super-massive Black Hole

Student Presenter: Angel Morales
Faculty Mentor: Alan Marscher (CAS Astronomy)
Newbury Center Award

Black holes are one of, if not the most, extreme objects in the universe and due to this quality they are gravitational engines that power the most energetic phenomena in the universe. One such example is an object known as an active galactic nucleus (AGN), which is essentially a supermassive black hole that is in the process of feeding. Some of these AGNs produce jets of high-energy plasma, whose origin is not yet firmly established, along its poles; when these jets are pointed in our general direction they are known as blazars, the topic of this study. Explaining blazars would advance our understanding of extreme astrophysical phenomena. In this study, I fit models to what we call knots, which are essentially blobs of plasma which travel along the aforementioned jet, and use these models to track the positions of the knots over time and estimate an ejection time for each knot. I then compare the ejection times to dates of gamma-ray flares observed by NASA's Fermi satellite, finding that there is an apparent correlation, the reality of which I assess statistically. I also study whether any knots are ejected during a recent period when the gamma-ray flux was very low. Such data will allow us to create more accurate simulations and models of the emission from blazar jets in our attempt to understand these mysterious objects.

Large Scale Synthesis of Key Building Blocks to Access Spiromeroterpenoids and Simplified Derivatives

Student Presenter: Amira Oladokun
Faculty Mentor: John Porco (CAS Chemistry)
UROP Award

Spirocyclic-compounds have been used in drug discovery and have been used to treat a variety of different health conditions. DMOA-derived spiromeroterpenoids have shown promising biological activity; our lab's first synthesis of DMOA-derived spiromeroterpenoids paved a solid foundation for further development. My studies focused on a refined large-scale access to Rawal's diene and a key chiral alcohol fragment which may facilitate the streamlined synthesis of natural products and analogues on a hundred-milligram scale. A further goal is to use the chiral fragment in coupling reactions with various abundant terpenes for construction of a spirocyclic library. The synthesis of Rawal's diene used cost-effective chemicals; the 4-step synthetic route utilized acetone formylation, condensation, acylation, and a silyl-protection sequence. The diene was then used in a key Salen-Cr(III) catalyzed, asymmetric Diels-Alder reaction to prepare the allylic alcohol and establish the stereochemistry of the quaternary-carbon center. For the spirocyclic library synthesis, sequential deprotonation and Li-I exchange of the allylic alcohol produced a lithium dianion species which was employed in a 1,2- addition. The resulting diol was oxidized to generate the spirocycle. We optimized a 4-step synthesis of Rawal's diene and synthesized over 30 grams. This material was processed to the key chiral fragment on a gram-scale. However, the lithium halogen exchange and 1,2-addition were tested, but proved difficult and did not yield the expected results. The decagram scale synthesis of Rawal's diene allowed access to the key allylic alcohol on a gram scale. We hope to further explore conditions to synthesize a spirocyclic library.

A Satellite-Based Analysis of Chlorophyll-a and Sediment Discharge Trends at the Intersection of Rivers and the Java Sea in Pekalongan, Indonesia

Student Presenter: Sydney Peacock
Faculty Mentor: Magaly Koch (CAS Earth & Environment)
UROP Award

Pekalongan, Indonesia is a coastal city in Central Java facing many environmental issues stemming from rapid growth and climate change. These environmental threats include flooding, land subsidence, coastal erosion, and water pollution. The combination of these issues has created sediment and nutrient dominated rivers. To investigate the impact this may have on the coastal ocean along Pekalongan, chlorophyll-a and sediment discharge from three separate rivers within the city were observed through satellite imagery. The sediment discharge from these rivers may contain pollutants in addition to nutrients. In the satellite images, chlorophyll-a was used as an indicator for pollution and total suspended sediments (TSS) was used to map sediment movement within the water column. Through the application of different algorithms to manipulate these satellite images within SeaDAS, an image processing software, chlorophyll-a and TSS observed data was able to be extracted. Observations from two different sensors, Landsat 9 and Terra MODIS, were compared to each other and the in-situ data measurements to verify results. Trends were also analyzed over the span of 20-years to visualize parameters on a greater temporal scale. Observed measurements of chlorophyll-a fluctuated between 3 mg/m3 to 5 mg/m3 around the mouth of each river over 20-years with the observed measurements of all three rivers following distinct trends over specific years. This study will be furthered with the goal of equating changes in TSS to changes in sediment supply and land use change in order to understand the response of coastal environments to different natural and anthropogenic factors.

Exploring the miR-726 Gene's Role in Color Vision using CRISPR/Cas9 in Zebrafish

Student Presenter: Marvens Ravix
Faculty Mentor: Daniel Cifuentes (CAS Biochemistry)
UROP Award - SURF

The miR-726 gene is found in certain vertebrate animals with tetrachromatic color vision and is thought to be necessary for this function. Interestingly, the miR-726 gene is lost in nocturnal animals that do not express the entire repertoire of opsins. We hypothesize that it regulates the mutually exclusive expression of each opsin gene in different photoreceptor cells to ensure color vision. This study examined how this gene might control color vision by focusing on its effects in zebrafish, known for their ability to see a wide range of colors. Using CRISPR/Cas9, we targeted the miR-726 gene in zebrafish, known for their tetrachromatic vision. We then injected this molecule, the CRISPR/Cas9 complex, into single-cell zebrafish embryos with a guide RNA targeting miR-726. When the molecule finds the miR-726 gene, it makes a cut in the DNA, which the cell tries to fix. However, when selecting the cut, the cell accidentally changes the miR-726 gene, creating a mutation. This process led to some fish carrying a deletion mutation in the miR-726 gene. With this change, these fish were bred to create a new group of zebrafish line with a loss-of-function in miR-726. This is a stepping stone for future work where we plan to make a homozygous line of these mutant fish to see if and how the loss of miR-726 affects color vision, precisely the expression of other related genes called opsins. Our work successfully created a new zebrafish line with a mutated miR-726 gene. This opens the door to further studies to understand how different genes contribute to animal color vision.

Confirmation of LArTPC Calibration Methods for protoDUNE and DUNE

Student Presenter: Luke Saunders
Faculty Mentor: Zeynep Demiragli (CAS Physics)
UROP Award

Due to its highly desirable features, Liquid Argon Time Projection Chamber (LArTPC) technology has been chosen worldwide as the next generation of giant, underground detectors in the field of astro-particle physics. This project focused on testing a small-scale LArTPC for the purposes of confirming its functionality, utilizing Monte Carlo simulations to better understand and validate calibration methods performed on real data. In doing so, Deep Underground Neutrino Experiment (DUNE) researchers are assured that the technology and hardware used at the Sanford Underground Research Facility (SURF) will be properly tuned for the purposes of their experiments. In order to calibrate the aforementioned detector, a radioactive source of bismuth 207 was used due to its relatively high energy beta decay products. The physical processes that govern the emissions and their travel through the active volume of the TPC was then modeled in Python. With a functional Monte Carlo simulation, the viability of calibration methods could be tested on simulated events. Once the simulation reached a certain level of sophistication, this project confirmed certain methods of LArTPC calibration were valid and did not obscure any important physics occuring in the detector. With this confirmation, researchers around the world have access to a plethora of tested and easily reproducible LArTPC calibration methods.

Synthesis and Charaterization of Spinel Calcium Ferrite and Its Dopants.

Student Presenter: Ruoshui Xu
Faculty Mentor: Kevin Smith (CAS Physics)
UROP Award

We present a simple method to synthesis spinel calcium ferrite, CaFe2O4, with different phases and their vanadium dopants, CaFe(2-x)VxO4, by ball milling and calcination. We successfully eliminated the other two phases of calcium ferrites by 2-stpes synthesis so that pure and vanadium doped spinel calcium ferrite were made. The samples were characterized by X-ray diffraction (XRD), Scanning electron microscope (SEM), and energy dispersive X-ray spectroscopy (EDX). XRD, SEM and EDX gave us the crystal structure, the particle morphology, and the atom composition, respectively. We found that particle sizes, ratio of elements and post annealing process influenced the phase composition of calcium ferrite. We control the phase morphology and make micron scale pure phase calcium spinel ferrite by simple method. Because it has a divalent cation, calcium ferrite and its analogues present a standard reference material for divalent electrochemical systems. By preparing crystal and size-controlled particles, this study will enable future spectro-microscopy measurement on this system.

Social Sciences

Jaunpur Social Network Study

Student Presenter: Ananya Agarwal
Faculty Mentor: Mahesh Karra (Pardee International Relations)
UROP Award

JSNS is an ongoing randomized controlled trial that has been conducted with 671 women of reproductive age in Jaunpur, India. The main aim of the trial was to identify the causal impact of a social networks-based family planning intervention on women's family planning behavior, fertility preferences, and well-being in rural India. Over the summer of 2018, women were randomized into treatment and control arms. Women assigned to the treatment arm were offered subsidized family planning services. Additionally, a subset of treated women was encouraged to incentivize others to visit the clinic with them. A follow up survey was conducted with all 671 women in 2019, and data was used to estimate the causal impact of the intervention. Over the summer, I have been involved in the transcription and translation of qualitative interviews that were conducted with a subset of subjects, following completion of the trial. The aim of the interviews was to document the experiences of women and providers with the family planning intervention. Findings from the qualitative analysis will be combined with and will supplement the quantitative results to provide a more comprehensive understanding. As part of the coding process, I first transcribed audio recorded interviews, which were conducted in Hindi, and I translated these transcriptions into English in preparation for thematic coding. At this time, I have started reviewing interviews and am using qualitative analysis software to highlight recurring main themes. Analysis and thematic coding of these interviews is ongoing and will continue into the fall 2023 semester.

Evolving Minds: Natural Selection in Third-Grade Classrooms

Student Presenter: Taelor Anderson
Faculty Mentor: Deborah Kelemen (CAS Psychological & Brain Sciences)
Newbury Center Award

Evolution by natural selection is a key but pedagogically difficult concept in science education, about which misconceptions are abundantly common. The Evolving Minds Curriculum, a twelve-lesson science unit created by the Child Cognition Lab, seeks to help third-graders understand evolution through narratives. The present study examined its effectiveness in 9 classes in the Greater Boston Area (N = 151). Prior to the start of lesson 1, a pretest was administered that included forced choice and open ended questions and a posttest asking the same questions was given after the conclusion of lesson 12. These assessments included 11 forced choice questions covering topics such as differential survival, differential reproduction, fossilization, environmental change, and numerical takeover. Posttests showed significant improvement in ten out of the eleven forced choice categories, $p<0.05$. The question on fossilization with sedimentary layers had no significant change between the pretest ($M=0.768$, $SD=0.423$) and the posttest ($M=0.84$, $SD=0.368$) assessments and therefore had no significant change in understanding after the lesson, $t(152)=1.69$, $p=0.093$. Results indicate that the Evolving Minds curriculum led to a significant change in understanding for 91% of post curriculum assessment questions, therefore appearing to show strong effectiveness in cultivating children's understanding of these complex biological concepts. The current study therefore provides evidence that teaching complex biological concepts from early in elementary school is entirely feasible.

The Role of Acetylcholine in the Striatum: Understanding the neural mechanisms governing associative learning

Student Presenter: Aaquib Attarwala
Faculty Mentor: Mark Howe (CAS Neuroscience)
UROP Award

The striatum is involved in associative learning that associates cues with actions and rewards. Dopamine (DA) has been regarded as the primary neurotransmitter modulating striatal output pathways and has been found to bi-directionally interact with cholinergic interneurons (CIN), which release Acetylcholine (ACh). An increase in DA levels in the striatum is accompanied simultaneously by a synchronized pause in firing in CINs. This pause is thought to create a temporal window for learning to occur allowing for formation of these cue-response associations. While past research has shown spatial differences in DA encoding of cues and actions across the striatum, it is currently unknown how acetylcholine encodes instrumental cue and action associations across the striatum. My project focused on understanding the dynamics of acetylcholine in the striatum and how it interacts with dopamine spatially and temporally in an instrumental learning task. To explore this, I used a technique developed by the Howe Lab that allows for recording of ACh release at multiple sites across the striatum with the help of several optical fibers and a fluorescent ACh sensor. To do so, I fabricated and implanted the multi-fiber arrays and trained mice on an instrumental stimulus-response task. I successfully trained and implanted three mice on this task. Initial recordings indicate that we are able to measure ACh with a good signal-to-noise ratio. This data will allow a better understanding of the temporal and spatial interactions between DA and ACh which allows for a more holistic understanding of the functioning of this brain region.

American Promotion of Democracy Abroad: Where and Why?

Student Presenter: Sahika Aydinol
Faculty Mentor: Jeremy Menchik (Pardee International Relations)
Humanities, Arts, and Preprofessional Scholars Award

The National Endowment for Democracy is a congressionally funded private nonprofit foundation with the principle of "supporting freedom across the world." Accordingly, NED administers over 1,600 grants annually which are directed towards various activities aiming to "promote democracy." Despite NED's prominence and lucrative funding stream, scholars have a poor understanding of its operations, effects, and evolution over time. In 2021 alone, the NED invested over 250 million dollars across 100 countries, a substantial portion of this arriving from the U.S. congress and American taxpayers. The NED spending database currently under construction at Pardee is the most extensive example of its kind. It attempts to shed light on questions such as: Which countries or regions are NED's priority for democracy promotion? How have NED's priorities changed since the 80s? Do these priorities reflect the era or the agenda of the incumbent presidential administration? What does NED see as success and failure?
To that end, I qualitatively and quantitatively analyzed a dataset curated at BU featuring NED spending on over 150 countries since 1984. I used descriptive statistical analysis to specifically highlight the recent surge of poorly detailed "Global Grants" NED has allocated. My goal was to create a user-friendly, visual dashboard to demonstrate trends in NED spending by country, by region, by decade and by presidential party. I want to further this analysis by particularly looking into NED activities in the MENA region- which skyrocketed after 2003- to discuss their possible goals of improving soft-power and public diplomacy in the region.

Investigating the Role of Vasculature as Scaffolding in the Migration of New Neurons in an Adult Songbird HVC

Student Presenter: Brooke Bedell
Faculty Mentor: Benjamin Scott (CAS Psychological & Brain Sciences)
UROP Award

My research looks at the relationship between the vascular system of juvenile songbirds and the pathways of their migratory neurons. In the adult brain of mouse animal models, it has been discovered that after their birth, new neurons rely on blood vessels to travel to their final destination. However, this study previously had not been looked at for non-mammals, specifically avians, who have a higher rate of neuronal migration. One transgenic (green fluorescent protein positive) juvenile male zebra finch had a cranial window surgically implanted over its HVC. The male was then injected with sulforhodamine and imaged across ~12 hours. ImageJ (Fiji) software was used to track the migratory paths of neurons, which were then manually analyzed against the location of the bird's blood vessels. If a neuron came into contact with a blood vessel at any point during its journey, its behavior was characterized and marked as associated. Our research discovered these migratory neurons may use vasculature as a scaffolding material or "highway" to get to their destination more efficiently. Statistical analyses revealed neurons that follow the paths of blood vessels have a higher average velocity than their non-associated counterparts. Association with vasculature could be a large factor of neuronal migration in non-mammals in the same way it is within mammals. Future experiments could continue to test this relationship by lesioning blood vessels to observe changes in migration, or testing the molecular connections between migratory neurons and blood vessels through histochemistry.

Equal Justice Under Law? A Comparison of the Rhetoric in Massachusetts Criminal Rape and Assault Cases

Student Presenter: Lilian Belisle
Faculty Mentor: Sarah Miller (CAS Sociology)
UROP Award

In the wake of the #MeToo and #BelieveHer movements, the general public has been forced to reckon with the undeniable reality that there remains a profound cultural bias against survivors of sexual assault. The criminal legal system is one of the many systems within which this prejudice can be located. Through a comparative analysis of criminal cases arising from non-sexual assault- and sexual assault-related charges, my project examines the attitudes displayed by those in power when discussing sexual violence in a legal setting. Incorporating evidence from a four month-long period of court observations and 25 in-depth interviews, my preliminary findings are that in criminal rape cases, juries operate as though there is a higher burden of proof, witnesses are shown greater skepticism, and defense arguments are more intimately focused on personal attacks of the complaining witness. These discrepancies must be addressed. With an increased awareness of these structural failures and a simultaneous recognition of the fact that incarceration is not a productive solution, the courts system has the potential to serve as a leader in driving forward the compassionate and equitable response to and prevention of all forms of sexual violence.

Music and Society: The Effects of Capitalism on Busking

Student Presenter: Amana Bhumitra
Faculty Mentor: Leland Clarke (CFA Music)
UROP Award

Busking refers to musical street performing, coined in the 1860s, it is an integral part of cities and the music world. This study investigates the performer's passion for music and how they interact with societal structures. Using Facebook groups and approaching people at popular busking locations in New York City, I interviewed 15 musicians to investigate their experiences. Several of the participants are full-time buskers, but many do not or can not solely financially support themselves by busking. The main recurring themes in the interviews were public perception, monetary compensation, opportunity, and passion. The public reception of the music is highly important to the musicians as giving back to the people was the motivation behind many of the musician's performances, however, most musicians felt that they were looked down upon and felt like they were 'begging' because of their low-status job and location. The monetary compensation is a drive for the musicians who solely depend on busking, however, several of the musicians would still continue busking without the compensation because performing their music is a basic necessity, similar to rent and food. Another motivation is the opportunity it provides them with, the ability to practice, find their sound, and be seen. These interviews can help shed light on the art form and foster a deeper appreciation of busking. It examines an overlooked, pure form of music and artistry. This research will be used for my thesis, aiming to analyze capitalism and busking in New York City and Boston.

Overcoming COVID-19: An analysis of the cultural coping mechanisms utilized by Black families in the face of adversity

Student Presenter: Taylor Bolan
Faculty Mentor: Stephanie Curenton (Wheelock Applied Human Development)
UROP Award

The purpose of this study is to understand how Black families have been surviving in response to COVID 19 and to explore their lived experiences during the pandemic. Conceptual and empirical literature have long established the diverse forms of cultural practices among Black families that reflect their agency and resistance to varied forms of racialized oppression in the U.S context. To further build on such lines of inquiry, the present study sought to investigate the particular cultural strategies that Black families employed during the COVID pandemic. We asked the following questions: How are Black families enacting agency during this pandemic? How are Black families talking about what they need? Using the Rapid Assessment of Pandemic Impact on Development–Early Childhood, data was analyzed from a subset of Black caregivers who had children between 0–3 years of age. Eligible families completed a baseline survey concerning their family's circumstance, health, and well-being. After analyzing the data obtained, an extensive literature review was conducted to further build context and cultural understanding of the topics that emerged. Prominent themes that arose, including religion, kinship networks, adaptability of family roles, and a variety of other cultural coping mechanisms, are consistent with the extant scholarship on Black families as agentic groups. The results of this study thereby challenge dominant tropes of anti-Blackness and deficit-oriented narratives of Black parents and caregivers.

Exploring the influence of family cohesion on families with autistic youth during the adult transition period

Student Presenter: Samantha Brayton
Faculty Mentor: Kristin Long (CAS Psychological & Brain Sciences)
UROP Award

Higher family cohesion is defined as strong emotional bonding between family members and a tendency to rely on internal support within the family. In western contexts, high family cohesion is typically considered "unhealthy" as it may lead to enmeshment and stunted growth of individual family members. In contrast, high cohesion in families with autistic children may promote the development of adaptive support strategies. This study aims to explore the ways in which family cohesion influences the experiences of families with autistic youth during the adult transition period, a period associated with elevated family stress and "poor" adult outcomes. Autistic youth (ages 14-21, n=3) and parents (n=12) completed semi-structured interviews that were audio-recorded and transcribed verbatim. Transcripts were systematically coded and analyzed using applied thematic analysis. Results suggest that higher family cohesion may enhance within family support during transition planning, and lead to optimistic outlooks in parents regarding the transition to adulthood. Families who reported involvement of autistic youth, siblings, and/or other family members in the future planning process described satisfaction with their child's anticipated adult outcomes, even when these outcomes differ from those of neurotypical or other autistic children. Specifically, their optimism relates to milestones representing the unique successes and capabilities of their autistic youth. Understanding this positive effect of within family support on family experiences of the adult transition period will help to develop future program initiatives focused on enhancing skills and strategies needed to support autistic youth and their family.

Characterizing the clinical features of PANDAS and PANS: A profile of patients within MassGeneral for Children's Pediatric Neuropsychiatry and Immunology Program

Student Presenter: Elliott Carlisle
Faculty Mentor: Alyssa Farley (CAS Psychological & Brain Sciences)
UROP Award

Few studies have characterized the presentation of a clinical sample of children with Pediatric Autoimmune Neuropsychiatric Disorder Associated with Streptococcal infections (PANDAS) and Pediatric Acute-onset Neuropsychiatric Syndrome (PANS). This study aimed to describe a clinical sample of patients with PANDAS and PANS and better understand potential risk factors for these diagnoses. All patients (N=101) were evaluated at Massachusetts General Hospital's Pediatric Neuropsychiatry and Immunology Program (PNIP) and diagnosed with PANDAS or PANS. Each patient's symptom presentation, infection history, psychiatric history, developmental history, and family psychiatric and autoimmune history were recorded through a clinical interview or parent-report questionnaire. The most reported symptoms among PANDAS and PANS patients were obsessive-compulsive symptoms (PANDAS=83.6%, PANS=73.5%) followed by emotional lability/depression (PANDAS=67.2%, PANS=61.8%) and irritability/aggression/severely oppositional behaviors (PANDAS=59.7%, PANS=58.8%). Symptom onset was rapid, with most children reaching peak symptom severity within one week of symptom onset (PANDAS=66.7%, PANS=63.3%). Attention-Deficit/Hyperactivity Disorder (PANDAS=33.8%, PANS=27.3%) and Generalized Anxiety Disorder (PANDAS=27.9%, PANS=12.5%) were the most reported psychiatric diagnoses pre-dating PANDAS/PANS. Compared to the general population, patients had an increased prevalence of psychiatric disorders and autoimmune disease among their first-degree relatives. Patients presenting with acute-onset neuropsychiatric symptoms should be thoroughly evaluated for PANDAS/PANS, which are disorders associated with complex and varied presentations. Future research should examine potential associations between certain biological factors and PANDAS/PANS to help identify risk factors and inform interventions.

Following the Waters: A Comparison Between Haitian Vodou and Cuban Lukumí Ritual Usage of Water and the "Cooling Head"

Student Presenter: Demian Choi
Faculty Mentor: Margarita Guillory (CAS Religion)
UROP Award

Water plays an important role in the Africana Diaspora religions of Haitian Vodou and Afro-Cuban Lukumí (otherwise known as "Ocha" or the pejorative "Santería"). It cleanses practitioners of their ailments, purifies spaces, and symbolizes the concept of "coolness." Water also serves as the base of different herbal concoctions such as ozain or omiero in Afro-Cuban traditions. Thus, water can heal. In other manifest forms, water may act as a form of communication between humanity and the divinities to establish the presence of the spirits, whether it be in glasses, pipes, or the natural waters themselves. Through such bodies of waters as the ocean, one may find traditions of the dead and even Africa ("Ginen" in Haiti) residing underwater and beckoning the human world. By participating in the ceremonies and healing rites alongside being in conversation with engaged devotees, this ethnographic research examines these diverse uses of water by practitioners of Haitian Vodouizan and Afro-Cuban Ocha in the NYC and Boston areas. This research provides a nuanced understanding of these otherwise marginalized traditions, amplifying voices of the practitioners that are at times under-appreciated in academic studies of Vodou and Lukumí. Ultimately, this study provides a deeper insight into the vast, fluid role of a simple element and how these practitioners adapt to their surroundings.

Exploring the potential for a successful urban insurgency in Afghanistan

Student Presenter: Joseph Clark
Faculty Mentor: Thomas Barfield (CAS Anthropology)
UROP Award

This study examines the question of whether an urban based insurgency could succeed in toppling the current Taliban regime in Afghanistan whose historic strength has been in rural areas of the country. For the first time in the country's history, Afghanistan's increasing rate of urbanization and opposition to the Taliban's ideology among urban progressives has created the conditions for such an insurgency that has already manifested itself in the form of protests, strikes and urban guerilla attacks. It begins with a comparative analysis of urban rebellions elsewhere in recent history that have specific parallels to the situation in Afghanistan. It then cross-references these determining factors with conditions inside Afghanistan today derived from published reports and interviews with fourteen people (Afghan and international) who had information on the subject. The research concluded that the Afghan urban opposition already has many of the factors seen in successful urban insurgencies elsewhere and is likely to add more of these over time. However, a successful urban insurgency requires both that the opposition utilize these opportunities and that the antipathy toward Taliban's policies in urban areas be mobilized against them. Because Afghanistan's insurgencies have always been rural based in the past, the possibility of the Taliban facing an urban insurgency has been largely ignored by policy makers. Despite the strength displayed by the Taliban regime coming to power two years ago, this study argues that it would be a mistake to underestimate the difficulties it would encounter suppressing such an insurgency.

Democracy From The Dust: Ethnonationalism's Role in the State Building of Eastern Europe

Student Presenter: Michael Dupre
Faculty Mentor: John Stone (CAS Sociology)
UROP Award

With the dissolution of the Soviet Union, many believed liberalism would culminate in systems of representation across the globe, and the ideological supremacy of democracy would be realized. Yet since the end of the hegemonic Cold War, alternative forces have worked against the autonomous state-building that seemed inevitable. This is an analysis of why some states have succeeded in their state-building ambitions and others of similar historical context have faced more challenges. This study considers how ethnonationalist movements complicate this process by basing nations on ethnicity. Slavic culture is not monolithic and a historical comparative analysis of Poland and Ukraine between 1985 and 2000 demonstrates how ethnic factors have an omnipresent impact on the socio-political fabric of nations. This is achieved using methods of agreement to compare events of similar importance. The constitutional design and establishment of political institutions of the Presidential and Parliamentary systems are inherent to state-building. Modern states are characterized by centralized bureaucracies of leadership. Aided by a national spirit and identity, powerful social movements can either help or hinder the establishment and sustainability of such designs. Ukraine is a diverse state, yet the opposite holds true for Poland, a homogenous country by every metric. Such diversity caused strong movements that complicated Ukraine's transition to democracy in this period. Credence can be given to economic reforms, but this study finds diverging views on what constitutes the national identity as equally important.

Investigating Urban, Spatial Economic Trends in the Developing World

Student Presenter: Ryan Duswalt
Faculty Mentor: Yuhei Miyauchi (CAS Economics)
UROP Award

The overarching objective of urban economic study is to understand the fabric of a society in which most of us live-cities. This research involves a close, quantitative analysis of dense survey and geographic data to investigate the economic trends of urban areas around the world. For instance, with the wide range of demographic data available to us, we sought to uncover how income fluctuates as a function of the distance one lives from the city center, and why this trend might be present when placed in the greater context of that particular city. Using statistical software packages such as R and Stata, as well as QGIS, a system supporting the viewing, quantification, and analysis of geospatial data, and GitHub, a system used for collaboration and version control when writing code, we develop individual workflows to help organize and analyze our data. Further research is continually done to uncover additional statistics from online databases that may help in answering our questions. Finally, our research utilizes LaTeX, a document preparation system, to present tables, plots, graphs, and any general results. Among poor countries, our analysis has shown a positive relationship between income and the distance from one's home to the city center, a negative relationship between income and the distance of one's work location to the city center, and no relationship between commuting distance and the distance of one's home to the city center. These findings help untangle the economic complexities of cities and our place in them.

Investigating the relation between callous-unemotional traits and parenting from years 3 to 5

Student Presenter: Sevillana Ettinger
Faculty Mentor: Kimberly Saudino (CAS Psychological and Brain Sciences)
UROP Award

Children with callous-unemotional traits (CU), such as a lack of empathy, low emotional sensitivity, and limited displays of affection; are susceptible to developing later problem behaviors. Parenting is one factor implicated in the development of CU, though findings on the relation between CU and parenting remain mixed. Our research aims to clarify and expand upon previous findings by 1) examining both positive and negative parent feelings and 2) using random-intercept cross-lagged models, which examine parent feelings and CU in the context of both between-person trait-like effects and within-person age-specific effects. Six hundred and twenty children were longitudinally assessed at ages 3-, 4-, and 5-years. Parents rated CU using the Child Behavior Checklist. Parents reported their positive and negative parent feelings towards their children on the Parent Feelings Questionnaire. The random-intercept cross-lagged model between-person results showed that overall CU was associated with less positive parenting and more negative parenting. The within-person results revealed age-specific associations between CU and positive parenting at age 5 and between CU and negative parenting at all ages. However, CU and parent feelings did not influence each other from one age to the next. Our results demonstrate that prior mixed findings may be a result of undifferentiating positive and negative parenting as well as between- and within-person effects.

Sexual Liberation as a Utopia-Building Practice: A Contemporary Construction of Queerness

Student Presenter: Mara Farrell
Faculty Mentor: Marie McDonough (CAS English)
Humanities, Arts, and Preprofessional Scholars Award

Queer activists currently employ sexual identity as a social categorization tool, using "queer" as an overarching term for any divergence from the sexual norm. Historically, the queer movement sought to encourage a more radically transformative sexual liberation, eliminating sexual norms altogether. Today the focus has shifted onto creating more inclusive norms and building tolerance for different sexual identities, indirectly galvanizing cis-heteronormativity and overshadowing the nuances of complex sexual expression. Cornerstone queer scholars predicted this potential conflict long ago, but the emergence of social media as the key platform for queer youth discourse has solidified it as arguably the most pressing issue for the future direction of queer liberation. This paper aims to reexamine the meaning of "sexual liberation" in relation to "queerness" in this contemporary context. If these concepts are still in flux, how can we establish collective goals and ensure positive progress without some sort of consensual utopian ideal? Examining the linguistic and societal function of "labeling" in gender and sexuality, the landscapes of sexual oppression for women and LGBTQ+ identifying people, sexual power dynamics (age, gender, status, etc.), and the overall moralization of sexual acts, I propose a possible image of a liberation. My "queer utopia" is categorized by the "unframing" of gender and sexuality as the expression of feeling as opposed to prescribed identity. More akin to "sex-neutrality," this approach qualifies individual sexual autonomy in terms of connection, pleasure, and self fulfillment, as opposed to arbitrary or universal categories of "good" or "bad."

The Use of Technology in Academics

Student Presenter: Dima Ghalili
Faculty Mentor: Andrea Mercurio (CAS Psychological & Brain Sciences)
UROP Award

ChatGPT, an advanced Artificial Intelligence (AI) software model has gained considerable attention in educational settings. The actual and potential use of ChatGPT and other softwares, along with increased reliance on the internet and technology, has posed new questions regarding academic integrity. We conducted a pilot study with two primary aims: 1. to investigate how university students use ChatGPT and similar softwares in an academic context 2. to assess perspectives on the responsible use of AI with respect to academic work. We recruited college students to complete an online survey (N = 36). Results showed variation in the types of online tools used, with 82% utilizing Grammarly, 69% utilizing translation software, 63% utilizing assignment answers acquired online, and 38% utilizing test answers bought/found online. All but three respondents reported using ChatGPT (91%) with 73% using it for academic purposes. The most common uses of ChatGPT were to 'understand articles/passages' (35%), 'check grammar/sentence structure' (32%), 'debug code' (29%), and 'generate ideas for academic work' (29%). Interestingly, 45% of respondents were unsure if their institution had policies regarding ChatGPT. Eighty-three percent of the sample reported the need for guidance on the ethical use of ChatGPT. However, 45% of respondents indicated that instructors included policies regarding ChatGPT in their syllabi. Our research suggests that ChatGPT is gaining traction among students. This is concerning given that the potential misuse of online tools for academic work may be difficult to control and because the implications for learning and academic integrity are still unknown.

Navigating Expectations: Asian American Parents' Perspectives on Autistic Youth's Transition to Adulthood

Student Presenter: Shumin Guan
Faculty Mentor: Kristin Long (CAS Psychological & Brain Sciences)
UROP Award

Asian American parents often expect their children to achieve academic success and financial stability in adulthood, which may increase continued oversight of their children into adulthood, as compared to other racial/ethnic groups. Research is limited about Asian American parents' expectations in the context of autism. This study aims to understand Asian American parents' expectations of their autistic children and of their parental roles after their child enters adulthood. Seven Asian American parents/caregivers of autistic youth (57.1% Chinese, 28.6% Vietnamese, 14.3% Filipino; youth ages 14-21) participated in semi-structured interviews in English or Chinese. Interviews were audio-recorded and transcribed verbatim. Transcripts were systematically coded and analyzed using content analysis. Asian American parents expected themselves to remain the primary caregivers of their autistic children into adulthood. Parenting responsibilities included meal preparation and providing accommodation. Parents had high academic expectations for their autistic children. They also expected their children to find a stable job after graduation. Asian American parents anticipate continuing their caregiving role into the adulthood of their autistic children. Asian American parents' high level of parental involvement may contribute to their elevated expectations for their autistic children. For instance, parents expected their autistic children to attain higher education, equating independence with academic excellence. Future research should further investigate the relation between parenting practices and expectations, especially how these expectations in turn shape parents' utilization of services and definition of their autistic children's success during adulthood in order to develop services that match Asian American parents' cultural values.

Gender Inclusion at Summer Camp

Student Presenter: Riley Hennessy
Faculty Mentor: Daniel Kleinman (CAS Sociology)

Summer camps can be an important recreational and developmental setting for some American children. They can be a prime environment for development of personal identity. The social skills developed in camp settings can give kids personal tools to thrive. However, summer camps are not always inclusive of all children. Only a minority welcome gender non-conforming or transgender youth. Despite larger historical trends in the US of increasing awareness of people disrupting gender binary norms, inclusion is still contested. As more of these spaces to foster all youth are created, including those that don't conform to the traditional binary, it's important to examine the influence they may have on the greater culture of masculinity and femininity. Summer camps in particular often institutionalize gender beyond the familiar "bathroom" problem. Separate sleeping areas, groups, meals and counselors all contribute to a lack of gender neutrality. This research seeks to examine the transition to gender inclusive programming at a summer camp and its effects on concepts of masculinity and femininity at the institution. The camp was previously gender separate, being separated into gendered groups as soon as campers arrived. Now there is a third category of "all gender" groups that campers and parents can select. Through interviews of counselors implementing the new policies, this project seeks to understand their experiences of language changes, practices, beliefs, traditions and camper behaviors. The participation of counselors who had previously attended the camp as kids before gender inclusive programming is also compared to their observations of campers today.

Bite-mark Analysis: The Pseudoscience that Incarcerates at Random

Student Presenter: Kajsa Kedefors
Faculty Mentor: Andrea Asuaje (COM Journalism)
UROP Award

When most jurors hear "science" and "expert" in the courtroom, ears perk. People are inclined to believe scientific experts. Forensic odontologists—people who study dental science—often perform bite-mark analysis: a practice that attempts to match bite marks at the crime scene or on victims to alleged offenders. Forensic odontologists testify about their findings in court as experts. Their testimonies are extremely influential and are often attributed to deciding the verdict. Bite-mark analysis is not a scientifically valid method. The National Academies of Sciences (NAS), the President's Council of Advisors on Science and Technology (PCAST), the National Institute of Standards and Technology (NIST) and the Texas Forensic Science Commission (TFSC), along with peer-reviewed papers, have published concerns regarding bite-mark analysis since 2009, and several have called for its ban from the courtroom, including TFSC in 2016. Bite-mark analysis is still permissible as evidence in all 50 states. While federally commissioned reports and activists have raised the alarm, many judges, prosecutors and jurors still have little idea about the unreliability of forensic feature comparison methods like bite-mark analysis. Nearly 40 people incarcerated with bite-mark analysis have already been exonerated or had their cases dismissed, often with new DNA evidence. Many are still incarcerated on the basis of the pseudoscience. Using archival audio and interviews with experts, I created a pilot episode of a podcast series explaining the history, influence and current status of bite-mark analysis. The podcast discusses key figures that have perpetuated the practice and its role in convicting people in court.

Using prairie voles to model the effects of social deprivation on microglia

Student Presenter: Tori Keefauver
Faculty Mentor: Kyle Gobrogge (CAS Neuroscience)
Global Challenge Research Award

Major Depressive Disorder (MDD) is a leading cause of disability that affects 21 million people each year in the US. One domain that contributes to the development of MDD is social stress and isolation. The current study utilized Microtus ochrogaster, monogamous prairie voles, as a model of human social isolation to study the effects of pair bonding on microglia, which are a type of brain cell hypothesized to play a role in the pathology of MDD. Most humans form pair bonds, a biological bond between two partners, with their romantic or platonic partners, which makes prairie voles an excellent model species for studying human social relationships. Using a sample of eight postmortem vole brains, the study piloted a novel immunohistochemistry protocol to stain all microglia in the vole brain. The novelty of this protocol arises because voles are not commercially available, and so the available antibodies are usually not tested on them. Additionally, this study aimed to develop a protocol for free-floating immunohistochemistry instead of frozen or paraffin-embedded techniques, as it is a much more cost-effective protocol option for student projects. The results of the approach proved successful in producing a protocol that can successfully stain microglia in vole brains. The next steps in this project will involve comparing the microscopic morphology of pair-bonded vs. non-pair bonded voles in order to understand the effects of social stress on microglia. The better we understand the cellular pathology of depression, the better scientists can be at developing drug treatments for the disorder.

Designing Sacred Secularity: Religious Heritage & the Bahá'i

Student Presenter: Elizabeth Kostina
Faculty Mentor: Joseph Harris (CAS Sociology)
UROP Award

Religious sites such as the Bahá'í Holy Gardens in Haifa, Israel that are classified as world heritage sites are at once major tourist destinations and pilgrimage sites for the faithful. As such, these sites speak to both the secular needs of tourists and the religious needs of their community members. The physical architectures of these sites reflect this balancing act through the incorporation of symbols into the built environment. Therefore, how people will interact with religious sites becomes highly intentional and reflexive, shaping both interpretations of the space and allowing the space to shape how it is interpreted. This research is a qualitative interview and materials-based comparative analysis of the Bahá'i Holy Gardens in Haifa, Israel interested in understanding how members of the Bahá'i faith and tourists to the Holy Gardens 1) interpret and relate to their religious heritage 2) understand the role that the administrative branches of the religion play in regulating the religion for its adherents and outsiders and 3) exploring whether there are contradictions between these two facets and what the implications of those contradictions (or lack thereof) mean. Most specifically, this research is interested in the social and political implications of classifying religious sites as heritage sites for both 'tourists' of the faith and believers, positing that heritage classification of religious sites contributes to a positive discourse surrounding both minority religious rights and heritage.

Feature extraction and classification of autism spectrum disorder through convolutional neural networks

Student Presenter: Kelvin Kuang
Faculty Mentor: Arash Yazdanbakhsh (CAS Psychological & Brain Sciences)
Newbury Center Award

Autism spectrum disorder (ASD) is a group of neurodevelopmental disabilities that impacts how a person interacts, communicates, learns, and behaves. ASD has no single known cause, but genetics and environmental factors may play a role in how different cortical areas are connected and how neural communication works differently in ASD. Axon pathology is at the core of disruptions in cortical connectivity in ASD, but the extent and patterns of disruption in cortical pathways that travel in the superficial (SWM) and deep white matter (DWM), respectively, is unknown. This research utilizes deep learning, a method in artificial intelligence, to extract and localize axonal tract patterns in individuals with ASD and age/sex matched controls (CTR). These convolutional neural networks were trained on optical microscopy image data, provided by PI Basilis Zikopoulos from the Human Systems Neuroscience Laboratory. Preliminary results indicate that axon density, clustering, and myelin are key features for correct classifications, in line with previous studies that have shown significant differences in the density, size, and myelination of axons in ASD vs CTR. Incorrect classifications can also reveal clues about which certain features can cause confusion in pathology. The most misclassifications occurred with ASD DWM being misclassified as CTR SWM, which can indicate that ASD disrupts the connectivity of axons in DWM to the extent that it resembles SWM. Little research has been done on this subject and has been proven to be difficult, nevertheless we achieved ~70% accuracy for pathology.

Deeper into Children's Explanatory Preferences About Non-Living Natural Objects

Student Presenter: Ankita Kumar
Faculty Mentor: Deborah Kelemen (CAS Psychological & Brain Sciences)
UROP Award

Children are exposed to various explanations about the world, including non-explanatory statements (e.g., "Lakes have water because there's space with water inside"). These kinds of explanatory statements are commonly offered by adults to children (Callanan & Oakes, 1991), but they do not offer novel information and thus limit children's learning opportunities. Preliminary work suggests that repeated exposure influences children's memory of these explanations. This study examines if children's science-related belongingness influences their evaluation of non-explanations and their recall of them. We interviewed 5-to-8-year-olds ($n = 54$) at a science museum and showed participants 4 questions about natural phenomena (e.g. "Why are rocks pointy?") and corresponding non-explanatory statements. After a distraction task, participants were asked to recall these statements. While children's sense of belongingness in science (self-science identity) did not predict how they rated non-explanatory statements, children's perceptions of how much others might feel they belong in science (other-science identity) significantly and positively predicted how highly they rated non-explanations ($p > 0.05$). Children who rated non-explanations as lower in quality were more likely to correctly remember them ($p > 0.05$). Both self- and other-science identity interacted with the relationship between explanatory quality ratings and correct remembrance of the explanations (both p's > 0.05). These results provide critical insights into how children perceive explanations even when they do not contribute to children's knowledge. These results have implications for improving the education system to avoid providing children with low-quality explanations, thus preventing the formation of misconceptions about important scientific phenomena.

Latent Space Exploration of Generative Adversarial Networks on Alzheimer's Disease MRI Scans

Student Presenter: David Lee
Faculty Mentor: Arash Yazdanbakhsh (CAS Psychological & Brain Sciences)
Mary Erskine Undergraduate Research Award

Early detection of Alzheimer's Disease (AD) benefits at-risk individuals medically, socially and financially by alleviating more intensive and less successful care options down the road. Generative adversarial networks (GANs) can synthesize realistic prodromal AD MRI scans which help professionals screen for the disease. StyleGAN2, a state-of-the-art GAN, was trained on AD MRI coronal slices featuring the hippocampus, which deteriorates as AD worsens. The GAN's generator was used to encode newly introduced MRI scans into latent vectors. Principal component analysis was then performed on the sample domain of latent vectors. The latent space did not contain any evidence to suggest that the network had 'learned' AD progression. For example, no vector operation existed which could consistently transform latent vectors representing milder AD into those of severe AD. However, the GAN was able to replicate newly introduced images very well, with a structural similarity index measure of 0.938 ± 0.001. The evidence suggests that GANs are capable of generating synthetic AD MRI scans for purposes such as supplementing existing data for an image classification task, but do not necessarily 'understand' AD progression in an MRI scan.

"Save the Nation" – Mapping the YMCA and YWCA's Activities in Shanghai, 1922-1927

Student Presenter: Wenxuan Li
Faculty Mentor: Eugenio Menegon (CAS History)
UROP Award

The research mainly investigated how the Chinese leadership network of the Shanghai Young Men's Christian Association (YMCA), a Western missionary organization, influenced and was influenced by the turbulent era of the 1920s. Shanghai was then known as the "Paris of the East," one of China's most industrialized cities with the awakening sentiments of nationalism. The interaction between the Shanghai YMCA and the political dynamics around the May Fourth Student Movement and the May Thirtieth Incident originated the prototype of Sino-Western synthesis in Shanghai. By researching YMCA's letters, minutes, journals, and reports composed by the US secretaries and leading Chinese figures, I have outlined 'mindmaps' and literature reviews, demonstrating the complex composition of the YMCA's leadership, made up of elites who led other organizations in Shanghai, such as Fudan University, the Shanghai Chamber of Commerce, large-scale industrial companies, etc. The intricate networks of the YMCA's leadership strengthened the YMCA's social and political presence and facilitated the YMCA's daily operations, including charity and social services. However, considering the diversity of the YMCA leadership's goals for various non-YMCA positions, the conflicts of interests could hinder the general mission of the YMCA, especially in clarifying their tasks in social reforms to make progress in Shanghai's problematic social environment. It is crucial to note that all YMCA-related organizations comprised individuals with diverse backgrounds and interpersonal relationships, which should be explored to further understand Sino-Western relations.

How Fossil Fuel Companies Use Native Advertisements to Shift Environmental Narratives in U.S. Media

Student Presenter: Emma Longo
Faculty Mentor: Michelle Amazeen (COM Mass Communication, Advertising, and Public Relations)
Nelson Undergraduate Research Award

Using a rhetorical analysis, this study examines how fossil fuel companies portray climate issues in two native advertisements from the New York Times and the Washington Post. Native advertisements, which appear like posts that belong to platforms, are one of the ways fossil fuel companies attempt to share information on climate science. By investigating the covert advertising strategies used by fossil fuel corporations, researchers can better understand origins of climate misinformation and climate denial. The present paper argues that this advertising strategy contains elements of climate misinformation and falsely portrays how fossil fuels affect the environment, as established in the fifth IPCC report.

Unveiling Modern Femininity: Exploring the Intersection of Fashion Aesthetics Online and Offline Among Young Women

Student Presenter: Sofia Marin
Faculty Mentor: Heather Schoenfeld (CAS Sociology)
Newbury Center Award

This project investigates the role of social media on identity formation and the self. Specifically, I use the case of college-aged women's participation in the "Clean Girl Aesthetic." I aim to understand how women describe their reasons for participating or not participating in popular social media trends and uncover the factors that influence their reasoning and their own sense of style. I used a qualitative research method and recruited 5 college-aged women who self-identify with this trend and 5 college-aged women who do not identify with the trend but know what it is. I conducted semi-structured interviews and used a walk-through method to uncover each participant's understanding of norms around the trend, femininity, and fashion styles and compared and contrasted what kind of labor goes into self-presentation for participants and nonparticipants of the trend. The results of this study highlight how femininity is performed in digital spaces and the factors that contribute to its performance outside of those spaces. These findings are significant because they point to women's increased self-surveillance as a result of social media and its associated labor. Future research should focus on how, in the Bourdieusian sense, taste and preference are developed through social media, and examine the strategies fashion influencers use to perform their authenticity.

Time-Series Classification in Machine Learning: Long Short-Term Memory Networks

Student Presenter: Emma Martin
Faculty Mentor: Arash Yazdanbakhsh (CAS Psychological & Brain Sciences)
UROP Award

Deep Neural Networks (DNN) are information processors which mimic neural connectivity in the human brain. While Convolutional, Recurrent and Multilayer Perceptron Networks are paradigms for image classification, recent efforts towards classifying temporal data have resulted in the establishment of Long Short-Term Memory Networks (LSTMs). LSTMs show potential for applications in electroencephalography (EEG) as medical event indicators. This research aims to apply and optimize an LSTM for epileptic seizure prediction using EEG data from Boston Children's Hospital. To first ascertain the nature of EEG data, I extracted voltage spikes from the time-series throughout three sequential periods of EEG collection: interictal (no current seizure), preictal (preceding a seizure) and ictal (seizure). Preliminary results show a 328% increase in spikes in the ictal period relative to the interictal period, suggesting promise for the LSTM's ability to discriminate waveforms. To avoid confounding influence of noise, input data was bandpass filtered to include frequencies between 0.1 Hz to 127 Hz. Initial LSTM testing revealed a pseudo-high classification rate; inherently, ictal (seizure) periods are interspersed infrequently amongst hours of interictal (no-seizure) periods. This heavy imbalance led to over-memorizing (overfitting) interictal patterns relative to ictal waveform patterns. After experimentation with alternative data for hyperparameter optimization purposes, I have found that zeroing out over-represented classes and increasing the learning rate of the network reduces over-memorization. Moreover, using higher computational power and decreasing the amount of internal processors could also remedy poor generalization, all of which will be applied in future research and data analysis.

Investigating the Impact of Loneness on Radicalization into Extremism

Student Presenter: Jack Martin
Faculty Mentor: Jessica Stern (Pardee International Relations)
UROP Award

In recent years, violent extremism has increasingly and tragically become a prolific fixture of our cultural milieu. While radicalism has almost always existed in one form or another, new political movements and technologies like the internet have brought forth both novel means of spreading hateful ideology and new challenges to traditional methods of countering its march. This research project, through cooperation with the non-profit organization Parents For Peace, received access to first-hand accounts of radicalization through the eyes of loved ones close to the indoctrinated, and analyzed them in order to break down potential common risk factors throughout various instances of extremism. Specifically, a special emphasis was placed on the impact of loneness and social isolation on subjects in the set of codes utilized to filter the given data. This project primarily involved a small team of professors and students breaking down individual cases cooperatively, coding the data into a standardized sheet, and then discussing any potential discrepancies in their findings. The goal was to create a quantized database that can serve as a basis for future research into deradicalization, as well as aid in the development of new strategies to counter extremism that move beyond brute deterrence. Currently, the project is in the pilot phase, but should further funding be approved, even more expansive data can be collected through an expanded coding set.

Investigating How Heterosexual University Students Desire and Construct Romantic Relationships

Student Presenter: Sarah McArdle
Faculty Mentor: Alya Guseva (CAS Sociology)
UROP Award

As women are increasingly empowered with the economic and legal agency to support themselves, it is worth challenging the traditional understandings of romantic relationships that center heterosexual marriage as a vital source of security for women. While our modern understanding of romantic relationships emphasize romantic love and emotional connection, the rates of dating and sexual intimacy among young Americans are steadily decreasing. With these factors in mind, the value of heterosexual romantic relationships to young, educated women has become far less apparent. Through conducting semi-structured interviews with young (18-25 years old), heterosexual students at academically-rigorous universities in the Boston metropolitan area, this study aims to gain a stronger understanding of this sample's expectations and experiences in romantic relationships, as well as how they evaluate these relationships in relation to their educational and career pursuits. The majority of the interview questions are open-ended, designed to encourage respondents to be detailed and transparent with the information they share. Several patterns have emerged in the present data, namely that many respondents prioritize their educational and career pursuits over romantic relationships. Further, some respondents have identified a desire to be in a romantic relationship, but have discussed not having strong motivation to pursue dating. As more data emerges, these patterns—as well as other trends—may become more prevalent, perhaps allowing for a stronger understanding of the factors that influence the dating attitudes and behavior of young students similar to the sample.

Zooarchaeology and Animal Use at Birsama, Israel

Student Presenter: Caroline Metcalf
Faculty Mentor: Catherine West (CAS Anthropology)
UROP Award

The Birsama site in Israel was occupied 1,800 years ago during the Late Roman period, and this study focused on human modification of animal bones excavated from this site. Zooarchaeology, or the study of animal bones from archaeological sites, at Birsama reflects how people lived and how they interacted with animals. The goals of this research project were: 1) to compile data on the animals at Birsama, 2) to understand how human relationships with animals shape the environment, and 3) to understand how the site operates as a whole. During the 2023 field season, animal bones were excavated, identified, and photographed, modifications were noted, and the assemblage was interpreted. This study established zooarchaeological methods at Birsama for ongoing research and provides a view into the use of animals at the site. The animal material at Birsama came from a dump near the mud brick wall of the settlement, and are dominated by sheep/goat (Ovis sp.) remains. The majority of the modifications were evidence of burning, showing a consistent temperature of 500°C based on bone discoloration. The results suggest the bones came from a midden, or trash dump. This research will be used to expand zooarchaeological knowledge of the area and to guide future excavations, which should focus on this area in particular to discover more about human-animal relationships at Birsama.

Fostering Development: Exploring Parental Traits and Supportive Language in Parent-Child Interactions

Student Presenter: Angel Miller
Faculty Mentor: Amanda Tarullo (CAS Psychological & Brain Sciences)
UROP Award

Providing emotional support and autonomy support during parent-child interactions is crucial to children's cognitive and social development. Parents' inhibitory control (ability to control attention and actions) and mindfulness (internal and external self-awareness) are both associated with the quality of parent-child interactions. The implications of these unique parental attributes for supporting children's development through language remain unexplored. Understanding these mechanisms can inform future intervention strategies. The aims of this study are (1) to investigate the correlation between inhibitory control and mindfulness in parents, and (2) to investigate inhibitory control and mindfulness as possible correlates of autonomy support and emotional support. Parent-child dyads (age 4, n=78) completed a difficult puzzle task together while being recorded. Videos were then transcribed and coded for autonomy support and emotional support by trained, reliable coders (Kappa ≥ .80). Emotional support language included positive evaluations of the child and progress on the task. Autonomy support language included questions or statements encouraging the child to decide the dyad's next steps. Parents completed the Flanker, a standard test for inhibitory control, and the Mindful Attention Awareness Scale (MAAS) indexed mindfulness. There was no correlation found between inhibitory control and mindfulness (r= -.056, ns). This indicates that mindfulness and inhibitory control make unique contributions to parent-child interactions. Future Pearson correlations will be run to assess how parental inhibitory control and mindfulness relate to autonomy and emotional support. Understanding the interplay between parental traits and their linguistic support is vital to improving the quality of future interventions for parents and children.

Exploring the potential for a successful urban insurgency in Afghanistan

Student Presenter: Carolyn Moyle
Faculty Mentor: Thomas Barfield (CAS Anthropology)
UROP Award

This study examines the question of whether an urban based insurgency could succeed in toppling the current Taliban regime in Afghanistan whose historic strength has been in rural areas of the country. For the first time in the country's history, Afghanistan's increasing rate of urbanization and opposition to the Taliban's ideology among urban progressives has created the conditions for such an insurgency that has already manifested itself in the form of protests, strikes and urban guerilla attacks. It begins with a comparative analysis of urban rebellions elsewhere in recent history that have specific parallels to the situation in Afghanistan. It then cross-references these determining factors with conditions inside Afghanistan today derived from published reports and interviews with fourteen people (Afghan and international) who had information on the subject. The research concluded that the Afghan urban opposition already has many of the factors seen in successful urban insurgencies elsewhere and is likely to add more of these over time. However, a successful urban insurgency requires both that the opposition utilize these opportunities and that the antipathy toward Taliban's policies in urban areas be mobilized against them. Because Afghanistan's insurgencies have always been rural based in the past, the possibility of the Taliban facing an urban insurgency has been largely ignored by policy makers. Despite the strength displayed by the Taliban regime coming to power two years ago, this study argues that it would be a mistake to underestimate the difficulties it would encounter suppressing such an insurgency.

Visual-Haptic Crossmodal Aftereffects in Curvature Perception

Student Presenter: Jonathan Mu
Faculty Mentor: Arash Yazdanbakhsh (CAS Psychological & Brain Sciences)
UROP Award

The mutability of perception manifests itself in sensory aftereffects, wherein one's detection of sensory attributes is directly affected by their exposure to a conditioning stimulus briefly beforehand. Demonstrating these aftereffects in a controlled environment carries great implications on the integration of perceptual inputs within the cortex. Curvature perception was selected due to its prevalence in both vision and haptics (touch). The study consists of four separate paradigms, each with unique pairings of conditioning and test stimuli: visual-visual (VV), haptic-haptic (HH), visual-haptic (VH), and haptic-visual (HV). The two pure paradigms (VV and HH) measure aftereffects within a single modality, whereas the two crossmodal paradigms (VH and HV) measure the effects of one modality on the other. For each test curve, subjects respond "up" or "down" to report convexity, and their detection probabilities are fitted to psychometric sigmoid functions. Aftereffects are measured by the shift in one sigmoid's position relative to another, which indicates a change in response sensitivity under a certain condition. VV and HH subjects consistently demonstrate negative aftereffects for both convex and concave conditions, indicating a general desensitization to a condition's curvature direction. VH and HV subjects, however, vary greatly. Both desensitization and sensitization are observed across subjects, unlike in the pure paradigms. Subjects can be affected equally by both convex and concave conditions, but many are affected only by one. Though this implies vision and touch directly affect one another, the mechanism seems to be far more variable across subjects than the aftereffects confined within either modality alone.

The Evolution of Education Systems from 1970s Somalia: Barre's Secular Push and the Role of Islamic Education

Student Presenter: Nasra Noor
Faculty Mentor: Betty Anderson (CAS History)
Humanities, Arts, and Preprofessional Scholars Award

My research is on the topic of the dual education systems of Somalia in the 1970s, during President Mohamed Siad Barre's administration. This study investigates why Barre's push for secular education was more successful than both his predecessors and those who came after him. Furthermore, this study investiages the role of the Islamic education at the time. The first phase of this study sorted through the documents in the BU African Studies Library. The second phase took place in the capital, Mogadishu, and the third, in Garoowe, a city in the state most successful in contemporary education. The study found that Barre succeeded in part because he governed over a uniquely stable Somali government and he used force, in the form of threats, to provide motivation for expanding the secular education system. In order to promote literacy, Barre shut down schools for a little less than a year and sent anyone who knew basic literacy skills to all parts of the country as teachers. Barre argued that the role of Islam was to be in the private sphere rather than the federal. As for the current role of Islamic education, those in the Ministry of Education are now discussing using the previously private Islamic schools as a form of a national preschool education. The significance of this research is that it highlights the fact that the Somali education system is in a new age of reform in which it combines the two education systems for the first time.

The Consequences of Counseling: The Effects of Same-Race Dyads on Black Mental Health Professionals

Student Presenter: Camille Ofulue
Faculty Mentor: Celeste Curington (CAS Sociology)
Global Challenge Research Award

Black mental health professionals (MHP) experience distinct joys from working with Black clients, such as establishing therapeutic rapport faster and easier. However, Black MHPs also experience challenges from these same-race dyads because of insufficient therapeutic boundaries and the tremendous emotional labor necessary to perform when working with Black clients. This research aims to uncover how same-race dyads impact Black Mental Health Professionals, focusing on the secondary traumatic stress (STS) and burnout experienced by Black mental health professionals during and after the COVID-19 Shelter in Place. This study utilizes a mixed-methods approach to ask Black mental health providers how the pandemic and racial uprising have affected their work and professional quality of life, measuring STS and burnout. The survey data will uncover the possible effects of this dual pandemic on Black mental health providers and compare the level of STS and burnout concerning the proportion of Black clientele. The interview study will pinpoint how Black mental health providers respond to the conditions that most impacted their work and how they navigate the interpersonal and emotional impacts of same-race dyads on Black MHPs. Studying how emotional labor unfolds among Black mental health professionals, a group already given little to no training on same-race dyads, will therefore generate further insight into how emotional labor is racialized and gendered as how it is experienced uniquely by Black mental health professionals. The information gathered from this study can be used to improve current curriculums to better train and support Black MHPs.

Time Perception Modulation by States of Discomfort Induced by the Cold Pressor Task

Student Presenter: Edison Park
Faculty Mentor: Sam Ling (CAS Psychological & Brain Sciences)
UROP Award

Time seems to fly when we are having fun, but what about when we are in pain? The current study explores this question by having participants perform temporal judgments while undergoing the cold pressor task, which consists of submerging one's hand in ice water. In the temporal judgment task, participants were first shown a visual stimulus presented at two different time durations (e.g., 0.2 and 0.8 seconds), defined as either the Short or the Long duration. Then, in a series of temporal bisection tasks, participants indicated whether the visual stimulus was presented for a time duration closer to the Short or Long duration. Visual stimulus durations tested were equally spaced between the Short and Long durations (e.g.,0.2,0.3,0.4,0.5,0.6,0.7,0.8 seconds). To induce different states of discomfort during the temporal task, participants submerged their hands in cold water in the pain condition, and in warm water in the control condition. Differences in time perception between the conditions were compared through an analysis of the bisection point, which is the time duration in which the participant reported the stimulus as long 50% of the time; the bisection point would be higher if time is perceived to slow down. Time perception is generally an understudied perceptual process, and this project attempts to investigate factors that could influence time perception. A follow up study will attempt to explore whether auditory stimuli influence time perception differently from visual stimuli.

Conjuctive representation of what and when in primary visual cortex

Student Presenter: Luke Pemberton
Faculty Mentor: Marc Howard (CAS Psychological & Brain Sciences)
UROP Award

History in PFC and hippocampus expresses as conjunctive firing of what and when with a compressed representation of time. However, it is uncertain how history is expressed and how time is represented in other parts of the brain, such as the visual cortex. In this study we show that history in V1 and higher order visual regions is expressed as conjunctive firing of what and when with a compressed temporal representation, though on a shorter scale than seen in PFC and hippocampus. Using ANOVA, linear discriminant analysis, and generalized linear models, we analyzed neuropixels recordings of mouse visual areas from the Allen Brain Institute visual coding dataset. We specifically looked at spike data from viewed static gratings and natural scenes images and analyzed the decoding of stimuli accuracy and temporal receptive fields. Cells in primary visual cortex and higher order visual areas were sensitive to image identity but fired in a consistent sequence across image types. These sequences extended past the first stimulus presentation and showed decreasing resolution for time points further in the past. Both the distribution of receptive field peak times across neurons and the linear correlation of peak time to field width indicates compressed memory. These results suggest a general organizing principle of time in the mammalian brain.

Relative readings of ordinals

Student Presenter: Wilder Perkins
Faculty Mentor: Elizabeth Coppock (CAS Linguistics)
UROP Award

A nested definite description with a superlative in the embedded noun phrase, such as "the apple on the highest stair", can be interpreted using an absolute reading ("the apple on the highest stair [overall]") or a relative reading ("the apple on the highest stair [that has an apple]"). This study investigated whether a similar relative reading exists for ordinals ("first stair"). We carried out experiments in which participants were presented with an image featuring various objects placed on a sequence of tables or stairs. Participants were asked questions about the placement of various objects, involving nested definite descriptions, phrased such that there was no absolute reading available. The dependent variable was whether the question was rejected by the participant (i.e. if they answered "doesn't make sense" or similar). The survey results showed respondents consistently rejecting relative readings for ordinal modifiers in the embedded position, while more readily accepting them for comparative and superlative modifiers. This finding indicates that ordinals behave differently in semantic composition than comparatives and superlatives. More generally, this finding shows that there is diversity among modifiers that motivates a non-uniform approach to the analysis of relative readings.

Subject Use in Spanish-Speaking Bostonians

Student Presenter: Thomas Piernikowski
Faculty Mentor: Daniel Erker (CAS Linguistics)
UROP Award

This project presents research that builds on recent sociolinguistic evidence demonstrating how the contact of English and Spanish in Boston and other parts of the US has led to interesting variation in the way that Spanish speakers use their language. I investigated this phenomenon through an examination of 30 Spanish-speaking Bostonians, specifically looking at subject placement and what social and linguistic factors condition this variable. To do so, recordings were produced of interactions with the participants and the investigator; interviews were conducted in Spanish, aiming to elicit conversational speech. The data were coded for various dependent and independent variables such as subject type, verb type, and subject position, which will allow for a quantitative analysis to be done. While the project presents work in progress, it is expected that the study will produce evidence that demonstrates the impact of contact with the English language on the way participants use subjects in Spanish. Participants with more frequent contact with English and higher levels of fluency are expected to have higher rates of preverbal subjects when speaking Spanish compared to participants with less exposure to English. These results, although preliminary, are expected to be relevant to various linguistic fields. The most important aspects of this study provide empirical evidence that, on a narrow focus, help further understand how Spanish is evolving in the United States influenced by contact with English varieties. On a larger focus, the results should help better understand the mechanisms of language change through contact.

Exploring the Associations between Affect and Persistence Decisions

Student Presenter: Maria Sol Sanchez
Faculty Mentor: Joseph McGuire (CAS Psychological & Brain Sciences)
UROP Award

Delay of gratification is often linked to achieving long-term goals, but optimal behavior can require curtailing persistence. This study explores how affective states (valence and arousal) relate to individual differences in waiting behavior. Participants completed two 10-minute blocks of the Willingness-To-Wait Task in two sessions held 14-28 days apart. The task consisted of a token worth 0¢ appearing on the screen that matured to 10¢ after a variable delay. Participants had to decide whether to wait for the token to mature or to move on to a new trial. Two task versions (active and passive) investigated the influence of varying motor contingencies on persistence decisions. Participants ranked their current arousal and valence states on a Likert scale ranging from 1-9 before, during, and after the task. Additionally, the UPPS-P scale collected self-reported positive and negative urgency scores, indicating the likelihood of acting impulsively based on positive and negative affect. Our analyses showed that longer behavioral waiting times were associated with more positive pre-task affective valence in the passive condition ($r = 0.21$, $p = 0.007$) and with greater pre-task affective arousal in the active condition ($r = 0.17$, $p = 0.028$). A linear regression model revealed no evidence for a theoretically predicted interactive effect of pre-task arousal and urgency on wait times. The model did, however, reveal an unpredicted effect of pre-task valence and urgency score on wait time in the active condition. Further research will explore the association between affect and adaptation to persistence, and investigate links to urgency.

How Emotions Shape Children's Judgements of Fairness

Student Presenter: Ari Schifman
Faculty Mentor: Peter Blake (CAS Psychological & Brain Sciences)
UROP Award

Moral emotions - how people feel when treated unfairly - are considered a key factor in children's moral development. Research on fairness has found that young children consider unequal distributions less fair than equal distributions and also show negative emotional responses to receiving less than another child. In the current study, we investigated whether the emotions of a child who receives less than a peer has a causal effect on judgments of fairness. Children 4-7 years old (N=157) were told about two other children who received an unequal amount of stickers (1 vs 6 stickers). Children were randomly assigned to one of three conditions: in Disadvantaged-Happy (DI-Happy), they were told that the disadvantaged child felt happy; in Disadvantaged-Sad (DI-Sad) that the child felt sad; or a Control condition in which they were not told about the recipient's emotions. Afterwards, they were asked how each recipient felt and how fair the unequal distribution was. Results show that the emotion manipulation worked: children rated the disadvantaged child as less sad in the DI-Happy condition compared to the Control and the DI-Sad conditions. Fairness ratings did not vary by condition, as we predicted, but we did see evidence of a causal role of emotion for older children in the DI-Happy condition, the main test condition. Those who rated the recipient as more happy also rated the inequality as more fair. Overall, these results suggest that changing children's perceptions of the emotions of disadvantaged recipients directly impacts their assessment of the fairness of inequality.

Third Culture Kids and the Varying Perceptions of Community

Student Presenter: Hannah Semaya
Faculty Mentor: Jonathan Mijs (CAS Sociology)
UROP Award

This study focuses on the concept of the "Third Culture Kid," or "TCK," which is a term used to describe how those who do not fit into the culture of their home or ethnic background, fit into a new "third" culture with other TCKs, by comparing two specific groups within this identity group (children of expats and bi- or multiracial individuals). This study investigated whether these two groups had similar or varying perceptions of community, which is an essential part of the human experience, and a topic not often discussed in TCK research. For this research, I conducted semi-structured interviews with ten people from each TCK group (and did not overlap). I chose this approach to understand the experiences from people of each group and to make sure I can let them explain all their thoughts and experiences without interruption. From the research conducted some of the major results included community being important to TCKs who are children of expats because the experience of moving around or not being in a place of their usual "community" meant that they had to find communities in their own ways. As for TCKs who are bi- or multiracial, many explained that they noticed their communities consisted of people who are also mixed or are of similar background to them. The results from the study deem the research to be important because it will allow others to understand why it is important to understand all types of TCKs to explore every experience.

Maternal age and income in relation to sociocontextual risk and child cognitive function

Student Presenter: Kelsey Smith
Faculty Mentor: Amanda Tarullo (CAS Psychological & Brain Sciences)
UROP Award

While impacts of adolescent motherhood on child development are well established, implications of having a child in early adulthood are less studied. This study assessed how maternal age and income relate to socio-contextual and cognitive dimensions in children using archival data from 124 mothers with 5-year-old children. Mothers reported demographics, neighborhood quality, and social support. Children's hair cortisol levels (indexing chronic stress) and nonverbal intelligence were assessed. The mothers' ages were divided into ≤30 years (Range:22-30,M=27.000) and >30 years (Range=31-48,M=37.692). Age 30 signifies a cutoff of 25 years at childbirth. Mothers under 30 had a lower average household income ($36,013) than mothers over 30 ($115,225) (t=-3.126,p=0.002).Younger mothers reported lower neighborhood stability (t=3.029,p=0.003), were less likely to identify as non-Hispanic white (X^2=(1,107)=10.431,p=0.001), and were less likely to have graduated college (X^2=(1,124)=10.754,p=0.001). Families were classified into high and low-income. Mothers whose household income was below 300% of the federal poverty line had lower neighborhood stability (t=3.272,p=0.001), were less likely to identify as non-Hispanic white (X^2=(1,106)=37.333,p=<0.001), were less likely to have graduated college (X^2=(1,123)=44.561,p=<0.001), and had lower social support (t=-3.176,p=0.002). Lower income related to higher child hair cortisol levels (t=2.956,p=0.004) and lower child nonverbal intelligence (t=-3.127,p=0.002). My results indicate the considerable income gap between younger and older mothers. Maternal age and income negatively correlated with key socio-contextual risks, with income related to child biological stress and cognitive function. Future studies should include further exploration into age by including paternal age and use a longitudinal framework to detect significant life trends in younger-mother children.

The Path to Moksha: Examining Attitudes Towards Mental Health In Upper Middle Class Families in Chennai, India

Student Presenter: Reshma Subramonian
Faculty Mentor: Merav Shohet (CAS Anthropology)

In India, although younger generations are more open to confronting mental illness/health, attitudes towards this still-stigmatized issue differ greatly, from condemning it as a personal failing to viewing it more neutrally as a medical condition. This research investigates inter-generational differences in the experiences of and opinions about mental health among upper middle class families in Chennai, India. I conducted semi-structured, open-ended interviews with eight young adults and college students in Chennai who self-identified as having experienced mental health conditions, to understand their experiences and what social and cultural pressures affect them. I also interviewed four older adults (ages 50-70) to gain perspective on their attitudes and changes in opinions towards mental health across time. The research revealed pressure in upper middle class families to maintain a perfect image, which may account for people's reluctance to discuss mental health struggles. Ethnographic interviews and observations also point to how the importance of education in ensuring future social mobility and economic comfort can exacerbate feelings of anxiety and cut-throat competitive behaviors deemed key for succeeding academically and in the workplace. The present research, contextualized by a review of existing literature, will be presented as an ethnography-based creative nonfiction KHC thesis by the end of this academic year.

Assessing the Relationship Between Mental Health, Trauma, and Individual Radicalisation

Student Presenter: Jasmin Tagijeva
Faculty Mentor: Jessica Stern (CAS Global Studies)
UROP Award

In the past two decades, acts of domestic terrorism have become a significant threat to American domestic security. While most media and research focus on terrorist organisations, with the rise of technology and social media use, radicalisation no longer requires membership in an organized extremist group and can happen on an individual level. Attacks by lone offenders, such as the 2022 Buffalo mass shooting, show that it is possible to be radicalised through extremist content online without ever engaging with a group. This ongoing research assesses factors affecting the radicalisation trajectory of individuals. Trauma and mental health issues are one of the most prominent factors contributing to individual extremism. The data for this study was provided by the organization Parents for Peace, which works with individuals affected by radicalisation aiming to rehabilitate victims of extremist ideologies and prevent potential violence. The dataset includes a multitude of interviews with extremists across the ideological spectrum and/or their relatives and friends. These transcripts were coded for reoccurring factors including ideological orientation, childhood and adulthood trauma and mental health diagnoses. This project investigates the possible link between mental health and radicalization. It also seeks to define factors that push people to adopt extremist ideologies, the common characteristics and thought processes leading to radicalization, and what motivates individuals to engage in terrorism. This research, therefore, adds to the understanding of domestic extremism by examining the reason for radicalisation in individuals.

Factors Affecting College Tuition and Fees

Student Presenter: Jinxin Tian
Faculty Mentor: Ishita Dey (CAS Economics)
UROP Award

Students demand higher education, and colleges supply it. An increase in the demand for education, a decrease in the supply, or changes in both could lead to tuition inflation. Prior studies explored the impact of changes in a few types of student financial aid, changes in instructional staff salaries, and changes in state appropriations on tuition. By generating an institutional-level panel data set on postsecondary education from the Integrated Postsecondary Education Data System (IPEDS) and controlling for institution and year-fixed effects, this study re-examines the impact of demand-side factors (various student financial aid programs) and supply-side factors (labor costs and government appropriations) on tuition. It extends prior research using data from more recent years (2018-21), includes more types of student financial aid, and accounts for non-instructional staff salaries. The results reveal that supply-side factors do not affect tuition much. Among the demand side factors, the increase in average Pell Grant decreases tuition, and the increase in average institutional grant increases tuition, but these effects vary for public 4-year institutions. Other types of student financial aid, including federal and state grants and loans have minor effects on tuition.

For My Family: Transnational Kinship, Care, and the Filipino Diaspora

Student Presenter: Katrina Tronco
Faculty Mentor: Merav Shohet (CAS Anthropology)
UROP Award

Since the 1980s, the Philippines has become the world's largest exporter of nurses in response to nursing shortages in the United States and Saudi Arabia, the desire of the Philippine government to establish an export and remittance economy, and the underpayment of nurses in the Philippines. As part of an honors thesis project in sociocultural anthropology, this study investigates the educational, work, and immigration experiences of Filipina nurses who are currently living in New York to gain a more comprehensive understanding of the global nursing chain, transnational migration, and family care. The study is using an ethnographic approach, including semi-structured, open-ended in-person interviews and participant-observation, to collect qualitative data, and is relying on library research to contextualize interviewees' experiences and to serve as a model with which interview findings can be compared. Interviews with Filipina-American nurses explore the ways in which transnational nurses negotiate financial opportunity and family care. For example, Filipina migrants maintain closeness with family members abroad through Facebook Messenger and sending boxes of gifts. Also examining the impacts of the feminization of the transnational Philippine workforce, we find that fathers often take on increased child care responsibilities once mothers move abroad and that this pattern continues after the entire family relocates to the United States. We also find that women who have migrated abroad for work are still expected to care for their elderly parents, through financial support or by helping their elderly parents migrate to the United States.

The Advocacy and Socio-political Thought of Paulina Luisi, Unsung Latin American Feminist

Student Presenter: Andrea Ventura
Faculty Mentor: Andrei Mamolea (Pardee International Relations)
UROP Award

Paulina Luisi (1875–1950) was a highly influential Uruguayan political activist, doctor, and diplomat, who campaigned for women's and children's rights and was particularly interested in sexual health. Although recent work has examined her approach to international relations as well as her lifelong commitment to eugenics, Luisi's feminist thought, which was largely based on gender essentialism, merits further exploration. Moreover, Luisi's activism for other causes intersected with and depended on her feminism. Through rigorous analysis of Luisi's correspondence, the present paper seeks to connect Luisi's interpretation of feminism to the rhetoric she employed in advocating for other social and political causes. First, we find that Luisi's published works and personal correspondence characterized women as intrinsically maternal and pacifist. Second, we maintain that this perception served as the basis for the interconnectedness of her efforts, as her feminism was connected to her socialist, republican, and democratic advocacy.

Using Large Language Models for Massive Political Science Data Scraping

Student Presenter: Victor Verma
Faculty Mentor: Jetson Leder-Luis (QST Markets, Public Policy, and Law)
UROP Award

Large Language Models like ChatGPT have recently gained popularity, but much of their potential still needs to be explored. For this project, I developed Python software utilizing ChatGPT's ability to efficiently summarize large amounts of text in order to obtain the biographical data of nearly 150,000 U.S. State Representative Candidates who ran for office between 1967 and 2017. Specifically, I gathered the college major, undergraduate institution, highest degree and institution, and work history of each candidate. Prior to this effort, there was no comprehensive database containing the desired biodata for this scale. This unique dataset offers us insights into the background experience and influences of state legislative candidates. First, I used the Google Custom Search JSON API to identify relevant websites for each candidate. Next, I scraped the chosen websites using the Beautiful Soup and PDF scraping libraries in Python. Finally, I utilized the ChatGPT API to efficiently summarize the scraped website text and extract the desired biodata. I found that approximately 40% of all U.S. State Representative Candidates between 1967 and 2017 had biodata available online on Google, but this percentage generally increases as one searches for more recent candidates. The gathered biodata will be used as part of a larger project studying lobbying laws and the revolving door in politics. The methodology used in this project is extremely powerful and can serve as a general blueprint to create large-scale information databases related to any topic that can be searched on the web using Google.

Against Transracialism: Not Just Ethically Wrong but Metaphysically Impossible

Student Presenter: Allison Vidovich
Faculty Mentor: Derek Anderson (CAS Philosophy)
Humanities, Arts, and Preprofessional Scholars Award

The notion of transracialism has recently become a center of political and philosophical controversy. Many philosophers recognize there is something about transracialism that is intuitively wrong and politically important to resist, but it is important to spell out the metaphysics to show why transracialism is impossible. My paper takes the moral and political imperatives to reject the possibility of transracialism as an epistemic guide. What was found in this investigation were stark differences between the origins and metaphysics of our constructs of race and gender. These ontological differences show that an inference from the validity of transgender identities to the validity of transracial identities cannot be confidently made. Additionally, this paper proposes a number of substantial differences found in its comparison of race and gender that show why the constructs, while similar in being oppressive social constructs, are not functionally similar to the extent that self-identification has the same transformative power over one as it does the other. As long as the metaphysics of transracialism remains in question, there will be arguments made in defense of transracial identities. The phenomenon of transracialism is an extraordinarily harmful one, and these dialogues must be met with legitimated resistance. This paper contributes to our understanding of how these confusions arise and why they shouldn't be acted on by investigating some fundamental metaphysical differences between race and gender. In future research, I plan to further explore the nature of these constructs, as well as continue to explore the political harms of transracial activism.

Children believe that they will feel better than peers when treated unfairly

Student Presenter: Isabella Villafuerte
Faculty Mentor: Peter Blake (CAS Psychological & Brain Sciences)
UROP Award

By 8 years of age, children tend to believe that they will have higher moral standards than their peers as reflected in their "moral emotions." For example, they believe that they (self) will feel bad when they transgress but that their peers (other) will not. In the current study, we investigated whether 4-7 year olds (N=157) would show a similar self-other effect for an unfair allocation of resources between two children (1 versus 6 stickers). We asked children how they thought each child would feel (other) and then asked them to imagine being each recipient and what they would feel (self). In a Disadvantaged (DI)-Sad condition, we told children that the child who received less was very sad and in a Disadvantaged (DI)-Happy condition we told them that child was very happy. In a Control condition, we did not tell them how the recipients felt. Results showed that children in both the Control and the DI-Sad condition believed that they (self) would feel happier about receiving 1 sticker than another child (other) would. This suggests that children might be bad at predicting how they will feel about getting less which could motivate more generous behavior. Interestingly, children also believed that they would be happiest about getting 1 sticker when told that another child would feel happy. This suggests that children try to match the emotions of their peers as well as the norms of moral behavior.

Comparing auditory and visual temporal attention

Student Presenter: Juneau Wang
Faculty Mentor: Rachel Denison (CAS Psychological & Brain Sciences)
UROP Award

In our everyday world, the brain must process relevant information like sensory stimuli. Voluntary temporal attention lets us prioritize sensory information at specific, task-relevant points in time. Here we investigated how voluntary temporal attention affects auditory vs. visual perception. We designed an auditory temporal attention experiment matched to a previous visual temporal attention experiment to allow a direct comparison between the two. The stimuli are auditory sweeps that either sweep up or down from one of five or two central frequencies. Two sequential sweeps (targets, T1 and T2) with independent directions and central frequencies are presented at predictable times. The precue instructs participants with varying validity to attend to either T1, T2, or both. The response cue instructs participants to report the sweep direction (up or down) of either T1 or T2. To measure effects of attention on perception, task difficulty is titrated for each participant by adjusting the sweep slope. Mean discrimination accuracy and reaction time were well-matched across the auditory and visual experiments, indicating similar levels of task difficulty. However, the experiments showed different effects of temporal attention on accuracy, with a stronger effect of validity on visual vs. auditory discrimination performance. Further, in the auditory task, precue validity affected performance for T1 but not for T2, whereas in the visual task, validity affected performance for both targets. Our future directions are to determine whether attentional tradeoffs in auditory perception across time depend on (1) temporal integration across stimuli, and (2) the time interval between stimuli.

The Effect of Extreme Weather Events on US Military Installations

Student Presenter: Claire Williams
Faculty Mentor: Rosella Cappella Zielinski (CAS Political Science)
UROP Award

The project "The Effect of Extreme Weather Events on US Military Installations" aims to analyze the effects of hurricanes and tropical storms on United States Air Force (USAF) bases from 2000 to 2020. Using publicly available resources, the investigation has identified individual bases that sustained damage and the estimated repair costs from these events, while Freedom of Information Act (FOIA) requests provided more detail of these damages and repairs from said bases. Because all FOIA requests haven't yet been received, one current goal of this project is to finish collecting all information on all bases that experienced weapons platform evacuations, personnel evacuations, or damages and the storms associated into a datasheet. The ultimate objective of this endeavor is to consolidate all gathered insights into an openly accessible report, aiming to demonstrate the comprehensive financial repercussions linked to each affected military installation. In conjunction with this report, an opinion editorial will be released to the BU International Relations Review to illustrate the influence of climate change-induced extreme weather events on USAF bases and other military installations and the threat these damages pose to US national security. The current results of this project show the economic ramifications associated with extreme weather events are extensive, which not only disrupt regular military operations but are also considerably underrepresented in official records. These observations have emphasized the need for standardization and transparency surrounding the military's documentation practices and how these record-keeping hang-ups also threaten US national security in tandem with the associated costs for damages.

Determination of Biodiversity within Gunung Palung National Park using Camera Trap Data

Student Presenter: Amanda Wu
Faculty Mentor: Cheryl Knott (CAS Anthropology)
UROP Award

The tropical rainforests in Borneo, Indonesia are known for their high species richness and their pivotal role as a carbon sink, mitigating climate change impacts. Yet this region faces growing anthropogenic pressures from illegal logging, hunting, and the wildlife trade. To address these challenges, camera traps have emerged as valuable tools in discreetly capturing wildlife activity, aiding researchers with understanding species diversity, behavior, and anthropogenic influence. This project focuses on comparing biodiversity between primary and degraded forests by utilizing camera trap data gathered by researchers in Gunung Palung National Park at the Cabang Panti Research Site (in primary forest) and the Rangkong Research Area (degraded forest) to evaluate the effects of anthropogenic disturbance on wildlife activity. We obtained a collection of 2,492 camera trap videos sourced from 16 cameras, distributed across 8 diverse habitats—12 in Cabang Panti and 4 in Rangkong. We developed a system to identify and categorize these camera trap videos with the TimeLapse image analysis program to record different metrics including date-time, weather, species identification, age, sex, and behavior. From these data, we calculated taxonomic diversity with the Shannon Index (H), using the Relative Abundance Index to comparatively gauge species diversity between Cabang Panti and Rangkong. Our results suggest that primary forests (H = 0.792) host a higher biodiversity compared to degraded 'forests' (H = 0.519). However, to solidify these findings, we recognize the need to incorporate additional biometric variables. Further studies will be conducted as more camera trap videos arrive from Borneo with future examinations of species diversity between animal trails and human trails.

Change in Behavior Under China's Zero-Covid-19 Policies

Student Presenter: Junchu Wu
Faculty Mentor: Ana Villarreal (CAS Sociology)
UROP Award

When the Novel Coronavirus Disease (Covid-19) initially struck mainland China in December 2019, the country demonstrated unity under the Zero-Covid-19 policies as they transformed busy cities into "ghost" towns with the intent to demolish the deadly virus through self-isolation. This research seeks to investigate the cause behind behavioral change among Chinese college students throughout the pandemic. Qualitative research method of snowball sampling was employed, and the interview results suggested that changes of social behavior were triggered by negative emotions towards the lack of uniformity on policy implementation during lockdowns. The policies were deemed a necessity by the majority of the sampled participants in the initial stages of the pandemic, while perspectives shifted as many believed the three-year long policy had gone overboard, restricting their return to the normal way of living. Collective resistance was not only caused by the excessive administration of strict policies, but also the immense suffering endured by individuals who were inadequately prepared to support themselves during waves of sudden long-term lockdowns imposed by the regional authorities. These factors led to the change in the construction of societal norms which triggered the reshaping of social behavior, contributing to the series of collective resistance by the people and the unforeseen reversal of the Zero-Covid-19 policies issued by the Chinese regime.

Game of Truth: Leveraging Large Language Model to Examine the Spread of Misinformation

Student Presenter: Yusen Wu
Faculty Mentor: Dokyun Lee (QST Information System)
UROP Award

This work-in-progress paper examines the application of large language models (LLMs) as an instrument to emulate human behavior concerning misinformation. The study uses LLMs to reproduce three laboratory tests adapted from Pennycook et al. (2021) and van der Linden et al. (2017), which examine the effects of perceived accuracy and nudginginterventions on individuals' misinformation sharing habits, and inoculation intervention on individuals' personal belief on the scientific consensus regarding climate change and human activities. Preliminary findings indicate that the simulated agents successfully qualitatively reflect not only adverse human bias, such as partisan bias and the disjunction between sharing intentions and accuracy perception, but also positive behavior changes to the nudge intervention. Nevertheless, a consistent discrepancy remains between LLMs and human reactions, with the former demonstrating a superior ability to identify false information and a markedly increased inclination to circulate accurate information. This research lays the groundwork for the subsequent application of LLM agents in social network simulations.

Arts & Literature

Translating the Memoir of Najati Sidqi

Student Presenter: Anas Bin Alfadino
Faculty Mentor: Margaret Litvin (CAS Arabic)
Humanities, Arts, and Preprofessional Scholars Award, Lena Mandell Research Award

Najati Sidqi – early Palestinian recruit to the Communist Party, outspoken anti-fascist, and literary translator – is an important Arabic figure from the twentieth century. However, his masterpiece is a book relatively unknown in English-speaking academia: a memoir he wrote in the late 1970s and published in 2001. In this memoir, Sidqi chronicles his eventful life full of historically significant encounters. This English translation presents Sidqi's memoir in an European language for the first time. This translation aims to be accessible, elegant, and clear. To achieve this, I have worked through reiterative revision with Prof. Litvin and my colleague, Gideon Gordon. Sidqi also describes various places that he visited and the figures he met during his travels across Europe and the Middle East. Sidqi himself is a primary source – in several places in the memoir, he introduces new historical data. We made use of publicly-accessible archives, scholarly accounts, and forums to source documents and information that corroborate the data that Sidqi presents in this memoir. Sidqi's straightforward and entertaining style make his memoir an especially valuable text for scholars and students at all levels, including those with no prior knowledge of the Middle East. In the future, I aim to make use of the skills I have developed in this research to translate and conduct research into Middle Eastern history and politics.

Refugee Laws as Determinants of Racial Identity in Diasporas: A Study in the Plurality of Vietnamese Americans' Racial Self Imaginings

Student Presenter: Nathan Duong
Faculty Mentor: Takeo Rivera (CAS English)
Humanities, Arts, and Preprofessional Scholars Award

On January 6th, 2021, the decades-old national flag of the South Vietnamese government billowed in the wind among "Trump 2020" and Confederate American flags. Later that year, in a jarring about-face, Vietnamese Americans were also seen supporting and resettling the new Afghan refugees after the fall of Kabul, Afghanistan. Between these vastly different political movements within the Vietnamese American population, a shocking continuity emerges: the use of racial and refugee identity to justify both conservative and liberal political mobilization by Vietnamese Americans. This research project investigates this tendency for identity politics within the Vietnamese American population by examining the underexplored role of U.S. refugee law in the formation of racial politics. This project asks: how did traversing the mechanisms of U.S. refugee law create a racial identity used to justify radically different Vietnamese American movements and political expressions? Drawing upon reflections of racial and refugee identity in Vietnamese American film and political expression -- as well as works in critical refugee studies and Asian American studies -- this project illustrates a diaspora population's use of identity as a form of moral authority. Hinging upon hues of gendered white-saviorism and American exceptionalism in war-time international adoption, parole migration, and other U.S. refugee migration pathways at the time, these findings support the argument that Vietnamese American identity was heavily shaped by American desires for moral authority -- a quality later appropriated by Vietnamese Americans themselves.

The Philosophy of Grief: To Philosophize is to Learn to Live

Student Presenter: Hanna Dworkin
Faculty Mentor: Matthew Parfitt (CGS Rhetoric)
UROP Award

The greatest philosophers have studied concepts of life and death for thousands of years. Yet, there is a significant gap in philosophical literature that analyzes what lies between life and death: grief. Drawing from philosophers such as Socrates, Montaigne, and Nussbaum. "The Philosophy of Grief: To Philosophize is to Learn to Live" seeks to answer: What role does grief play in the human condition? The paper argues that Aristotle's philosophy of moral virtue (a balance between excess and efficiency in emotion) suggests that grief, despite the suffering it causes, is essential to human flourishing. Lenses of stoicism and utilitarianism are used to demonstrate that, in grieving, one does not mourn solely the loss of a person– they mourn the loss of a relationship, and of all pleasure that came from that relationship. Grief entails going from the presence of pleasure to a complete void. Thus, the grieving process ultimately strives toward an Aristotelian balance of emotion of virtue and (ultimately) flourishing. As the project's research continues, it will investigate: the virtue of grief; lenses of philosophy as they apply to grief; and overall, the validity of Montaigne's most famous thesis: That to philosophize is to learn to die.

Music Through the Scope of Disability: Collaborative and Inclusive Pedagogies

Student Presenter: Spencer Hart-Thompson
Faculty Mentor: Ruth Debrot (CFA Music Education)
UROP Award

The purpose of this Critical Participatory Action Research (CPAR) study was to co-create student-centered holistic performance pedagogies, informed by the classroom practices that emerge from critical interactions between student and teacher. The study took place in the context of an undergraduate self-directed study centered on vocal performance, adapting lessons to mediate accommodations related to the co-researcher's disability. The goal of the research was to begin to move away from the reproduction of prescribed models and historical practices perpetuated by traditional academic disciplines because prescriptive models do not account for the great diversity represented by artists and fail to utilize accommodation methods in an increasingly hybridized, technologically driven, post-human world. The co-researchers (student and teacher) focused on the physicality of performance in relation to disability. The participants engaged in a dialogic, in-the-moment process of inquiry, generating quantitative data using the NASA Task Load Index (TLX), Numerical Rating Scales, and a self-evaluation rubric for the course. Qualitative data were generated through performance videos, written reflections, and dialogic interaction in the classroom/rehearsal space. Data analysis centered on ways that teaching and learning practices were transformed through engagement in cooperative, synergistic, and collaborative practices, and an ongoing critique of those practices. The final report will reflect the development of new, inclusive pedagogies. Discussion will be centered on new pedagogical possibilities for vocal instruction within undergraduate popular music performance education.

Contemporary Observational Painting: Mapping the Relevance of Plein Air in the 21st Century

Student Presenter: Kennedy Harwood
Faculty Mentor: Josephine Halvorson (CFA Painting)
Arts Research Award

Painting has continually redefined itself, and over time, painting from life has been relegated to a populist and preparatory status within the discipline. Though there is much literature around historic observational painting, examining the practices of contemporary painters allows us to recenter painting discussions today. It is crucial that our focus remains on the contemporary moment as there are no thorough surveys of how this method of painting has found its way to the present. Towards the development of Josephine Halvorson's series of essays, we have extensively reviewed art historical literature, examined critical writing about contemporary artists, and conducted interviews with living painters. Building out from the merely historic through interviews, we have uncovered untold perspectives on how this artistic approach is continually relevant. Interdisciplinary scholarship – such as the science of vision and the relationship between painting and digital technologies – has also provided important context for these essays. Thus far, our work has yielded more detailed definitions of art-specific terminology, allowing us to establish a conceptual framework that more accurately describes facets of contemporary observational painting. With newly agreed upon definitions, future research can be more pointed in its discussion of the conceptual and practical nuances of painting from life. This research will continue with more interviews, analysis of relevant literature, and eventually culminate in a book written by Halvorson. The book of essays will guide continuing conversations around observational painting with specific language, as well as serve as a resource to artists, critics, teachers, and students.

Price's Musical Tapestry: The Influence of Spirituals on the Chamber Music of Florence Price

Student Presenter: Virginia Jansen
Faculty Mentor: Leland Clarke (CFA Ethno/Musicology)
Arts Research Award

Florence Price (1887-1953) was the first African American woman to have her work played by a major American orchestra but due to discrimination her music was ignored or forgotten by many after her death. A member of the Chicago Black Renaissance, Price's music often incorporated enslaved African Spirituals, a genre that originated from West African music and Protestant hymnody. This project explores the influence of those Spirituals on Price's chamber music for strings. Through studying Price's influences, including her early life, education, and other chamber music of her time, her choice to embrace Spirituals in her music is better understood. After studying the scores of her chamber works in the archives at the University of Arkansas, the influence is clear through through both quotations of specific spirituals, such as in the "Five Folksongs in Counterpoint" and "Negro Folksongs in Counterpoint," and inclusion of their melodic, harmonic, and organizational idioms, such as in the "Quintet in A Minor." Comparison with other small-scale works, like her arrangements of Spirituals for piano, revealed how Price used chamber music to further develop these themes, as well as interweave them with other movements in classical music and their typical idioms such as Romanticism and Modernism. This same method of analysis can be applied to her symphonies, concertos and other larger scale works. Understanding this influence plays a part in supporting the performing and recording of Price's compositions and this research is an element of the essential effort towards equity in classical music.

Too Many Cooks in the Kitchen: Food Production in The Handmaid's Tale

Student Presenter: Kathryn Lakin
Faculty Mentor: Marie McDonough (CAS Writing)
Humanities, Arts, and Preprofessional Scholars Award

Canadian novelist Margaret Atwood is well known to scholars from the relatively new field of literary food studies, which applies a critical lens to the role of food in literature. While they have discussed the politics of eating and the role of women in Atwood's first novel, The Edible Woman, and her later novel, The Handmaid's Tale– and especially the ways in which patriarchal structures confer upon women the status of consumable objects–the politics of food production (how food is grown and prepared and by whom) has not been treated at length. This means overlooking much of the work food accomplishes in Atwood's works. Through an examination of food production in The Handmaid's Tale, this essay explores the way that concepts of sexual reproduction and the production of food parallel each other, and the way that both forms of state-regulated production exploit existing racial and gender hierarchies in an attempt to prevent the destabilizing potential of desire. I track the novel's references to food production across three sections: The Earth, The Kitchen, and The Table. In these sections I interrogate how agricultural labor, domestic labor, and the regulation of consumption operate within the structure of Gilead. By examining how the state succeeds (and fails) to regulate production, I advocate for an approach to literary food studies that questions not what lies on the table, but how it got there.

Justice, Law, and the State: Policing the Creek Nation (1867-1907)

Student Presenter: Eitan Marshall-Pinko
Faculty Mentor: Sarah Phillips (CAS History)
Humanities, Arts, and Preprofessional Scholars Award

My research this summer was in preparation for a fifty page Honors Thesis, finished by the end of the school year. It will be writing a revisionist history of the Creek Nation's Lighthorse police force from the years 1867 to 1907. During that time period Creek leaders, like Spieche (Isparhecher) and Samuel Checote, managed a mounted force that was in charge of maintaining order over a more and more racially heterogeneous, more and more economically unequal, and more and more politically divided Nation. All the while, representatives of the U.S. government, like Agent John Tufts and Senator Henry Dawes, regularly undermined Creek sovereignty, asserting that the U.S. had the final say on what happened in the Creek Nation. Prior academic histories of the Creek Nation have not focused specifically on the impact of law enforcement in the development of Creek history, and historians of U.S. policing have not paid any attention whatsoever to Indigenous communities in general, let alone the Creek Nation. In order to better understand the broader history of settler colonialism in America, Americans must specifically pay better attention to Indigenous institutions and individuals as they faced the epochal challenges of the late 1800s. In setting Creek archival records in conversation with contemporaneous newspaper accounts, secondary literature, and the Creek oral histories of the Indian-Pioner Archive, I will be able to tell a dramatic story, one that is a powerfully important part of the history of America.

The Decolonization of Women's Traditional Fashion - Contemporary Uses of the Sari

Student Presenter: Shi Qing Elizabeth Natalie Ng
Faculty Mentor: Arianne Chernock (CAS History)
Humanities, Arts, and Preprofessional Scholars Award

In discussing the decolonization of the Indian subcontinent, individuals often overlook the cultural and political identity that fashion creates. Diving deeper into the confluence of British and Indian fashion, the definition of traditional Indian wear has constantly been redefined by the masses. In particular, the sari - swaths of fabric worn mainly by women and few men - has seen vast transformations in its contemporary uses from their fight for independence. From being a tool of revolution and empowerment for women of all castes to being a soft power dress for women in politics, the sari has been reclaimed by women during turbulent political turmoil. Examining fashion as a political tool, this research explored interviews and perspectives from different generations, from East to West and North to South India, thereby showcasing the soft power of the sari. Furthermore, this project explores the versatility of the fabric, especially in allowing individuals to express themselves as an empowering vessel. Contributing to the development of anti-racist and culturally progressive design pedagogy, this study looks at Indian womanhood and socio-economic emancipation during the decolonization period, specifically examining political power groups like the Gulabi Gang and freedom fighters during the Swadeshi movement in India. In showing support for India's liberation, the women threw away sarees manufactured using Manchester-made threads and used handloom sarees woven by Indian artisans. This research aims to shine a light on the minority voices during the decolonization process, and how they reclaimed their power and redefined fashion in their own way.

Unveiling the Mask: An Interdisciplinary Investigation of Women's Artistic Tradition in Mask-Making.

Student Presenter: Anna Paradise
Faculty Mentor: Felice Amato (CFA Art Education)
Arts Research Award, Humanities, Arts, and Preprofessional Scholars Award

My research project was designed with the primary objective of creating a web-based interface for Dr. Felice Amato's Women and Masks project. Amato designed the original website to complement a conference held from 2021-22, prompted by historical exclusion of women in mask-making across rituals, theater, and masquerade, as well as the resurgence of interest in mask-related work used by women to explore diverse themes. My goal was to revise the platform to counteract this disparity in women's visibility by restructuring the site to continue to serve this subfield. To achieve this, I archived materials from the prior conference, undertook substantial efforts to enhance the project's website–focusing on increasing user-friendliness, updating biographical details of women related to mask-making, and refining informational panels dedicated to both artists and scholars associated with the project–and I conducted original research, ranging from crafting masks to scholarly inquiry. I explored techniques pioneered by women, like papier maché methods by the Sartori family and Melody Anderson, and experimented with new approaches mainly with papier maché. I also researched the implications of the Italian Renaissance morètta mask. The Women and Masks Project website will launch in the upcoming fall. It will serve as a conference archive, researcher database, a platform for sharing work, and a resource for exploring masks' transformative potential in self-expression, empowerment, and resistance. This research offers a significant resource for insights into women's mask work, embracing its historical and contemporary relevance.

Literature Review: Disability Studies Approaches in Medieval and Early Modern Scholarship

Student Presenter: Mackenzie Pike
Faculty Mentor: Amy Appleford (CAS English)
UROP Award

Disability Studies is a relatively new field that has widespread implications for the way we understand society as it recognizes disability and impairment as social constructs. This shifts the narrative from the individual to society, as the core tenet of Disability Studies is that a person's disability is exacerbated due to inaccessible infrastructure, cultural norms, and stigma. This project aimed to establish a comprehensive bibliography of literature focusing on disability in medieval and premodern eras with an emphasis on religious influences. This research was conducted using the Medieval International Bibliography, the MLA International Bibliography, and BU Mugar Library. The first stage of this project was to compile an annotated bibliography and literature review of recent and influential publications regarding Disability Theory and Disability Studies to date. Then, a bibliography of about 120 peer reviewed articles, books, and essays on medieval and premodern literature and culture that draw on Disability Theory or use a Disability Studies framework was compiled in the Chicago style; this material will be of great value to Professor Appleford as she completes her monograph. The future applications of this project are significant, not only because there is potential for Appleford's study to contribute to the fields of premodern Disability Studies, but also because it offers a framework for the development of advanced research skills and familiarization of this important field. A broader understanding of Disability Studies will be beneficial to disabled and able-bodied people alike, as most will encounter disability at some point in their lives.

International Theater Through the Prague Quadrennial 2023

Student Presenter: Grant Powicki
Faculty Mentor: Jon Savage (CFA Scenic Design)
Humanities, Arts, and Preprofessional Scholars Award

This study investigates the diverse experiences and offerings of international theater education programs and their representations at the Prague Quadrennial Student Exhibit. Through first-hand research conducted at the renowned Prague Quadrennial event in June 2023, the experiences of 14 participating countries were examined. The study and evidence collected focused on government support and funding, artistic expression and cultural representation, international influences and collaborations, as well as challenges faced. The research highlighted five key groups of countries based on their relationship to theater. Findings showed countries such as the Netherlands, Austria, and the Czech Republic received government grants and funding. Countries such as Brazil, Bulgaria, and Germany experienced limited or no government assistance. Unique forms of artistic expression and cultural depictions were witnessed across various countries. International connections were visible through influences, representations, and collaborations. Lastly, nations like Canada and Austria faced notable challenges due to geographical scope and funding difficulties respectively. Ultimately, the research emphasized the significance of international theater education and the Prague Quadrennial in providing a platform for cultural exchange and artistic growth despite worldly challenges. It highlighted the transformative power of theater and need for greater accessibility and support. Hopefully this research highlights the importance of international theater education and funding as it is essential to the development of theater artists. This research was made possible in part, thanks to funding from BU UROP.

My Hidden Neighbor: The Co-existence of Jewish Refugees and Former Nazi Officers in Post-War Argentina

Student Presenter: Zachary Sherman
Faculty Mentor: Rady Roldan (STH Theology)
Humanities, Arts, and Preprofessional Scholars Award

This project explores the little-known history of how former Nazi officers and Jewish refugees coexisted in Argentina after World War II. Divided into three sections, this study involved primary source material and artifacts from across the world. The first section is about the history of Jewish refugees in Argentina, including their migration patterns and the challenges they faced in integrating into Argentine society. Next, the second section summarizes the "ratlines" that brought Nazi officers to Argentina and their life within the region. The final section of the project examines how the Argentinian Jewish community used its resources to capture notorious former Nazi criminals across South America and their current legacy today. Aiming to shed light on a unique period in history, the project was structured to both expose the aftermath of the Holocaust with these officers and preserve the legacy of over six million Jewish victims.

The Tale of Genji Poetry Database Project: Utilizing Technology for Literary Analysis

Student Presenter: Bryan Teoh
Faculty Mentor: Keith Vincent (STH World Language and Literature)
Humanities, Arts, and Preprofessional Scholars Award

This study delves into the 11th-century Japanese masterpiece "The Tale of Genji," shedding light on the lives of Heian-period courtiers. "The Tale of Genji Poetry Database" project" is an online platform designed to enhance accessibility to the 795 poems scattered throughout the 11th-century Japanese masterpiece, in the original Japanese and in multiple translations, while harnessing the power of technology for textual analysis. The narrative's complexities have inspired five distinct English translations. Our aim was to employ Natural Language Processing (NLP) techniques to unveil latent patterns. Our approach involved a variety of measurements and tools. We assessed mood shifts with sentiment models, generated a list of quantitative textual statistics, and created a MicroSearch tool that allows users to visualize word distribution throughout the text. The main challenge was data preparation, which involved cleaning the data for input into language models and scripts to improve the accuracy of the results. This project demonstrates a data-science approach to literary analysis, customized to individual texts. Looking ahead, we hope to make the platform adaptable for use with other classic literary texts.

Historical and Anthropological Analysis of Boone, North Carolina and its Community's Boundaries Formed Throughout the Late 19th and 20th Centuries

Student Presenter: Sierra Wilkins
Faculty Mentor: Betty Anderson (CAS History)
UROP Award

The relationship between the town of Boone, North Carolina, and Appalachian State University (ASU) throughout the late 19th and early 20th centuries reflects a modern American college town story but with unique environmental and cultural aspects. The history and environment of Boone is a sharp contrast to its university's campus with paved asphalt roads and modern coffee houses. Boone's rolling mountains are dotted with solitary neighborhoods with little to no public transportation and a lack of sidewalks to the point where the town becomes impossible to traverse without a vehicle. Meanwhile, the university boasts a direct bus route to and from the campus limits to the rest of the connected businesses such as roads to King Street, NC. The town's inhabitants mesh with the dynamic environment of the mountains where one might seem it unlikely to be a place for an urbanized university campus. Research and analysis into the complexity of the relationships formed over the late 19th and 20th centuries between Boone and ASU show a transgression of boundaries while still having clear differences between the two. This project uses local and university newspapers to analyze the origins of town-to-university cooperation, working with sources mainly supportive of the university's perspective and of Boone's residents' perspectives. This study is meant to further understanding of how American historical and anthropological study can better enlighten us on ways modern American communities form and how those same communities may construct intentional and unintentional physical boundaries amongst one another.

Unveiling Mystical Insights: Rediscovering Medieval Women's Intellectual Legacy in Global Middle Ages and Contemporary Impact

Student Presenter: Kenneth Wong
Faculty Mentor: Philip Haberkern (CAS History)
Humanities, Arts, and Preprofessional Scholars Award

Between the fifth and eighteenth centuries, historical-philosophical narratives within the Judeo-Christian, Arabic, and Buddhist traditions characterized the medieval era as the 'Dark Age,' particularly evident in Latin West's scholasticism. Despite this prevailing view, endorsed by medieval scholars, my project seeks to challenge and reshape this perception. I begin by investigating how scholastics in the medieval period, often male authors, perpetuated a biased representation of female mystics. These women were frequently reduced to mere objects of fascination, obscuring their distinct identities. My inquiry extends to medieval women across diverse traditions, consistently depicted in ways that undermined their agency, philosophical acumen, and influence. Intriguingly, medieval Japan's context allowed space for outspoken female poets, suggesting an early form of proto-feminism. At the core of my research lies the application of Thomas Aquinas's dialectical methodology. This approach, known for its judicious analysis and reasoning, serves as a key to comprehend the intricate nature of mystical experiences that often elude straightforward explanation. My contention is that Thomistic ethics can effectively illuminate female mystics through my innovative integration of theology and philosophy in this project. This study delves deep into the otherworldly encounters of female mystics, seeking comprehension of the insights, divine visions, and truths that shaped their lives. By revisiting and reevaluating history, this work aims to confer upon these remarkable women the recognition and respect they justly deserve.

Medieval Studies: A Global Future

Student Presenter: Emily Yoder
Faculty Mentor: Sunil Sharma (CAS World Languages & Literatures)
Humanities, Arts, and Preprofessional Scholars Award

Redesigning the Global Medieval Studies website to facilitate accessible research while presenting the program in a truly global context is crucial for transforming undergraduate research methodologies and guiding medieval studies away from a Eurocentric past toward a global future. Comparable undergraduate programs at other universities were critically assessed to determine the extent to which they were global and how they presented the period from late antiquity to the early modern period to their audiences. Online databases of research resources were then critically evaluated to consolidate reputable scholarly resources available to the general public, which were then synthesized into a database for website viewers. While a select few undergraduate programs in medieval studies communicate Islamic areas of study, undergraduate degree programs are predominantly Eurocentric. Likewise, many existing research resources emphasize Europe or include exclusively European sources. These results are significant because, although some programs include global foci, the undergraduate field is predominantly Eurocentric, and programs must incorporate Africa, Central America, Asia, and the Middle East to move toward a more comprehensive future of medieval scholarship.

Migrating the "Tale of Genji Poetry Database" to Next.js for Enhanced Security

Student Presenter: Yu Zeng
Faculty Mentor: Keith Vincent (CAS World Languages & Literature)
Humanities, Arts, and Preprofessional Scholars Award

The "Tale of Genji Poetry Database" is a database containing all 795 poems in the Japanese classic novel, The Tale of Genji. Students in Professor Keith Vincent's course LJ 250 on the Tale of Genji have entered the poems in the original Japanese and five different translations along with associated metadata. Previously, the site was hosted on a React-based website and hosted on an Amazon server. There are two members working on the database during the summer. Bryan Teoh is the other team member and his research focused on using Natural Language Processing to conduct mood analysis on the poems. My research's goal was to transition the existing React-based website to a Next.js framework in Javascript. The website under React was directly connected to the database which can lead to possible data exposure. Under the Next.js framework, the "Tale of Genji Poetry Database" is a full stack project comprising a front end, a back end, and a database. By distinguishing the front end from the back end, the system achieves enhanced security. The project utilizes Neo4j, a graphical database, which can dynamically render data as Nodes and edges in response to user requests that are sent through to the back end. Such an upgrade ensured secure hosting on the university domain. The site's evolution underscores the potential of modern technology to intensify textual engagement, laying the groundwork for future digital projects within the university.

Characterizing the Eating Timing Behavior of Urban and Rural Households in Ghana Using the Automatic Ingestion Monitor (AIM-2).

Student Presenter: Sorochi Anyaibe
Faculty Mentor: Megan McCrory (SAR Health Sciences)
UROP Award

Eating timing has relevance to metabolic health in high-income countries, but there is a lack of such data in low-middle income countries. We characterized eating timing in Ghanaians among 30 rural and 30 urban households, each with a father, mother, child under 5, and adolescent. The Automatic Ingestion Monitor-2 (AIM-2), a device attached to eyeglasses that automatically captures images of dietary intake, was used to collect timing data across 2 weekdays and 1 weekend day. We hypothesized that the eating window (the time period between the first and last eating occasions), and meal duration would be longer in urban households and on weekends than weekdays in both locations. After processing, AIM-2 images were loaded into custom software for nutritional analysis and assessment of eating timing. Data were analyzed with SPSS 29.0.1. Eating frequency was ~2.9 times/d, not differing significantly between urban and rural households, and only 33% of both urban and rural households snacked. Urban households trended towards a longer eating window than rural households ($p=0.051$), due to an earlier start time in urban households ($p<0.05$). Both meals and snacks were longer in urban compared to rural households ($p<0.05$). There were no significant differences across days for most variables; however, meal frequency was higher ($p<0.05$) and there was a trend towards a longer eating window on weekday 1 than the weekend day ($p=0.067$). These results support that eating timing in Ghanaians is not uniform and demonstrate the need for follow-up studies that elaborate these findings across different family members.

Analysis of Walking Speed and Propulsion Symmetry Changes After Functional Electrical Stimulation Training in Individuals Post-Stroke

Student Presenter: Noah Barrow
Faculty Mentor: Lou Awad (SAR Health Sciences)
UROP Award

Many efforts in gait rehabilitation for post-stroke individuals focus on increasing walking speed without addressing the inefficient gait compensations typical of post-stroke walking. This study examines how functional electrical stimulation (FES) may alter gait speed and propulsion symmetry across a single-day visit, exploring an additional metric that can contribute to how clinicians define recovery. Ten participants in the chronic phase of stroke, signed an informed consent form before performing multiple overground walk tests around an indoor track, during which motion capture, inertial sensor, and electromyography (EMG) data were collected. Pre-training and post-training 3-minute treadmill walks were performed with a back-mounted metabolic system (COSMED K5). Participants completed a 30-minute overground training walk with functional electrical stimulation applied to the plantarflexor and dorsiflexor muscles. A physical therapist was present to guard participants and record the time elapsed as participants completed the overground walks. Force data was collected using force plates in the track and treadmill and exported to MATLAB for further processing and visualization. Across all ten participants, there was an average speed increase of (Δ: 3.7%; 0.02 ± 0.15 m/s). For those whose gait speed improved, the average improvement was (Δ: 9.1%; 0.092 ± 0.069 m/s), and those who experienced a decrease in gait speed experienced a (Δ: 6.8%; 0.14 ± 0.15 m/s) decrease on average. Propulsion symmetry data will elucidate the underlying components of these observations and prospectively contribute to developing a commercialized functional electrical stimulation system.

Quantifying the flourishing of a hospitality experience: a system of measurement to define the relationship between received hospitality and human flourishing in consumer settings

Student Presenter: John Barton
Faculty Mentor: Makarand Mody (SAR Research//Marketing)
UROP Award

As many may or may not always be aware, hospitality is constantly surrounding us. While many times this is evident, others may be less obvious or even tangible. To contrast that, the concept of human flourishing has taken recent strides to better define the over generalized term 'well-being' commonly misused in hospitality publications. This research provides a quantitative approach to measuring the relationship between hospitality received (consumer) and the recipient's level of flourishing as a direct result of the event. This correlation is explored through the metric set forth prior by Van Der Weele that both considers the external (demonstrated flourishing) and internal (virtuous) impacts of hospitality. In particular, the hypothesis of a linear versus exponential or varied relationship is examined with associated confounding variables such as the varied forms of hospitality, wealth, geographic status and physical condition of the recipient as examples. This research builds on prior work that attempted to distinguish between well-being and human flourishing in a hospitality context. In particular, this project provides a system to measure the magnitude of a hospitality experience to therefore compare flourishing outcomes. Elements such as frequency, quality and duration are considered. This project was designed to provide a tangible measure for hospitality operators to gauge impact of consumer experiences, with follow- up research aiming to specifically draw upon a sample pool to reinforce findings.

Beat Processing in Relation to Language Fundamentals Among Preschool Children

Student Presenter: Marion Bensing
Faculty Mentor: Jennifer Zuk (SAR Speech, Language & Hearing Sciences)
UROP Award

Rhythmic beat perception skills have been shown to be related to reading development; however, there is limited knowledge about their connection in preschool children. The preschool years constitute a critical period of language development. Investigating the relationship between beat perception and language fundamentals in preschool-aged children can shed light on processes preceding formal reading instruction. In this study, preschoolers (N = 17) aged 4-5 years completed a battery of language-related assessments, including the Clinical Evaluations of Language Fundamentals Preschool-3 (CELF P-3), a measure of early language abilities. To measure participants' speech perception, a computer-based syllable discrimination task was administered in which they were asked to determine if two heard syllables were the same or different. The Beat Alignment Task (BAT) was administered to assess beat perception, in which participants identified whether or not clicks superimposed onto musical excerpts were aligned with the beat. Spearman correlations revealed a positive correlation between beat perception sensitivity and composite core language scores, indicating those who have a higher sensitivity to beat perception also show more advanced core language skills. Additionally, syllable discrimination abilities were found to significantly correlate with beat perception sensitivity, suggesting that those who exhibited greater sensitivity to the perception of syllables, also demonstrated a greater sensitivity to beat perception. These results align with previous literature that shows positive links between beat perception and early language skills. The present findings further support motivation of future research aimed at understanding the interplay between beat perception and language development outcomes.

Investigating relationships between somatosensory feedback and functional speech outcomes

Student Presenter: Courtney Dunsmuir
Faculty Mentor: Cara Stepp (SAR Speech, Language & Hearing Sciences)
UROP Award

Persons with Parkinson's disease (PwPD) show impaired sensorimotor learning capabilities and higher reliance on auditory feedback for speech motor control. However, the role of somatosensory feedback in PD for speech production has not been explored. This study aims to investigate the contributions of somatosensory feedback control mechanisms on laryngeal and articulatory speech subsystems in PwPD and how it affects speech intelligibility and naturalness. Participants (PwPD: n = 29; Controls: n = 25) produced the words bid, hid, and id while sudden and unpredictable perturbations were applied to the larynx or jaw to elicit somatosensory perturbations with acoustic consequences. A certified Speech Language Pathologist rated naturalness and intelligibility using a visualized analog scale for uniquely generated Speech Intelligibility Test (SIT) sentences produced by each participant. Sentences were mixed with multi-speaker babble prior to intelligibility rating. Spearman's rank correlation coefficient (ρ) were calculated to identify relationships between 1) laryngeal somatosensory responses and naturalness ratings, and 2) articulatory somatosensory responses and intelligibility ratings in each group (i.e., PwPD vs Controls). All correlations were non-significant. Two-sample's t-tests suggested that intelligibility and naturalness were statistically significantly higher in the control group and that laryngeal somatosensory responses were statistically significantly weaker in PwPD. Results confirm that PwPD have somatosensory deficits in the laryngeal domain. However, it does not seem to directly affect perceived speech intelligibility or naturalness. These study outcomes provide crucial insights on how underlying feedback control mechanisms affect functional outcomes of speech.

Preprocessing Data to Understand Cortico-Basal Ganglia-Thalamic Loop Role in Speech Production

Student Presenter: Anita Keltcher
Faculty Mentor: Frank Guenther (SAR Speech, Language & Hearing Sciences)
UROP Award

Understanding how humans produce speech is important to treat speech disorders, however current models remain underdeveloped. This study was part of a larger experiment to determine the role of the cortico-basal ganglia-thalamic loop in speech production and modulation, in an effort to strengthen the current theoretical models for speech production. This UROP project was focused on the preprocessing of data for further analysis. Preprocessing tasks included manually scoring audio files with important timepoints such as speech onset, vocalization onset, vocalization offset, and speech offset, breaking up full session audio files into their respective trials, and creating a GUI for manual artifact detection of the ECoG and Deep Brain Stimulation probe data. The GUI displays the data for a single electrode along with the major trial timepoints such as syllable onset and offset and the user can then determine if that set of data is artifactual or not. The GUI can be applied to two groups of subjects, totaling about 30 subjects, each with around 300 trials and 70 electrodes each. Tasks such as scoring the timepoints in the audio files allows that data to be used for further analysis such as in the manual artifact detection GUI. The work done in this study will help to further the overall experiment as the data is closer to being able to be analyzed in the context of the goal.

Gaps in the System: Eliciting Perspectives of Fathers Living with and Beyond Cancer

Student Presenter: Kaden Litzinger
Faculty Mentor: Robin Newman (SAR Occupational Therapy)
UROP Award

While the healthcare system focuses on diagnosing and treating cancer, it often pays little attention to patients' lives beyond the hospital. There is a need to focus on the experiences of parents living with and beyond a cancer diagnosis, especially fathers, who are often underrepresented in cancer literature. My research aims to examine the following questions: What is the experience of parenting like for a father with a cancer diagnosis? How is his daily life impacted, and how does undergoing treatment change his ability to be a parent? Using a mixed-method descriptive design, approximately 25 fathers with various cancer diagnoses were surveyed and interviewed about how their diagnosis and treatment affected their daily lives and their role as a parent. A content analysis was used to analyze daily time logs of fathers for feelings, symptoms, activities, shifts in their daily lives, and strategies used to assist them during and after their treatment. Data analysis is ongoing and will provide opportunities for future analysis that will need to be conducted, with which we will create resources to inform a broader definition of patient care by including an occupational therapy lens to support oncology patients with their parenting roles. This information could help develop a patient-centered approach to care that helps to connect direct treatment of the disease with palliative care, mental health issues that arise as collateral concerns, and family systems issues related to how cancer impacts the entire household unit beyond the patient.

Protein Expression of Caveolin-1 Increases with Age in Vascular Smooth Muscle

Student Presenter: Audrey Lucerne
Faculty Mentor: Kathleen Morgan (SAR Health Science)
UROP Award

Muscular Dystrophy (MD) is a result of mutations in the dystrophin gene or in genes of Dystrophin-Associated Proteins (DAPs). Research suggests the vascular function of patients with MD is abnormal, but the role of dystrophin and DAPs in Vascular Smooth Muscle (VSM) is not fully understood. It is also known that vascular function declines with age, therefore we are interested in how aging affects DAP expression. Specifically, this project investigates the DAPs, caveolins, which are membrane proteins involved in caveolae formation. Aortic VSM was collected from young, 3 month male C57BL/6 mice, and aged, 23-24 month male C57BL/6 mice. Western blot analysis was used to quantify the protein expression of caveolins. In other muscle types, it has been shown that caveolins colocalize with other DAPs. Immunofluorescence was used to localize caveolins within the A7r5 cells and colocalize caveolins with other DAPs of interest. By western blot analysis, we conclude that aging significantly changes the protein expression of caveolins in vascular smooth muscle. I found that Caveolin-1 protein expression is significantly increased in aged VSM compared to young VSM ($p=0.0392$). Previous and unpublished findings from our lab show other DAPs' expression decreases with age. In future studies, the Morgan Lab hopes to further understand why aging has varying effects on different DAPs. Future research on dystrophin and DAPs has potential to aid in treatments for those with age-related heart disease and muscular dystrophy.

Creating and Analyzing Dietary Baseline Data to Measure Nutritional Adequacy of Indian Household Contacts of Diagnosed Tuberculosis Patients

Student Presenter: Kledion Naksi
Faculty Mentor: Lindsey Locks (SAR Health Science)
Global Challenge Research Award

Tuberculosis (TB) is a severe bacteria-caused illness with India contributing to nearly a quarter of the prevalence. Although malnutrition has been shown to impact diagnosed TB, there is a lack of research on the diets of TB-exposed adults. The Tuberculosis: Learning the Impact of Nutrition study investigates nutritional supplementation and parasitic infections' effects on TB immune response among household contacts (HHCs) of TB cases in Tamil Nadu, India. We created and analyzed a dataset with "baseline recalls," conducted before intervention from January 2019 to June 30th, 2023. 251 HHCs were screened where 139 completed ≥2 recalls. Food groups based on the Minimum Dietary Diversity for Women (MDD-W), an international indicator of dietary diversity for women aged 18-49 years, were created using SAS and Excel. Baseline data was also compared to recommended dietary intake (RDI) levels in India. In 139 participants, dietary metrics averaged 2069.64 kilocalories of 63% carbohydrates, 25% lipids and 12% proteins. Average zinc, iron and calcium were 6.83mg, 11.84mg, and 431.17mg, respectively. Food groups “Grains, Roots and Tubers,” “Beverages and Sweets” and “Meat, Poultry, Fish” contributed 62.53%, 15.48% and 7.7% of average calories respectively. Compared to RDI levels, males (n=51) exceeded fat and protein, females (n=88) exceeded fat, and both lacked minerals. We found adult HHCs of TB patients are deficient in several key nutrients. This baseline data will enable us to assess how the diets of TBLION participants change as longitudinal recalls with supplementation are completed and analyzed.

Are tendencies toward social motivation and pleasure associated with daily social experiences? An experience sampling study

Student Presenter: Celina Nguyen
Faculty Mentor: Daniel Fulford (SAR Occupational Therapy)
UROP Award

Social motivation is the drive for individuals to connect with others and participate in social experiences. Trait (or dispositional) social motivation can be measured with questionnaires like the Motivation and Pleasure Self-Report (MAP-SR) scale, which captures individual differences in social motivation, pleasure, and effort. Ecological momentary assessments (EMA) can be used to capture momentary reports of social motivation within the context of daily life. The extent to which trait and momentary reports of social motivation cohere remains poorly understood. This project explores the relation between MAP-SR and EMA reports of social pleasure and motivation. 93 participants completed the MAP-SR at baseline and then four EMA surveys per day via a smartphone app over two weeks. EMA questions assessed the number and amount of effort towards social interactions, degree of anticipated pleasure from social interaction, and current affect. Positively valenced EMA questions were significantly correlated with higher social motivation on the MAP-SR, including social effort ($r = 0.254$; $p = 0.014$), anticipated enjoyment of social interactions ($r = 0.419$; $p < 0.001$), and happiness ($r = 0.454$; $p < 0.001$). Negatively valenced EMA questions, including sadness, anxiety, and anticipated criticism, were infrequently endorsed and did not show associations with MAP-SR social motivation. Thus, people’s general tendencies towards social motivation and pleasure may be associated with momentary reports of social experiences. This suggests that individuals’ general assessments of their own social motivation may accurately reflect positive social experiences in daily life.

The effects of bilingualism and input variability in children's word-learning

Student Presenter: Renzo Quintero
Faculty Mentor: Kimberly Crespo (SAR Speech-Language Pathology)
Newbury Center Award

My research project focused on how children learned words when exposed to input variability, such as multiple talkers and multiple object exemplars. This project also examined whether bilingual language experience influenced children's word learning outcomes. This project considered interactions between variability in the input and variability in learner experiences, which current models of language development seldom account for. Ten monolingual English-speaking children and ten Spanish-English bilingual children ages 5 – 9 years were recruited and tested in 3 – 4 sessions. Participants learned 5 novel word-object associations in four word learning conditions: 1. No Variability, where they learned words from one speaker and one object exemplar; 2. Multiple Speakers, where they learned words from ten speakers and one object exemplar; 3. Multiple Exemplars, where they learned words from one speaker and three object exemplars; and 4. Combined Variability, where they learned words from ten speakers and three object exemplars. To measure children's language skills, we administered the Clinical Evaluation of Language Fundamentals – Fifth Edition (CELF-5), and the Forth Spanish Edition (CELF-4 Spanish). Children's nonverbal IQ was measured by administering the Visual Matrices subtest of the Kaufman Brief Intelligence Test - Second Edition Revised (KBIT-2 R). Preliminary results suggest that increased variability does not hinder learning, and that monolinguals and bilinguals accommodate variability similarly when learning new words. ed variability. Data collection is ongoing. Given that natural language learning environments are replete with variability, preliminary findings suggest that variability may not have consequences to vocabulary development for children.

Identifying Psychological Vulnerabilities to Differentiate Eating Disorder Behaviors

Student Presenter: Soumya Sathe
Faculty Mentor: Anthony Rosellini (SPH Epidemiology)
UROP Award

Although certain factors appear to broadly impact the development and expression of eating disorders (EDs) (e.g., neuroticism, body dissatisfaction), it is unclear what differentially predicts specific subtypes of ED behaviors. This project aimed to identify such distinguishing factors based on existing clinical data from 229 outpatients with emotional disorders (e.g., anxiety or depression) who also reported symptoms of either restriction/anorexia (AN), binge eating disorder (BED), or both binging and purging/bulimia (BN). We predicted that AN would be associated with a greater need for control and cognitive inflexibility, whereas BN and BED would be associated with greater impulsivity and poorer emotional regulation. Mean scores on measures of control, impulsivity, and emotion regulation were compared to identify differences between each ED symptom group. Patients with AN reported higher perceived stress control than those with BN or BED symptoms, while those with AN and BN symptoms were more conscientious and more extraverted than those with BED symptoms. IU and distress tolerance showed no significant differences across ED groups. These findings are consistent with our hypothesis and could guide research on the differential mechanisms behind ED symptomatology. The prevalence of anxiety disorders in our sample might be impacting these results, so it would be beneficial to replicate these findings in community-based samples.

Sequence-Perturbation Project: Assessing the Relationship between Auditory and Somatosensory Feedback in Speech Development

Student Presenter: Utkarsh Tannan
Faculty Mentor: Andrew Meier (SAR Speech, Language & Hearing Sciences)
UROP Award

The study investigates the role of auditory and somatosensory feedback in speech correction, particularly focusing on their significance in speech disorders like apraxia of speech. Inspired by the DIVA model of speech correction, the research aims to unravel feedback systems' contributions to speech motor learning, bridging theoretical understanding and practical applications. The study's core methodology centered on adapting a MATLAB script template to integrate essential components. This involved precise selection and cutting of audio stimuli samples to 1100 milliseconds, ensuring data quality and minimizing confounding variables for accurate speech production assessment. A pivotal enhancement to the experimental design was the development of a sophisticated randomizer script. By considering factors such as the number of values, maximum repetition, and percentage distribution, the randomizer script produced a comprehensive array of scenarios for syllable conditions, word selections, and perturbation levels. Subsequently, a matching script was created to synchronize these randomized values with the stimuli list, establishing a cohesive association between specific conditions and corresponding stimuli. The culmination of these steps paved the way for the commencement of pilot tests, setting the stage for a rigorous and comprehensive assessment of speech correction mechanisms. Results from pilot tests confirmed the validity of voice recordings, perturbation mechanisms, and task accuracy, ensuring robust data collection. Future endeavors will expand upon these findings, aiming to establish the role of feedback systems in speech disorders and advance our understanding of how different feedback mechanisms influence distinct stages of speech motor learning.

To what extent can Lombard responses be explained by feedback v.s. feedforward speech motor control processes?

Student Presenter: Kalei Volk
Faculty Mentor: Cara Stepp (SAR Speech, Language & Hearing Sciences)
UROP Award

Models of speech motor control help us understand neural involvement of speech production. This theoretical knowledge can guide development of assessment and treatment protocols for populations with speech disorders. Models suggest two interconnected systems for neural control of speech production: the feedforward (faster and adaptive) and feedback (longer and reflexive) control systems. The Lombard effect (i.e., a speaker's increase in vocal intensity during background noise), requires neural control of speech, but the contributions of both the feedback and feedforward systems are yet to be understood.The goal of this project is to investigate the neural control mechanisms of the Lombard effect. Participants read aloud sentences in various experimental phases. During the baseline phase, no noise was presented through the headphones. During the ramp and hold phases, speech-shaped noise was generated and presented through the headphones at increasing even intervals until it reached the maximum intensity level of 75 dB sound pressure level. Lombard responses were quantified as the difference in vocal intensity during the hold phase from the average baseline intensity. The full sentence was used to measure both the feedforward and feedback control systems and an early time window was used to isolate the feedforward system. Preliminary results show trends of Lombard responses in both the early time window and the full trial, which suggests contributions of both the feedback and feedforward systems. These results shed light on underlying neural processes of speech production in typical speakers, which can inform assessment and treatment for populations with speech disorders.

Medical Sciences

Gestational Opioid Exposure Alters Neonatal Mouse Ultrasonic Vocalization (USV) Profiles During Spontaneous Withdrawal: Role of Kappa Opioid Receptor Activation

Student Presenter: Nalia Abney
Faculty Mentor: Camron Bryant (MED Pharmacology)
UROP Award

Neonatal withdrawal syndrome (NOWS) is a condition that an infant may develop after exposure to certain drugs while in the womb. Symptoms include tremors, seizures, respiratory distress, and stunted weight gain. This experiment specifically focuses on withdrawal phenotypes using a mouse animal model to study the neurological symptoms associated with NOWS, such as hyperirritability and high-pitched excessive crying. Experimentation involves twice daily (AM and PM) injections of morphine (10 mg/kg, s.c.) or saline (20 ul/g, s.c.) to neonatal pups from postnatal day 1 (P1) to day 15 (P15). More notably, the goal is to determine the regulatory relationship between kappa opioid receptors (KOR) and ultrasonic vocalizations (USVs) in mice. Previous RNA sequencing confirmed an upregulation of KOR on P16 during withdrawal; this suggests that there is a relationship between increased KOR activity and the Complex 3 withdrawal phenotype. Understanding that KOR activation induces dysphoria, aversion and negative affective symptoms observed in withdrawal, we aim to determine if KOR are involved in the regulation of USV and Complex 3 emission, and further support our hypothesis that Complex 3 syllables may be a marker for a negative internal state associated with morphine withdrawal. In using norBNI, a KOR antagonist, we observed a significant reduction in the proportional emittance of Complex 3 syllables during withdrawal 44 hours post-pre-treatment with norBNI. Future directions involve using a KOR agonist to determine if the withdrawal phenotype, such as hyperirritability and excessive high-pitched cries.

Exploring the Strengths of Mothers with Histories of Substance Misuse

Student Presenter: Audrey Cantillon
Faculty Mentor: Michelle Stransky (MED Pediatrics)
UROP Award

Substance misuse is a growing concern among birthing parents across the United States due to its negative implications on parent and child health. We utilized exploratory analysis to 1) identify potential resources; 2) evaluate how resources cluster; and 3) determine how resources interact and build upon one another. Information on all parent-child dyads (n=369) enrolled in Boston Medical Center's Strengthening Our Families through Addiction and Recovery (SOFAR) clinic between 7/11/2017 - 12/31/2020 was hand abstracted from electronic medical records. We categorized parents by their use of medically assisted treatment (MAT) and/or counseling and mental health medication and/or counseling. Other potential resources we examined included residence, family situation, child custody, and sources of support. All analyses (descriptive statistics, Pearson's $\chi 2$, and one-way ANOVA) were performed using SPSS. : Most parents resided in recovery homes (32%) and did not have custody of their children (83%). The average number of residential and outside social supports was 1.4 (SD=1.01) and 0.96 (SD=0.65), respectively. Overall, 12% of parents used MAT only, 54% used MAT and another treatment type, and 13% had no treatment or exclusively a non-MAT treatment (no treatment available: n=76). Residence, family situation, child custody, and sources of support varied by treatment. For example, 52% of persons using MAT only resided in recovery homes compared to parents using MAT plus another treatment (35%) and no treatment or only non-MAT treatment (13%; $p<0.001$). Acknowledging the potential resources of birthing parents with substance misuse histories is essential for building partnerships with clinical teams.

Enhancing Motivational Responses to Facial Expressions through Targeted Transcranial Magnetic Stimulation for Addressing Social Avoidance Behavior

Student Presenter: Josephine Carlson
Faculty Mentor: Michael Esterman (MED Neuroscience)
UROP Award

Social avoidance behavior (SAB) plays a crucial role in psychological disorders like Major Depressive Disorder (MDD) and Social Anxiety Disorder (SAD) by disrupting social connections. SAB is defined as actively or passively avoiding interactions, which negatively impacts interpersonal, emotional, and occupational functioning. Existing interventions for MDD and SAD alleviate symptoms, but do not reduce SAB, possibly from failure in targeting SAB-relevant mechanisms. Previous research demonstrates SAB associates with sensitivity of approach and avoidance motivation responses of co-occurring happiness and anger (social reward-threat conflict), rather than approach-avoidance motivation responses to strictly happiness or anger. Potential neuroscience-informed treatments targeting SAB motivations remain largely untapped. To address this, we employ transcranial magnetic stimulation (TMS) to directly modulate the right dorsolateral prefrontal cortex, a region active in social reward-threat conflict, to increase motivational responses. Participants received placebo TMS or active continuous theta burst stimulation (cTBS), at separate sessions in a counterbalanced order. Afterwards, participants completed a social approach-avoidance paradigm (SAAP) to measure TMS-related changes in approach-avoidance motivational responses to social reward-threat conflict. Our hypothesis was cTBS increases approach and decreases avoidance motivational responses in SAAP compared to sham TMS. We found that participants (n=5) exhibited stronger increases in approach motivation and stronger decreases in avoidance motivation as social reward signals increased in intensity relative to co-occurring social threat signals ($d = 0.69$, $Z = 2.02$, $p = 0.04$). Ultimately, the project's importance is normalizing motivational responses to facial expressions to improve maladaptive social behaviors like SAB, but larger samples are needed for replication.

Investigating the role of KLHDC-X as a bimodal regulator of viral infection

Student Presenter: Faith Cerbo
Faculty Mentor: Florian Douam (MED Virology, Immunology & Microbiology)
UROP Award

The need to better understand the molecular mechanisms regulating human coronavirus (hCoV) infection and spread has been exemplified by the recent SARS-CoV-2 pandemic. Recently, our lab has identified a poorly characterized kelch domain-containing protein (referred to as KLHDC-X) as a novel host factor with a dual role during infection. Preliminary data shows KLHDC-X upregulated during SARS-CoV-2 and hCoV-NL63. Overexpressing KLHDC-X in lung epithelial cells (A549) attenuates early viral replication but prolongs long term viral particle release. These data demonstrate that KLHDC-X could play an important role in viral replication and particle release making it a potential target for anti-virals. During my UROP program, I clonally selected knockout (KO) cell lines (A549-hACE2-KLHDC-X KO) by screening single cell clones for the loss of KLHDC-X expression upon infection via quantitative PCR. I selected KO lines with similar hACE-2 expression and characterized effective KO upon infection with SARS-CoV-2. Interestingly, we found KLHDC-X upregulated in myeloid cell lines (THP-1) upon hCoV-NL63 infection and with DENV infection (a broadly circulating flavivirus) indicating its involvement in a diversity of viruses. This work will help to establish effective tools to better characterize the role of KLHDC-X during viral infection. Future steps include performing viral quantification on supernatants of infected KLHDC-X KO lines, characterizing a successful KLHDC-X antibody to identify the presence/location of the protein in cells and examine the role of KLHDC-X in monocytes and macrophages. Characterizing the role of KLHDC-X in the context of coronaviruses and flaviviruses will highlight its potential as a pan-viral host factor.

A Retrospective Chart Review of the Boston Medical Center Coping Clinic

Student Presenter: Jacqueline Chang
Faculty Mentor: Margaret Lee (MED Dermatology)
UROP Award

Psychodermatology is a field that studies the interaction between cutaneous and psychological conditions. The Coping Clinic at Boston Medical Center (BMC) is an interdisciplinary clinic where patients are seen by both a pediatric dermatologist and pediatric psychologist. The purpose of this study was to describe the demographics, dermatologic diagnoses, psychiatric diagnoses, and interventions for all patients attending Coping Clinic from 2018-2023. A retrospective chart review identified 94 charts for 50 patients. Data on dermatological diagnosis, behavioral health diagnosis, behavioral treatment recommendations, and reason for referral to Coping Clinic were noted. Of the 50 patients seen, 31 (62%) were female and 19 (38%) were male, with a mean age of 13.2 years. The most common dermatologic diagnoses were atopic dermatitis (32%) and acne vulgaris (28%). Nineteen (38%) of the 50 patients had previous behavioral health diagnoses but all 50 (100%) of patients reviewed received a new diagnosis at Coping Clinic. New behavioral diagnoses made at the Coping Clinic appointment were anxiety (18%) and adjustment disorder (14%). Twenty-one (42%) of the patients were recommended for therapy and 9 of those 21 (43%) met with a counselor or mental health provider at least once. Little research has been conducted on successful interventions for patients with psychocutaneous conditions, especially for pediatric patients. These results demonstrate that interdisciplinary pediatric psychologic and dermatologic care is feasible and helpful.

Investigating the Connection between Alzheimer's Disease and Down Syndrome through Correction of X-linked Gene Dysregulation

Student Presenter: Clara Chung
Faculty Mentor: Ella Zeldich (MED Anatomy and Neurobiology)
UROP Award

In Down Syndrome (DS), human chromosome 21 (HSA21) is triplicated resulting in neurodevelopmental abnormalities and an increased risk of early onset Alzheimer's Disease (AD). Triplication of HSA21 causes genes on all chromosomes to become dysregulated. Surprisingly, there is a particular downregulation of the X-linked BEX/TCEAL cluster of genes that are involved in neurodevelopmental processes. At the same time, there is an enhanced expression of long noncoding RNA XIST, responsible for the X chromosome de-activation in females. The potential connection between dysregulation of X-linked genes and the DS phenotypes is unknown. This study investigates the role of X-linked genes in DS by restoring trisomic X-linked gene expression to euploid levels through CRISPR interference-mediated knockdown of the XIST gene. The experiments were performed in induced pluripotent stem cells (iPSCs) derived from two female DS individuals. iPSCs were transduced with lentiviral constructs targeting XIST and control gRNA and dCas9-KRAB under a tetracycline inducible promoter. The successfully transduced cells were isolated with antibiotic selection. To achieve a genetically uniform population of cells, further selection was performed through a single-clone isolation. RT-qPCR analysis confirmed successful editing as trisomic iPSCs contained both constructs. Further modification of the iPSC lines through increased activation of the dCas9-KRAB promoter is needed to achieve more potent inhibition of XIST. Once sufficient inhibition of XIST is achieved, its impact and consequent upregulation of the BEX/TCEAL gene cluster will be analyzed. The results of this study will provide novel insights into the precise genetic etiology underlying the connection between DS and AD.

Investigating the mechanism of α-MSH to enhance the survival of Retinal Ganglion Cells in Mice Eyes following an Ischemia/Reperfusion injury

Student Presenter: Zaari Isabella Colón
Faculty Mentor: Tat Fong Ng (MED Ophthalmology)
UROP Award

The microenvironment of the eye is immune privileged, meaning it has several mechanisms to suppress the action of inflammation. A central mediator of this process is the Melanocortin (MC) peptide Alpha Melanocyte Stimulating Hormone (α-MSH), interacting with four MC receptors (MC1, 3, 4, and 5). Our objective was to assay for α-MSH's mechanisms and receptor involvement in promoting retinal ganglion cell (RGC) survival following Ischemic/Reperfusion (I/R) injury. This is a retinal injury commonly seen in patients with diabetes and hypertension. The I/R was performed, and the eyes were treated 1 and 5 days after with α-MSH receptor agonists. Seven days after I/R and treatment, the eyes were collected, sectioned, and assayed by immunohistochemistry for RGC viability. To understand the role of the receptors in enhancing RGC, we used the antibody Brain-specific homeobox 3A (brn3a) to detect and quantify the brn3a protein in the nuclei of viable RGC. The treatment groups of I/R eyes were: Untreated, α-MSH; Peptide A: MC1r; Peptide B: MC1r and MC5r; Peptide C: MC1r and MC3r; Peptide D: MC3r Antagonist/ MC5r Agonist, and Sham. The eyes were compared to the retinas of naive eyes. A one-way ANOVA was performed to compare the untreated condition.

Exploring the Role of MIRTD in Neuroblastoma Cells

Student Presenter: Aakash Dave
Faculty Mentor: Hui Feng (MED Pharmacology, Physiology & Biophysics)
UROP Award

MIRTD(Mitochondrial Respiration Generator of Truncated DLST) is a shortened variant of the full-length gene DLST (dihydrolipoamide S-succinyltransferase) which is known to be involved in the Tricarboxylic acid cycle. MIRTD RNA and protein are present within the intermembrane space in the mitochondria and studies have found that MIRTD contributes to the biogenesis of mitochondrial respiratory complexes.This research aimed to discern MIRTD's presence in Neuroblastoma cells. To accomplish this, MIRTD and DLST RNA were quantified using qRT-PCR across Neuroblastoma, Alzheimer's, Breast Cancer, and Induced Pluripotent stem cells. Likewise, MIRTD and DLST protein levels were assessed through western blotting, encompassing Neuroblastoma and other cancer cell lines. The qRT-PCR data showcased heightened MIRTD gene expression in SHSY5Y, a Human Neuroblastoma cell line, surpassing all other cell lines. Correspondingly, western blot results echoed this pattern, highlighting that all four Neuroblastoma cell lines exhibited the greatest MIRTD-to-Actin Ratio. The data portrays that MIRTD is present in higher concentrations in Neuroblastoma signifying excess respiratory complexes and greater respiration rates. Furthermore, the study explored the feasibility of designing a maxizyme, an innovative RNA-degrading technology, for Zebrafish with Neuroblastoma to facilitate future in vivo MIRTD impact investigations. The maxizyme should target MIRTD by binding to the junction between intron 7 and exon 8 and forming a cavity for Mg2+ to cleave the RNA strand. Overall, this study reveals that MIRTD plays a vital role in regulating respiration in Neuroblastoma cells, and if MIRTD RNA can be targeted and degraded it can potentially decelerate cell proliferation and growth.

Effects of Perinatal Choline Supplementation on Cortical and Hippocampal Synaptic Marker Levels in the APP NLGF Mouse Model of Alzheimer's Disease

Student Presenter: Rohan Dupaguntla
Faculty Mentor: Tiffany Mellott (MED Pathology)
UROP Award

Alzheimer's Disease (AD) is a neurodegenerative disease which progressively impairs memory and cognition. We previously showed that perinatal choline supplementation of the APPNL-G-F mouse model of AD reduced memory deficits and amyloid-beta plaque accumulation, a characteristic feature of AD. In this study, we used 12-month-old wildtype (WT) C57BL/6J and homozygous APPNL-G-F mice whose mothers consumed either control AIN76A diet or a choline-supplemented diet during pregnancy and lactation. Frontal cortex and hippocampus samples were collected from the offspring and used to conduct RNA-seq analysis to identify target genes with differential expression with respect to genotype and diet. Tissue was also used to perform Western blot (WB) analysis to measure protein levels of synaptic markers (SNAP25, PSD95, GAD1), as well as markers for neuroinflammation (IBA1, GFAP). RNA-seq indicated reduced RNA expressions of SNAP25, PSD95, and GAD1 in control-diet APPNL-G-F mice compared to control-diet WT mice. Choline supplementation prevented the reduction in RNA expression of these genes in APPNL-G-F mice. However, the same changes in protein expression were not observed, which may suggest differences between the regulation of RNA and protein levels in the tissues or that WB is not sensitive enough to measure small variations in protein expression between the groups. For IBA1 and GFAP, the results from RNA-seq and WB showed higher protein expression in APPNL-G-F mice, indicating increased neuroinflammation consistent with previous studies. We will continue to validate potential targets whose expression is influenced by perinatal choline supplementation and may contribute to preventing memory deficits in the APPNL-G-F mice.

Effector Functions of Hormonal Contraceptive Antibody (HCA) Variants

Student Presenter: Maura Farrell
Faculty Mentor: Deborah Anderson (MED Obstetrics & Gynecology, Immunology)
UROP Award

121 million pregnancies are unplanned each year globally, highlighting the need for effective and accessible contraceptives. This study further investigated the antibody effector functions of Hormonal Contraceptive Antibody (HCA), a monoclonal antibody that binds to a unique glycan epitope on CD52 in the male reproductive tract (MRT). CD52g binds to sperm and other cells in the MRT, and HCA is currently being tested for contraceptive efficacy and safety in clinical trials. The constant region of monoclonal antibodies can impact the potency of their effector functions. I studied how different constant regions would impact the ability of HCA to mediate antibody-dependent cellular phagocytosis (ADCP) and antibody-dependent cellular cytotoxicity (ADCC). To study ADCP, I ran a series of assays using macrophages as the effector cell, immune cells labeled with CD52g as the target cell, and different variants of HCA. I measured ADCP activity via immunofluorescence imaging after a 24-hour incubation. To study ADCC, I ran a series of assays using natural killer (NK) cells as the effector cell, sperm as the target cell, and different variants of HCA. I measured ADCC activity via absorbance using a lactate dehydrogenase kit to measure cell death. In the ADCP assay, IgGt and IgG variants had the highest ADCP activity, while LALA-PG and FIF had low activity. As for ADCC activity, the assay is still under development and the effector function is to be determined. These results can help to optimize monoclonal antibody contraceptives, and bring us closer to providing safe, effective, and accessible contraceptives worldwide.

Investigating the impact of altered myelination in Trisomy 21 using hOLS

Student Presenter: Grace Field
Faculty Mentor: Ella Zeldich (MED Anatomy and Neurobiology)
UROP Award

Down Syndrome (DS), characterized by the triplication of the 21st human chromosome (HSA21), is associated with disrupted neuronal signaling and cognitive deficits. Oligodendrocytes are responsible for axonal myelination, which is necessary for neuronal signaling, and plays a pivotal role in cognitive function. This project utilized induced pluripotent stem cells (iPSCs)-derived 3D organoid models to quantify changes in oligodendrocyte development in DS. To properly recapitulate oligodendrocyte development, the lab utilizes organoids and assembloids generated from the fusion of ventral and dorsal organoids. The organoids and assembloids were fixed, cryoprotected, and sectioned at distinct developmental time points (day 90, day 120, and day 150). Immunohistochemistry using targeted markers to identify different stages of the oligodendrocyte lineage (SOX 10, NKX 2.2, CC1, BCAS 1, PDGFRalpha) was employed on each slide. Slides were imaged using confocal microscopy, targeting the specific wavelengths of each fluorescently labeled marker. Quantitative analysis, normalized against DAPI-stained nuclei, was used to determine each marker's expression. The analysis of the images revealed that in assembloids, the ventral portions exhibited a trend of elevated myelination marker expression relative to dorsal sections, signifying the developmental origin of the oligodendrocytes. We also detected diminished markers of differentiation and maturation of oligodendrocytes across stages in trisomic organoids as compared to euploid control, supporting abnormal oligodendrocyte biology. These results are only a piece of a larger model that will contribute to a greater understanding of oligodendrocyte development in DS and could hold the key to developing treatments and/or therapies for DS that target myelination.

Resolvin Therapy of Injured Cardiomyocytes with Leakage of Intracellular H-FABP as a Quantitative Readout

Student Presenter: Colin Gao
Faculty Mentor: James Hamilton (MED Pharmacology, Physiology & Biophysics)
UROP Award

In this study, the objective is to investigate a novel quantitative measurement of cell membrane damage based on the leakage of heart-fatty acid binding protein (H-FABP) from cultured cardiomyocytes. We explore the therapeutic impact of a natural molecule (resolvin) derived from dietary omega-3 fatty acids that have been shown to treat systemically linked inflammatory diseases with high morbidity and mortality, including cardiovascular disease, diabetes, and renal failure. Quantitative ELISA assays established H-FABP as a precise and dependable biomarker for quantifying cardiomyocyte membrane damage triggered by lipopolysaccharide (LPS). Additionally, ELISA assays were used to assess the healing potential facilitated by RvE1, a specialized pro-resolving mediator (SPM) from eicosapentaenoic acid (EPA) that mitigates systemic inflammation that is linked to restoring optimal homeostasis. Our results demonstrate that RvE1 reduced cardiomyocyte H-FABP leakage by up to 86%, substantiating our hypothesis that therapeutic interventions can be used to target inflammation as a mechanism of injury. Among a cohort of 40 patients admitted to Boston Medical Center for respiratory distress, there was a significant correlation between higher levels of H-FABP and confirmed clinical pathologies of cardiovascular disease (CVD), diabetes, and end-stage renal disease (ESRD). This underscores the potential of H-FABP not only as an indicator of CVD-related damage but also as a valuable metric for individuals dealing with a combination of inflammatory disease comorbidities, which are prevalent in COVID-19 patients and need to be monitored along with viral infection.

Establishing a High-Throughput Assay for the Identification of G-protein Interacting Peptides

Student Presenter: Elena Green
Faculty Mentor: Mikel Garcia-Marcos (MED Biochemistry)
UROP Award

G-Protein-Coupled Receptors (GPCRs) initiate signaling in response to a wide variety of extracellular stimuli, and represent the largest family of druggable targets in the human genome. They transmit signals by activating heterotrimeric G-proteins, which are molecular switches that propagate responses in the cytoplasm. In examining the patent literature, we identified a collection of uncharacterized peptides that presumably bind to G-proteins in either their active or inactive state. Such peptides could become useful to develop tools like biosensors or probes to modulate the signaling activity of G-proteins. I have established a protocol to screen binding of a curated set of >100 peptides to G-proteins in a high throughput format. The approach consists of co-transfecting the peptides of interest fused to nanoluciferase with a Venus-tagged G-protein in its inactive conformation or bearing a mutation that renders it constitutively active. The interaction between peptide and G-protein is reported by bioluminescence resonance energy transfer (BRET) between the luciferase and the fluorescent protein Venus, which is readily measurable by live-cell luminescence. I leveraged ten peptides with known affinities for the active or inactive form of G-proteins as controls to benchmark the assay. Using these controls, I scaled up HEK293T cell transfections from a 6-well to a 24-well format to increase throughput, and I have prepared a transfection-ready library of the >100 peptides of interest. This high-throughput assay will allow to rapidly screen many peptides for binding to inactive or active G-proteins of different types, which could yield useful research tools.

Presynaptic Cannabinoid Receptor Localization on Lateral Prefrontal Cortex and Amygdala Inputs to Anterior Cingulate Cortex

Student Presenter: Maxine Hsiung
Faculty Mentor: Maria Medalla (MED Anatomy and Neurobiology)
Newbury Center Award

As part of the prefrontal executive network and limbic system, the anterior cingulate cortex (ACC) is heavily involved in decision-making by regulating cognitive and emotion processing through its connections with the lateral prefrontal cortex (LPFC) and the amygdala (AMY). Endocannabinoids are robust neuromodulators of the limbic system that have been shown to modulate stress and inhibit neurotransmitter release by binding to their presynaptic receptor, CB1. The ACC, LPFC, and AMY, as well as the endocannabinoid signaling system are selectively vulnerable in stress and affective disorders. To better understand the endocannabinoid neuromodulation of the ACC, we investigated the anatomical localization of cannabinoid presynaptic receptor, CB1, on LPFC-ACC and AMY-ACC axon terminations. Using tract-tracers to label LPFC and AMY axons in ACC, immunolabeling of CB1 receptors and confocal microscopy in rhesus monkeys, we assessed the regional and laminar distribution of LPFC vs AMY axonal boutons terminating in distinct ACC sub-areas and the CB1 receptor colocalization on these boutons. We found regional distribution differences between the LPFC-ACC and AMY-ACC axons, which provide novel insight on the circuit-specific neuromodulation of the ACC. LPFC boutons are densest in rostral and dorsal ACC, while AMY boutons are distributed more evenly across ACC subdivisions. Furthermore, cannabinoid receptor CB1 was more densely co-localized in superficial ACC layers. To ultimately develop therapeutic strategies for recovering neurochemical imbalance, it is important to understand the receptor expression and anatomical localization of these ACC circuits that mediate affective behavior.

Unraveling the Role of Microglia: Characterizing Phagocytic Activity and Morphological Phenotypes

Student Presenter: Clifton Johnson
Faculty Mentor: Tuan Leng Tay (MED Anatomy and Neurobiology)
Loren E. Wold Research Award

Alzheimer's disease, a prevalent neurodegenerative disorder, afflicts millions worldwide, causing memory loss, cognitive decline, and behavioral changes. Microglia, resident immune cells of the brain, play vital roles in injury repair and brain health regulation. In an acute neurodegeneration mouse model induced by facial nerve axotomy (FNX), our lab observed that microglial cells proliferated in response to brain tissue damage. To investigate microglial response, we employed immunostaining techniques using LAMP2 to indicate lysosomal activity and CD68 to identify phagocytic activity. Microglia are known to phagocytose debris in brain injury; thus, we hypothesized an increase in LAMP2 and CD68-positive microglia on the affected side of the brain. Quantitative analysis revealed a significant elevation in LAMP2 and CD68-positive microglia on the ipsilateral side compared to the contralateral side at 30 days after FNX. Our findings suggest a robust activation of microglia on the affected side of the brain in response to acute neurodegeneration. This heightened lysosomal and phagocytic activity underscores their role in clearing cellular debris. Future applications of this research could include exploring potential therapeutic interventions that modulate dynamic microglial responses to mitigate neurodegeneration-associated damage. Understanding the mechanisms that drive microglial activation could pave the way for targeted therapies aimed at ameliorating neurodegenerative disorders like Alzheimer's disease.

Identifying and locating sub-populations of inhibitory neurons along the Entorhinal Cortex

Student Presenter: Han Kahvecioglu
Faculty Mentor: Jean-Pierre Roussarie (MED Anatomy and Neurobiology)
UROP Award

The Entorhinal Cortex (EC) acts as the gateway for information entering and leaving the hippocampus, part of the brain primarily responsible for memory processes. The EC is known as one of the first areas affected in Alzheimer's Disease (AD) patients. While previous research describes the cytoarchitectonics and connectivity patterns of the EC, there is not enough analysis on the distribution of molecularly defined subpopulations of cells constituting the EC, especially for interneurons. This research seeks to identify the spatial distribution of various interneuron sub-populations in the EC. Based on previous studies suggesting that the most vulnerable neurons of EC, layer Il neurons, are regulated by a potent inhibitory drive, it was also investigated if specific interneuron subpopulations could be responsible for this wall of inhibition. For the methodology, cells were first categorized into subpopulations based on their expression of genes using snRNAseq on mouse EC tissue. Then, in-situ hybridization experiments were performed on brain sections to stain for markers in combinations selected from the snRNAseq results, to spatially locate all the subpopulations. Results suggested that most subpopulations of inhibitory neurons are distributed sparsely across the EC instead of forming clusters, while some formed more organized patterns varying with layers of the EC or location in the brain. Regarding the inhibitory drive in layer II, findings showed that the Parvalbumin and Cholecystokinin expressing subpopulations were localized in this layer. Further analysis will be performed to understand the exact distribution of the superficial interneuron populations around vulnerable layer II neurons, and whether they are affected by Alzheimer's susceptibility factors.

Racial Disparities Within the Practice of Organ Donation Following Brain Death Declaration

Student Presenter: Baran Khoraminejad
Faculty Mentor: Ali Daneshmand (MED Neurology)
UROP Award

In the face of the severe state of organ shortage declared by the National Organ Bank, this study aims to better understand the racial disparities associated with organ donation. This was a retrospective, single-center chart review conducted on patients declared brain dead at the Boston Medical Center from 2012-2022. Brain death declaration requires two neurological exams as well as an apnea or ancillary test for confirmation. Patients' demographic data, medical history, and information from all neurological and confirmatory brain death exams were gathered for analysis. Patients whose race was recorded as "Other" or "Unknown" were excluded from analysis. 141 patients were included in our analysis. Those who identified as "White" were far more likely to consent to organ donation (57.6%). Asian patients were the second group most likely to consent (40%). African American patients were the cohort least likely to consent to donation (33.3%). We found that white patients and families were far more likely to consent to organ donation than Asian or African American families. This is most likely due to cultural and religious differences in the idea of organ donation. Our study falls in line with previously conducted research which shows that African Americans tend to have the lowest rates of signing up for organ donation, with white people having the highest rates. This can also be attributed to racial mistrust of the medical system and in the equity of the organ donation system.

Study the role of novel genes in kidney macula densa cell development

Student Presenter: Olivia Kierul
Faculty Mentor: Weining Lu (MED Nephrology)
UROP Award

SLIT is the ligand for the ROBO receptor. The SLIT/ROBO pathway plays an essential role in kidney development. Mutations or knockout of either SLIT or ROBO cause Congenital Anomalies of the Kidneys and Urinary Tracts (CAKUT) in humans and mice. Single-cell sequencing data suggested that SLIT and ROBO are also expressed in the macular densa cells. However, the role of SLIT and ROBO in developing macula densa cells is unknown. We performed immunofluorescent staining of SLIT and ROBO in developing mouse kidneys. ImageJ was used to quantify the expression of the SLIT/ROBO protein. We also generated SLIT/ROBO knockout mice and analyzed the macular densa cells' morphology in the knockout kidneys compared to wild-type controls. We found that SLIT and ROBO proteins are expressed in developing mouse kidney macula densa cells. ROBO protein is also expressed in human kidney macula densa cells. However, we did not observe SLIT in the same human kidney macula densa cells. Normal MD cell morphology was observed in wild-type fetal developing mouse kidneys. In contrast, the MD cells in knockout fetal developing mouse kidneys appeared to vary in location and orientation. These results suggest that ROBO is expressed in mouse and human kidneys, while SLIT is expressed only in mouse kidneys. Our data suggest that the SLIT/ROBO pathway plays a role in the mouse's macula densa cell development. Future experiments are needed to determine if the SLIT and ROBO genes play a crucial role in the initial formation of normal MD cells in developing fetal kidneys.

Assessing the Synergistic Interactions of Alternative Lengthening of Telomeres (ALT) Pathway Targeted Chemotherapeutics: Ataxia telangiectasia and Rad3-related protein & Translesion Synthesis Inhibitors

Student Presenter: Monica Laryea
Faculty Mentor: Monica Laryea (MED Pharmacology)
UROP Award

Cancer cells that utilize the Alternative Lengthening of Telomeres (ALT) pathway are distinct in their ability to self-immortalize even in the absence of the enzyme Telomerase. This presents unique challenges in the treatment of neuroepithelial and mesenchymal origin cancers where ALT prevails in over 50% of cases. Among the several therapeutic modalities that have shown preclinical success, the inhibition of the DNA damage response kinase Ataxia telangiectasia and Rad3-related protein (ATR) has been the most promising. Previous research has established that the inhibition of ATR has been proven to shrink tumors in difficult to treat cancers such as Osteosarcomas and Platinum Resistant Breast Cancers. This is miraculous except for the fact that ATRi must often be treated in combination with highly toxic chemotherapeutics. My research seeks to antiquate the use of chemotherapy in the treatment of ALT positive cancers by increasing the efficacy of ATRi. Towards this mission, a large focus was directed onto Translesion Synthesis Inhibitors that perpetuate large gaps in DNA which further sensitize cells when combined with ATRi treatment. Our research confirmed that ATRi and TLSi independently decreased cell viability as predicted. However, together, we did not observe a dramatic synergistic effect such as expected. This could be due to cell type, experiment run time, possible senescence, cytostacity, activation of redundant DNA damage repair pathways, etc. Future directions will assess the molecular activity of ALT readouts through the use of Immunofluorescence (IF-FISH). This will provide valuable insight.

Defining the role of SNAIL-CoREST interactions in melanoma development, tumor cell plasticity, and targeted therapy resistance

Student Presenter: Charles Lau
Faculty Mentor: Rhoda Alani (MED Dermatology)
UROP Award

The SNAIL family of transcriptional repressors contribute to epithelial-mesenchymal transitions (EMT), which have been implicated in the progression of epithelial cancers and therapeutic resistance. SNAIL's capacity to bind DNA and recruit corepressors through a conserved SNAG domain near its N-terminus is central to its functions in tumor cell plasticity and therapy resistance. SNAIL has been shown to interact with the LSD1 domain of the CoREST corepressor complex to drive EMT. Although melanoma is not of epithelial origin, it exhibits EMT-like phenotype switching events associated with the development of metastatic properties during the vertical growth phase. Since the precise epigenetic mechanisms underlying this transition are unknown, we aim to investigate the SNAIL-CoREST interaction within melanoma. Previously, through immunoprecipitation in SNAI1 overexpression cell lines, we identified a protein-protein interaction between SNAI1-LSD1 in melanoma. To investigate the direct nature of the SNAI1-CoREST interaction and the importance of the SNAG domain binding site, we perform bacterial purification followed by vitro binding assays using wildtype SNAI1 and mutant SNAI1 lacking the SNAG domain. Moreover, we evaluate the potential disruption of these interactions by treating with corin, a dual-warhead inhibitor of CoREST. Subsequently, we explore the interaction between SNAI1 and CoREST in a cellular context and investigate whether SNAIL is responsible for recruiting CoREST to chromatin through co-immunoprecipitation and chromatin immunoprecipitation quantitative PCR. Ultimately, we explore the nature of the SNAIL-CoREST interaction while elucidating the role of the SNAG domain on protein-protein interactions and recruitment to chromatin, providing valuable insights into targeted therapies for melanoma.

Calibrating an Accelerometer, Magnetometer and Gyroscope within a Combined Sensor Body Frame in the MRI Environment

Student Presenter: Nicholas Leung
Faculty Mentor: Simon Warfield (Non-BU Harvard Medical School)

Understanding the motion of a patient's head within the MRI (Magnetic Resonance Imaging) environment is very important to achieve viable imaging. This project showcases an MRI-safe IMU (inertial measurement unit), consisting of an accelerometer, magnetometer, and gyroscope sensor developed by BIOPAC Systems for this project. The goal is to utilize these high-speed sensor outputs alongside slower means of MRI POSE (position and orientation) estimations to obtain an accurate real-time, high-speed POSE estimation system. Our work thus far focuses on the calibration processes for this IMU to relate all its sensor voltage values to real-world measurement units. This is vital to be able to utilize sensor fusion to get accurate POSE estimations. This process relies on relating these sensor voltages to real-world values through a non-linear least squares model consisting of a 3 x 3 'S' matrix that accounts for rotational and scaling tendencies as well as a 3 x 1 offset matrix 'O'. By applying this model in different variations among different sensors, static vectors, and sensor combinations, we can relate sensor voltages to real-world values within a singular reference frame. This would allow for accurate sensor fusion in the future when combining calibrated accelerometer, magnetometer, and gyroscope data. This will also support accurate POSE estimations over longer periods when using Kalman filtering combined with other MRI POSE techniques via software to correct for sensor drift. In future applications, understanding the position and orientation of a patient's head will allow for applications of various techniques to increase final image quality.

siRNA Mediated Knockdown of PAX3: Investigating Effects of NMD Target Genes

Student Presenter: Joyce Liang
Faculty Mentor: Deborah Lang (MED Dermatology)
UROP Award

Paired domain-3 (PAX3) is a transcription factor critical for melanocyte lineage specificity, yet its molecular mechanisms in gene expression regulation during differentiation remain unclear. Overexpression of PAX3 has been found in melanoma cells. Immunoprecipitation assays unveiled that PAX3 interacts with several core and peripheral proteins of the exon junction complex (EJC), which highlighted its involvement in protein-protein interactions. The EJC triggers nonsense-mediated decay (NMD) to degrade mRNAs containing premature termination codons, and its dysregulation is linked to tumor suppressor gene degradation. PAX3 overexpression can promote NMD to subsequently decrease expressions of NMD-targeted gene expression, suggesting enhanced degradation of potential tumor suppressors. However, little is known about NMD-targeted gene expression upon PAX3 knockdown. Therefore, small interfering RNAs targeting PAX3 gene were used to efficiently knock down PAX3 expression, validated via immunoblots in melanoma cell lines A375 and SK-MEL-23. RNA extraction, cDNA synthesis, and real-time quantitative PCR revealed that PAX3 knockdown led to upregulation of NMD-targeted genes in SK-MEL-23, but unexpected variations in NMD-targeted gene expression emerged in A375 cell. This shows support for a connection between PAX3 protein levels and downstream NMD consequences. So, our future works will expand on our investigation of other melanoma cell lines, such as MEL537, examining NMD activities through gene expression. We believe that unraveling PAX3's modulation of the NMD pathway and its downstream impacts on mRNA expression will help us understand PAX3's role in further mechanistically driving melanoma.

Developing a super-sensitive Meso Scale Discovery (MSD) immunoassay for a novel biomarker in chronic kidney disease.

Student Presenter: Easton Liaw
Faculty Mentor: Weining Lu (MED Nephrology)
UROP Award

Chronic kidney disease (CKD) affects an estimated 13% of the population in the US and over 850 million people worldwide. However, only a few kidney-specific CKD therapies and diagnostic tools are available, posing a significant unmet medical need. The purpose of this project was to develop and test a reliable and super-sensitive Meso Scale Discovery (MSD) immunoassay using an electrochemiluminescence (ECL) detection technique that could potentially replace the regular ELISA to detect and quantify a specific biomarker protein in CKD. We first conjugated a capture and detection antibody pair compatible with the target biomarker protein. In a process similar to a sandwich ELISA assay, we detected and quantified standard biomarker recombinant protein and unknown biomarker concentration in mouse samples using the newly developed super-sensitive MSD assay and MESO QuickPlex SQ120 instrument. Our data showed a greater dynamic range and more precise and accurate readings for the biomarker protein compared to regular ELISA. We also found the optimal concentrations of the capture and detection antibodies that best suit the biomarker measurements. Although the newly developed biomarker MSD assay is reliable for detecting low protein levels, some cell culture- conditioned medium samples yielded a high protein concentration level, suggesting a potential non- specific binding that warrants further investigation and optimization. Our results indicate that further testing using this super-sensitive MSD assay on human or animal samples is necessary to optimize the assay condition for potential diagnostic applications using this biomarker in CKD.

Senescence is related to liver damage in aged mice

Student Presenter: Liuqian Ling
Faculty Mentor: Zhen Y. Jiang (MED Pharmacology, Medicine)
UROP Award

Aging is a complex biological process associated with various physiological changes, including an increased liver damage. Age-related tissue damage has been linked to the accumulation of senescent cells, characterized by irreversible cell cycle arrest, which disrupt tissue functions. My current study focuses on exploring the impact of aging on liver pathology and evaluating senescent cells in the liver from mice with different ages. Liver tissues from C57bl/6 mice with ages at 6 weeks, 18 months and 22 months on normal chew diet were examined. Hematoxylin and eosin (H&E) staining compared pathological changes between young and old mice in each group. The results revealed significant liver tissue alterations in aged mice compared to their younger counterparts, suggesting that aging contributes to liver damage and structural changes. Furthermore, the expression of the senescence marker p16 was investigated using immunofluorescence staining. The analysis of p16 expression in liver tissues provided insights into the cellular mechanisms underlying liver senescence. A notable expression of p16 was observed in WT old mice, indicating aging related senescence increased in the liver of old mice. In conclusion, this study highlights the impact of aging on liver pathology, emphasizing p16 as a significant change in aged mice compared to their younger counterparts. Additionally, we are in the process to further evaluate factors influencing the liver senescence process.

Development of semi-automated recombinant mycobacterial cell wall hydrolase enzymatic assays using the Octet BLI System

Student Presenter: Haile Luong
Faculty Mentor: Lingyi Deng (MED Medicine)
UROP Award

The biosynthesis and degradation of the bacterial cell wall is regulated by a group of enzymes known as cell wall hydrolases (CWHs). CwlZ is a protein encoded by a putative CWH gene that presumably regulates and modifies metabolic processes in the cell wall of Mycobacterium tuberculosis - the causative agent of tuberculosis. However, the unique role that each CWH plays in mycobacteria cell division and pathogenesis has made the standardization and development of enzymatic activity assays challenging. Therefore, the objective of this study was to develop a standardized and semi-automated enzymatic assay to confirm CwlZ hydrolase activity. This was accomplished through Bio-Layer Interferometry on the Sartorius Octet R8 system, which quantifies the binding rate between two interacting molecules. An antibody targeting Micrococcus luteus cell wall was immobilized on Protein A biosensors and immersed in wells with solubilized peptidoglycan (PG) of M. luteus to which it could bind. Lysozyme was used as a positive control for cell wall digestion once PG was bound. Different molecular orientations of these three components on the biosensor were implemented and tested. Various parameters were optimized such as the antibody concentration, peptidoglycan concentration, incubation times, and shake speed. Different buffer systems (with the inclusion of detergents/ions) were also tested. It was found that activity, function, and stability of assay components varied based on manipulated conditions. By using the optimized factors found in this study, CwlZ enzymatic activity can be measured, characterized, and compared with other CWHs as a way of standardizing enzymatic activity assays.

Ultrasonic vocalization syllable composition during neonatal opioid withdrawal in BALB/c substrains and the effect of Zhx2 genetic variants on behavior.

Student Presenter: Teodora Misic
Faculty Mentor: Camron Bryant (MED Pharmacology)
UROP Award

Infants in utero that are exposed to chronic opioid use are at an increased risk of developing neonatal opioid withdrawal syndrome (NOWS). We aim to investigate the genetic contributions to differences in the severity of NOWS symptoms using a CRISPR mouse line. These mice possess a knockout of the gene, Zhx2, which the lab recently identified as a potential gene associated with differences in oxycodone metabolism and reward learning. From postnatal day 1 through 14 (P1-P14) the mice (WT, HET, Zhx2-KO genotypes) were injected with either morphine or saline twice daily. During spontaneous withdrawal (16 hours following evening injections) at P7 and P14, we evaluated NOWS phenotypes such as hyperalgesia and hyperirritability ultrasonic vocalization (USV) emission. We recently found that opioid withdrawal alters the USV syllable profile on P14, as characterized by a significant increase in the proportion of the Complex 3 syllable. We hypothesize that Complex 3 may be a signal for the aversive internal state associated with withdrawal. USV emission was explored using machine learning, with the goal to identify differences in USVs and complex 3 syllable emission patterns. We did not see a difference in USV emission of complex 3 emission across the three genotypes and treatment groups, thus there may not be a relationship between Zhx2 expression and morphine withdrawal symptom severity.

Investigating the Pathogenic Role of PIM1 in Idiopathic Pulmonary Fibrosis

Student Presenter: Kristina Nicolas
Faculty Mentor: Giovanni Ligresti (MED Medicine)
UROP Award

Idiopathic Pulmonary Fibrosis (IPF) is an aging-associated lung disease characterized by the sustained activation of resident fibroblasts which abundantly secrete collagen and matrix proteins, resulting in compromised organ function. Proviral integration site for Moloney murine leukemia virus 1 (PIM1) is a serine-threonine kinase that was previously implicated in cancer development, and our recent studies suggest that PIM1 also plays a role in the pathogenesis of IPF (Pham et al, 2022). The goal of my study is to identify genes and pathways that PIM1 regulates that are critical for the fibrogenic activation of lung fibroblasts. To achieve this goal, human lung fibroblasts were transduced with a lentiviral vector carrying the PIM1 gene or with a control vector. Bulk RNA sequencing followed by pathway analysis revealed that PIM1 overexpression in normal lung fibroblasts resulted in the dysregulation of several pathways related to ECM organization, focal adhesion, and collagen secretion. Additionally, PIM1 overexpression upregulated genes associated with fibroblast activation including *CTHRC1* and *SPP1*. To validate the RNA sequencing findings, I carried out qPCR and Western Blot analysis on PIM1-overexpressing or control cells, confirming increased expression of pro-fibrotic marker genes, such as *SPP1*. Although this data supports a role for PIM1 in IPF, the molecular mechanisms underlying PIM1 fibrogenic activity remain unknown. Because PIM1 is a nuclear factor that interacts with epigenetic regulators, it is likely that PIM1 works in concert with epigenetic regulators to achieve its pro-fibrotic function. Additional experiments are necessary to determine how PIM1 integrates with epigenetic modulations to promote sustained fibrosis.

Investigating Structural RNA Components that Lead to Innate Immunity Evasion for YFV-17D

Student Presenter: Kohji Numata
Faculty Mentor: Florian Douam (MED Microbiology)
UROP Award

Much research has been done to unravel the role of specific viral proteins in enhancing the innate immune escape abilities of single-strand RNA viruses. However, not much is known about how specific RNA structures may affect innate immunity evasion of these viruses. In this project, we hypothesize that a potent live-attenuated vaccine, yellow fever 17D (17D), harbors RNA structures facilitating its evasion from cell-intrinsic immunity. By leveraging a 17D subgenomic replicon capable of RNA replication and viral polyprotein translation but unable to produce infectious viral particles, we created nineteen different 17D replicon constructs incorporating synonymous mutations throughout overlapping 500bp regions spanning over all of the viral non-structural protein coding genes. Our 17D replicon incorporates a Gaussia Luciferase reporter gene upstream of non-structural proteins, which acts as a surrogate of RNA replication and viral proteins translation, enabling rapid screening of specific viral genomic regions regulating these viral processes. The different 17D constructs were created via In-Fusion ligation and those products were transformed into JM-109 E. Coli cells. After isolating plasmids containing mutations of interest, plasmids were amplified and purified via Maxi preps. Purified plasmids were then used to generate 17D replicon RNAs via in vitro transcription. I now plan on transfecting these different viral RNAs into immunodeficient and immunocompetent cell lines to identify mutant constructs able to effectively replicate (i.e., as wild-type 17D replicon) in the former, but not the latter. Although results are still pending, my project may unravel novel mechanisms by which RNA viruses evade cell-intrinsic immune responses.

The Role of Melanocortin Receptors in Regulating the Thyroid Axis

Student Presenter: Juan Pagán
Faculty Mentor: Ricardo da Costa e Sousa (MED Medicine)
UROP Award

The Hypothalamic Pituitary Thyroid Axis (HPT Axis) is a hormonal system that regulates the functioning of many tissues in the body. Hypothalamic neurons secrete a hormone called thyrotropin-releasing hormone (TRH), signaling the pituitary to release thyroid stimulating hormone (TSH), and finally, causing the thyroid to release thyroid hormones (TH). It's been shown that TRH neurons in the hypothalamus express the melanocortin 4 receptor (MC4R) which is activated or inhibited by other neuropeptides. This experiment sought to determine if the activity of MC4R-positive neurons directly regulates the HPT Axis. To investigate this, stimulation of MC4R neurons in the paraventricular nucleus of the hypothalamus (PVN) was done using a chemogenetic approach. Mutant receptors were transfected via a bilateral injection of a Cre Dependent AAV into the PVN of MC4R-Cre mice, and when expressed the receptors are exclusively activated by an exogenous compound, clozapine-N-oxide (CNO). Two weeks after surgery CNO was injected every 12h for 36h. Body weight and food intake were recorded before, 1, 2 and 12 hours after activation of these neurons, and blood was collected before and after activation. to measure hormone levels. The brains were then dissected, processed for histology and their injection site was confirmed under microscope. The results showed little difference in body weight and food intake between MC4R-Cre and wild-type mice, and there was no significant difference in TSH levels between groups. Further investigation of how regulation of MC4R affects the HPT Axis is in progress and could uncover new connections between the MC4R and TH.

Prevalence of helminth co-infections among persons with tuberculosis in South India: a cross sectional analysis

Student Presenter: Susie Jiaxing Pan
Faculty Mentor: Pranay Sinha (MED Infectious Diseases)
UROP Award

Tuberculosis (TB) remains an enduring threat to human health, with the global distribution of TB overwhelmingly concentrated in tropical and subtropical regions. In these areas, the geographic overlap with intestinal parasitic infections is striking. The probability of intestinal parasitic infections in persons with latent and active TB is high, yet few studies have described the prevalence of parasitic infections in persons with TB (PWTB). The Tuberculosis – Learning the Effect of Parasites and Reinforcing Diets (TB LEOPARD) study assesses the prevalence of these infections among PWTB in Puducherry and rural areas of Tamil Nadu in India. This study is currently in the recruitment phase; thus, we present preliminary data. Fresh stool samples from 82 persons with TB were collected. After sonication of the stool specimen, we extracted DNA and conducted multiplex polymerase chain reaction testing for Ascaris lumbricoides, Strongyloides stercoralis, Trichuris trichuria, Necator americanus, and Ancylostoma duodenale. We found that 35 (42.68%) participants tested positive for at least 1 helminth infection and 8 (9.76%) tested positive for 2 helminths. The most common parasite detected was Necator americanus, constituting 52% of helminth infections. These preliminary data are intriguing as the prevalence of helminth infections considerably exceeds the expected rate of helminth infection (20-30%) for the general population. Future studies should assess the significance of asymptomatic carriage of helminths among PWTB given the potential impact of parasitic infections on the immune response to TB. Additionally, we should assess the value of systematic screening and treatment of helminths for PWTB in India.

Characterization of an Infectious Recombinant West Nile Virus Expressing Green Fluorescent Protein For Visualization of In Vitro Infection

Student Presenter: Jaii Pappu
Faculty Mentor: Florian Douam (MED Virology, Immunology & Microbiology)
UROP Award

West Nile Virus (WNV) is a flavivirus that is primarily transmitted through the bite of infected mosquitoes and is capable of infecting a wide range of hosts, including birds, horses, and humans. Although the majority of WNV infections in humans are asymptomatic, individuals can develop severe symptoms such as meningitis, encephalitis, and acute flaccid paralysis. Understanding the transmission dynamics and disease pathogenesis of WNV is critical in developing effective strategies to prevent and control its spread, which has now become an emerging infectious disease of significant public health concern. This project investigates the viral dynamics of WNV via two aims: (1) generating a recombinant WNV expressing a green fluorescent protein (rWNV-GFP), and (2) characterizing rWNV-GFP infection in vitro across mammalian and mosquito cell lines. Cell culture models provide controlled environments for studying viral infections and understanding their mechanisms. Thus, studying WNV infection in cell culture allows for a detailed investigation of the virus-host interactions and replication dynamics. To visualize in vitro infection, rWNV-GFP was used to infect three mammalian cell lines (VERO-E6, HEK-293T, BHK-21) and a C6/36 mosquito cell line. GFP signal expression correlates to infection, and signal expression was quantified across different cell lines to find the optimal cell line for viral growth. This recombinant virus is a useful tool for studying the replication, transmission, dissemination, and pathogenesis of WNV in vitro. Future studies will aim to optimize the fluorescent protein within the reporter virus for better visualization of infected tissues within live organisms (mice, mosquitoes, etc).

Investigation of the Effect of Netarsudil on the Inner Wall Endothelial Cells of Schlemm's Canal of Human Eye Using Serial Block-face Scanning Electron Microscopy

Student Presenter: Sarah Park
Faculty Mentor: Haiyan Gong (MED Ophthalmology)
UROP Award

Primary open-angle glaucoma (POAG) is the second leading cause of blindness worldwide. Elevated intraocular pressure (IOP) is a primary risk factor for POAG and is due to an increased aqueous outflow resistance in the aqueous drainage pathway in the eye. Netarsudil, a rho-kinase inhibitor, is a new class drug to decrease IOP in POAG; however, its effect on the inner wall (IW) endothelial cells of Schlemm's canal, an important site in aqueous outflow resistance regulation, has not been studied. Aqueous outflow is not uniform with high- and non-flow regions and whether netarsudil affects the IW cells differently in the different flow regions has not yet studied. This study investigated the morphological changes in the IW cells between the eyes treated with netarsudil and controls in high- and non-flow regions (n=10 for each group). Serial block-face scanning electron microscopic images were traced using Reconstruct and each cell was 3D reconstructed. Cellular, nuclear and GV volume, thickness, width, and length of each cell were calculated. Compared to controls, netarsudil treatment significantly increased cell thickness and width in nuclear regions and cellular, nuclear, and GV volume in the high-flow regions but not in non-flow regions. There was a 13 percent increase of type IV GVs (GVs with basal opening and I-pores) in high-flow regions while only a small percentage increase in type IV GVs in non-flow regions. Our study suggests that one mechanism that netarsudil lowers IOP is through increasing type IV GVs and that its effect on the eye is not uniform.

Impact of XMAP215 on Neural Crest Cell Migration and Craniofacial Development in Xenopus Laevis

Student Presenter: Olivia Perry
Faculty Mentor: Laura Lowery (MED Hematology, Oncology)
UROP Award

It has been previously demonstrated that the critical cytoskeletal regulator, XMAP215, plays an important role in promoting axon outgrowth and guidance. However, much is unknown about how XMAP215 might regulate other types of cell migration. Since it has recently been shown that the XMAP215 partner, TACC3, is important for neural crest cell (NCC) migration during craniofacial (CF) development, this study seeks to determine whether XMAP215 also plays a role in NCC migration. Knockdown of XMAP215 was critical in understanding the complex process of CF development via cell migration. Xenopus laevis embryos were injected at the two-to-four cell stage with morpholino antisense oligonucleotides to reduce endogenous XMAP215 levels, fixed at stage 42, then imaged by brightfield microscopy. Images were analyzed with ImageJ using previously validated metrics for quantifying CF development. In situ hybridizations were used to monitor pharyngeal arches to determine if NCC migration was affected in vivo. The data shows that XMAP215 knockdown results in statistically significant facial abnormalities, as well as changes in NCC motility patterns. Further, the results imply that one key mechanism by which XMAP215 impacts CF development is through regulating NCC migration, in which knockdown of XMAP215 may result in disturbances to the cytoskeleton that impact cell migration and cause CF abnormalities.

A subcellular enrichment approach to profile the proteome of different mouse brain regions

Student Presenter: Sanjana Prudhvi
Faculty Mentor: Manveen Sethi (MED Biochemistry)
UROP Award

Proteomic technologies such as high-resolution liquid chromatography-tandem mass spectrometry (LC-MS/MS) have provided insights into the organizational complexity of the brain proteome. This versatile tool has unveiled insights into protein abundance, subcellular localization, function, 3D structures, and protein-protein interactions. Leveraging the extracellular matrix (ECM) procedure developed by Naba et al.(2015), we isolated an ECM-enriched protein pellet while sequentially removing intracellular fractions (cytosolic (C), nuclear (N), membrane (M), cytoskeletal (CS)). This intricate process enabled us to explore the composition of intermediate intracellular fractions across various brain regions. Neurodegenerative disorders such as Alzheimer's, Parkinson's, and Huntington's have been linked to protein toxicity and subcellular proteome alterations. Alterations in the brain ECM have emerged as disease biomarkers for various neuropathologies. Analyzing the proteomic architecture of these subcellular fractions and comparing its alterations in neuropathological contexts can improve our understanding of the role of the proteome in neurodevelopment and can provide insights for potential therapeutic strategies to correct these alterations. Our study unveiled the proteomic composition of subcellular fractions in four anatomically and physiologically distinct brain regions: prefrontal cortex, cerebellum, hypothalamus, and striatum (n=8). We extracted the peptides using an in-gel enzymatic digestion assay for the intracellular fractions (C, N, M, CS) and on-pellet digestion for the insoluble ECM-enriched sample. The peptides were desalted and subjected to LC-MS/MS analysis (Sethi et al., 2020). We anticipate our results will show differentiation between brain regions for various intra- and extracellular fractions as each region's physiological function promotes unique cognitive function and neuroregulation.

The Effects of Lactic Acid on epithelial integrity and HIV susceptibility

Student Presenter: Samaa Rasheed
Faculty Mentor: Deborah Anderson (MED Infectious Disease)
UROP Award

The vaginal infection Bacterial Vaginosis is characterized by the absence of healthy bacteria Lactobacilli. This infection can lead to adverse reproductive health outcomes, including a heightened risk of acquiring Human Immunodeficiency Virus Type 1 (HIV). By increasing inflammatory cytokines that disrupt cell junctions holding together the cell walls in the epithelium, HIV is able to penetrate the female reproductive tract (FRT) and reach its target cells. Previous data suggests lactic acid (LA), the product of Lactobacilli, can enhance the epithelial integrity of the FRT and reduce HIV susceptibility due to its anti-inflammatory properties. Our goal was to further study this phenomenon in a more physiologically accurate tissue model such as the EpiVaginal tissues. These in vitro models consist of tissue cultures derived from human epithelial cells and dendritic cells. To understand the anti-inflammatory properties of LA, we simulated an inflammatory microbiome and studied its response when introduced to LA. EpiVaginal tissues were treated with the inflammatory cytokine TNFα to induce disruption in the tissue. Topical addition of LA was hypothesized to modulate the epithelial barrier and ultimately prevent HIV transepithelial migration. Data analysis ofTransepithelial electrical resistance (TEER) values, fluorescence microscopy, and various viability assays, has shown that these highly differentiated, stratified tissue models were unresponsive to TNFα and LA treatment. Our results indicate the need for biologically relevant cervicovaginal epithelial models to study the effects of LA on barrier integrity. Further research is needed on mechanisms to promote Lactobacilli dominated microbiota to protect against HIV and other sexually transmitted diseases.

Investigating the role of TrkB/BDNF signaling in lung capillary endothelial cells

Student Presenter: Jillian Schmottlach
Faculty Mentor: Giovanni Ligresti (MED Pulmonary, Arthritis)
UROP Award

Idiopathic pulmonary fibrosis (IPF) is an aging-associated lung disease characterized by fibroblast accumulation, excessive collagen deposition, and vascular abnormalities resulting in alveolar deterioration. Using single-cell RNA sequencing (scRNA-seq) analysis on fibrotic mouse (bleomycin-treated) and human lungs, our lab found that lung general capillary (gCap) and aerocyte (aCap) endothelial cells (ECs) activated the expression of Ntrk2, a gene encoding for tropomyosin receptor kinase B (TrkB). TrkB is implicated in neurite outgrowth and vascular remodeling but has an unknown role in lung injury and fibrosis. My study explored how TrkB signaling affects capillary EC responses through its ligand brain-derived neurotrophic factor (BDNF). I treated normal human lung capillary ECs with BDNF in vitro and assessed lung capillary EC identity gene and cell proliferation gene MKI67 expression using quantitative real-time polymerase chain reaction (qPCR). Additionally, I generated precision-cut lung slices (PCLS) to test BDNF/TrkB signaling effects on capillary EC identity and proliferation. Using these approaches, I found that BDNF promoted capillary EC marker gene and MKI67 expression. However, Ntrk2 expression was not significantly different in cells treated with BDNF. Experiments using PCLS showed that BDNF treatment upregulated capillary marker genes only in PCLS also treated with bleomycin, suggesting that lung injury promotes TrkB activation by BDNF. Similarly, Ntrk2 expression did not change significantly in PCLS treated with bleomycin and BDNF. Future directions include performing additional PCLS experiments using injured mouse lungs and fibrotic human lungs to validate my results and expand knowledge on the role of TrkB signaling in IPF pathogenesis.

Microvasculature Changes in Postmortem Human Prefrontal Dorsolateral Cortices with Stage III to IV Chronic Traumatic Encephalopathy (CTE)

Student Presenter: Erin Shivers
Faculty Mentor: Ann McKee (MED Neurology, Pathology)
UROP Award

Chronic traumatic encephalopathy (CTE) is a progressive neurodegenerative disease characterized by a unique distribution of hyper-phosphorylated tau protein. This project aimed to characterize neurovascular changes in late stage CTE compared to normal control (NC) healthy brains. Ten samples of dorsolateral frontal cortex were imaged using polarization sensitive optical coherence tomography (PS-OCT) for the entire depth of the sample. The sequential images were stacked to form a 3D representation of the tissue which was manually annotated for spiraling blood vessels with Fiji. The diameter of the tortuous vessels was measured by plotting the contrast of the vessel against its surroundings. A Mann-Whitney U Test was performed on the data collected, comparing the NC cases against the CTE cases for spiraling vessel amount, diameter, and volume. The tests indicated that the CTE cases did not have significantly more tortuous vessels ($p=0.402$), the vessel diameters were not significantly different ($p=0.463$), and the compared vessel densities were not significantly discrete from the NC cases ($p=0.142$). A power test of these samples reported at a 15% confidence level. Achieving an 80% confidence level, with a p value of 0.05, would require an additional 22 samples per group. These results indicate that spiraling blood vessels are not a feature of late stage CTE, however additional samples are required to improve significance. This is a preliminary study for a future project aimed at studying the relationship between spiraling blood vessels and neuroinflammation in early stage CTE.

Optimizing CRISPR mutagenesis to understand mechanism of hematopoietic progenitor migration.

Student Presenter: Su Yeon Song
Faculty Mentor: Elliott Hagedorn (MED Medicine, Hematology & Medical Oncology)
UROP Award

Hematopoietic stem and progenitor cells(HSPCs) are a population of cells capable of regenerating the entire blood and immune system. HSPCs require supportive niche microenvironments, which include specialized vascular endothelial cells that regulate the differentiation and maturation of HSPCs. Our lab previously identified that vascular endocytosis and vesicle trafficking driven by stabilin scavenger receptors, stab1/2, and sorting nexin, snx8a, may facilitate HSPCs crossing the blood vessel wall via transendothelial cell migration. Our objective in this study was to disrupt the aforementioned genes using CRISPR/Cas9 to elucidate their role in HSPC migration. To generate whole-animal knockout lines, we optimized the CRISPR/Cas9 system for genome editing in zebrafish. We first injected Cas9 protein and one single guide RNA(sgRNA) targeting snx8a into single-cell stage zebrafish embryos. CRISPR-induced mutations were confirmed by a PCR suppression screening method with headloop primers containing a complementary sequence to the wild-type Cas9 target locus. To create larger genome modifications, we co-injected Cas9 protein and two sgRNAs, ranging from 100 to 800 base pairs apart, targeting stab1/2. PCR amplification of the edited region revealed size discrepancies compared to the wild-type sequences, validating successful genome editing. We confirmed these edits through Sanger sequencing. These mutant F0s were in-crossed, and the F1 were genotyped to verify germline transmission. F1s carrying the desired mutation are currently being grown for further studies investigating HSPC migration within the niche. In the long-term, these studies could inform the development of new strategies to enhance the migration of HSPCs into the extravascular niche during bone marrow transplantation.

The effect of MSC-EVs on the inflammatory profile in a rhesus monkey model of cortical injury

Student Presenter: Rutu Tatke
Faculty Mentor: Tara Moore (MED Anatomy and Neurobiology)
UROP Award

Cortical injury is characterized by cell death and inflammation, which can lead to significant behavioral impairments. Our previous work has shown that mesenchymal stromal cell extracellular vesicles (MSC-EVs) administered intravenously, 24 hours and 14 days after cortical injury to the hand representation of the primary motor cortex (M1), facilitated recovery of fine motor function in rhesus monkeys. Our previous findings suggest that one mechanism of action of MSC-EVs is via promoting anti-inflammatory microglial phenotypes in brain tissue harvested 16 weeks post-injury. In the current study, we further investigated the transition between pro- and anti-inflammatory states in brain tissue, at a 6-week recovery time point. Using immunohistochemistry (IHC) in serial coronal brain sections, we labeled and quantified microglia (Iba1) together with an inflammatory signaling molecule - a phagocytic marker, Gal3 – in the perilesional cortex. Preliminary results show no significant differences in the number of Gal3+ 'phagocytic' inflammatory microglia between the two groups. However, there was a higher percentage of ramified microglia in the perilesional gray matter of treated monkeys. Further, qPCR assessments of mRNA expression of relevant inflammatory markers in perilesional cortex revealed higher Iba1 and Gal3 mRNA levels in the MSC-EV treated relative to vehicle treated animals. Together, these data suggest that MSC-EV treatment alters the temporal progression and balance of pro- and anti-inflammatory signaling across recovery and may upregulate microglial immune-activity to enhance clearance of damage at an early stage of recovery after cortical injury.

The Alpha2 Adrenergic Agonist Guanfacine Attenuates Chronic Alcohol-Induced Temporal Order Memory Deficits in Mice

Student Presenter: Olivia Velte
Faculty Mentor: Valentina Sabino (MED Pharmacology)
UROP Award

Alcohol use disorder (AUD) is characterized by chronic, detrimental alcohol use that can lead to the deterioration of Prefrontal Cortex (PFC)-mediated executive cognition. This deficit manifests as impaired decision making and compromised behavioral control in patients with AUD. Chronic alcohol use disrupts the norepinephrine system, but activation of adrenergic receptors, such as the Alpha-2 Adrenergic Receptor (A2AR), has been seen to reduce alcohol intake and symptoms of withdrawal. Guanfacine is an A2AR agonist currently approved for the clinical treatment of Attention Deficit Hyperactivity Disorder (ADHD). This project investigated whether Guanfacine treatment could restore PFC cognitive function in mice with a history of chronic alcohol consumption. We employed a Temporal Order Memory (TOM) test, to evaluate a type of PFC-dependent cognitive ability that is seen to decline with chronic alcohol exposure. This decline is indicated by a reduced ability to discriminate the relative recency of two objects. Male and female mice underwent a preparatory 10 weeks of intermittent access to alcohol and were then tested after a 24-hour period of complete withdrawal. The data revealed that both doses of Guanfacine significantly improved performance in the TOM test compared to the vehicle-treated animals, in both male and female cohorts. A slight sedative effect was observed in mice that received the active drug, so further research will be needed to determine optimal dosages for minimal side effects. This study suggests that A2AR agonist may be a promising pharmacological strategy to restoring PFC functioning in AUD patients.

Network efficiency and robustness shape the number of microRNAs encoded in a genome

Student Presenter: Samuel Wu
Faculty Mentor: Daniel Cifuentes (MED Biochemistry)
UROP Award

MicroRNA (miRNA) are small regulatory RNAs that suppress gene expression in cells. miRNAs bind to their target genes via a complementary binding site of 7-8 nucleotides. Because of this, there are 47 (16,384) potential seeds that can be utilized by miRNA. However, data indicates that in every species' genome, only a handful of seeds are used (2.3% in humans). The purpose of my research is to explain how evolution shaped this low seed selection. I hypothesize that miRNA evolved to maximize the number of transcripts targeted while at the same time maintaining the robustness of the target regulatory network. A miRNA seed that targets a high number of mRNA targets may be effective but is a liability in terms of robustness, that is, if this miRNA is lost or mutated, a large fraction of genes would be dysregulated. A miRNA seed must balance these two attributes to be effective. My research found that the number of miRNAs encoded in any given genome is not a biological variable but instead is hardwired to the mathematical rules of network efficiency and robustness.My research found that in all species, miRNA seeds cover significantly more than random but fall below the optimal solution. When measuring the usefulness of seeds, I found that optimal seeds were less useful, while random seeds were most useful. Real seeds outperformed optimal seeds in efficiency, performing at or better than random seeds while conserving network robustness. These results pinpoint the forces at play that shape miRNA evolution.

Distal Enhancer Regulation of ARPC5 in Melanoma

Student Presenter: Claire Wu
Faculty Mentor: Deborah Lang (MED Dermatology)
UROP Award

Paralog transcriptional co-activators YAP and TAZ are often considered to be functionally redundant although they have overlapping but divergent transcriptomes in melanoma. The ARPC5 subunit of ARP2/3 complex is a specific and essential target of YAP to maintain melanoma cell focal adhesion numbers. Through an unknown method of regulation, YAP promotes melanoma migration through driving the expression of ARPC5. Hi-C and CUT&RUN sequencing revealed potential distal enhancers that regulate ARPC5 via YAP. This study identified a distal enhancer, sequence 10, and investigated regions within the enhancer to identify potential transcription factors that interact with YAP to drive ARPC5 expression. Using site-directed mutagenesis, we deleted the first and second half of the enhancer. After transfecting two melanoma cell lines with the partially deleted sequences, we measured gene activity using the dual reporter Renilla Luciferase Assay System. Deleting the first half of the enhancer yields highly reduced expression of ARPC5 compared to expression with the full sequence. Deletion of the second half also shows reduced expression, although not as significantly. Deletions of the transcription factor binding sites, namely PRDM and ELF, located in this first half of the enhancer will allow us to determine possible YAP-specific interacting partners within this regulatory pathway. Not only will these findings aid our understanding of functional differences between YAP and TAZ in cancer progression and metastasis, but they will also provide insight into guiding the development of targeted therapeutic treatment in melanoma.

Morphologic Changes in the Distal Aqueous Outflow Pathway Responsible for Thrombospondin-1-Induced Outflow Facility Decrease in Porcine Eyes

Student Presenter: Michelle Yung
Faculty Mentor: Haiyan Gong (MED Ophthalmology)
UROP Award

Primary Open Angle Glaucoma (POAG) is the second leading cause of blindness worldwide. Elevated intraocular pressure (IOP), due to the increased resistance in the aqueous humor (AH) drainage pathway, is the main risk factor of POAG. From our previous study, perfusion of glycoprotein Thrombospondin-1 (TSP-1) into porcine eyes reduced the AH outflow facility, consequently it may elevate IOP. Furthermore, there were no morphological differences visually observed in the aqueous plexus and the trabecular meshwork of the TSP1-treated and control groups. This study aimed to identify the morphological changes in the distal conventional AH pathway induced by TSP-1. Four pairs of porcine eyes, perfused with either Dulbecco's phosphate-buffered saline containing 5.5 mM of D-glucose (GPBS) alone or plus TSP-1 (0.8μg/mL) for three hours followed by perfusion-fixation, were processed, embedded, and cut into 4-6 μm thin sections to be imaged under a light microscope. The cross-sectional areas of the episcleral veins (ESV) and intrascleral veins (ISV) were measured using ImageJ by NIH, normalized (normalized area= vein area of TSP-1 treated eye/ vein area of paired control eye), and compared between two groups. The normalized area of the ESVs and ISVs of TSP-1 perfused eyes were significantly smaller than the control eyes by 50±7% and 29±8% respectively. These findings suggested that TSP-1 lowered the outflow facility by reduction of the size of ESVs and ISVs and IOP can be regulated by targeting the size of ISV and ESV in the distal outflow pathway.

The role of thyroid hormone receptor beta signaling in the hypothalamic paraventricular nucleus on thyroid hormone action.

Student Presenter: Angela Zhang
Faculty Mentor: Ricardo H. Costa-e-Sousa (MED Medicine, Endocrinology)
UROP Award

Thyroid hormone (TH) is a major regulator of energy metabolism and changes in TH levels greatly affect energy expenditure and food intake. The pituitary hormone thyrotropin (TSH) is a key regulator of TH levels and TSH secretion is stimulated by hypothalamic thyrotropin-releasing hormone (TRH). This system is under control of a negative feedback loop where TH suppresses both TRH and TSH expression. Therefore, TH exerts important hypothalamic effects, but the exact mechanisms remain unknown. We hypothesize that the paraventricular nucleus (PVN) of the hypothalamus is the site of TH regulation through thyroid hormone receptor beta (THRB). To test this hypothesis, we used a stereotaxic approach to inject AAV.CMV.eGFP-Cre into the PVN of Thrb-floxed mice to produce PVN-specific Thrb knock out (KO) mice. Wild type mice were subjected to the same technique and used as controls. Food intake and body weight were measured 1 week before surgeries and regularly for 5 weeks after. At week 5, all mice were perfused, and their brain collected for histology analysis. Blood samples collected at multiple time points will be used to measure TSH and thyroxin concentrations. Remarkably, male KO showed increased food intake and body weight gain when compared to the control group. However, the female KO group and control group showed no difference in weight gain or food intake. These results show for the first time a sexually dimorphic regulation of body weight by TH. This can lead to future investigations focusing on Thrb role in the PVN to control body weight.

Innate Immune Memory in Mice Peritoneal Cells

Student Presenter: Jamie Zheng
Faculty Mentor: Andrew Taylor (MED Ophthamology)
UROP Award

Immunological memory is the ability of the immune system to remember previously encountered pathogens and allows our bodies to display stronger and faster responses to past diseases. Previously, it was believed that only one branch of the immune system, the adaptive immune system, was able to display trained responses. However, recent literature suggests that macrophages, cells of the innate immune system, are also capable of acquiring immune memory. This study investigated innate immune memory by measuring how the pre-treatment of macrophages with the ocular immunosuppressive neuropeptide alpha-melanocyte stimulating hormone (α-MSH) alters cytokine production following a subsequent pro-inflammatory stimulation. The hypothesis is that within the eye, through α-MSH, there is induction of innate immune memory in macrophages. Macrophages were first treated with α-msh, rested, and then stimulated with a pro-inflammatory signal, lipopolysaccharide (LPS). Cytokine levels from macrophages subjected to normal, inflamed, and protective conditions were compared. Cytokine production was measured with an enzyme-linked immunosorbent assay (ELISA). Both anti-inflammatory and pro-inflammatory cytokines were investigated over the course of the study. While it is known that α-MSH induces anti-inflammatory activity in activated macrophages, there was no effect of α-MSH pre-treatment on subsequent LPS stimulation of the macrophages. These results suggest that the anti-inflammatory actions of α-MSH are limited to the time of macrophage activation and on already activated macrophages. The implications are that α-MSH-based therapies will be limited to the immediate immune activity with no effect on subsequent immune responses.

Histone Epigenetic Effects of α-MSH

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

Innate Immune Memory refers to innate immune cells' ability to exhibit secondary exposure effects and infection responses. A partial mechanism for this phenomenon is the dynamic and potentially heritable modification of histone proteins, which post-translationally alter gene transcription. We investigated the effects of alpha-melanocyte-stimulating hormone (α-MSH), a neuropeptide with potent anti-inflammatory activity, on Histone 3 (H3) post-translational markers and its epigenetic effects on mouse macrophages. We conducted a pan-H3 analysis to identify key dose-dependent modifications, then focused on quantifying the changes in H3K4 global methylation, H3K9 dimethylation, and H3K14 acetylation levels in response to α-MSH treatment concentration. Methylation patterns of H3K4 and H3K9 and acetylation patterns of H3K14 proteins are post-translational modifications that regulate the accessibility of transcriptional start sites and promoters for gene transcription. In immune cells, changes in histone methylation and acetylation patterns alter the transcription of genes associated with immune activity, such as inflammation. Our analysis shows a dose-dependent response to treatment with statistically significant demethylation of H3K4, increased dimethylation of H3K9, and higher acetylation of H3K14 in the macrophages. We observed significant treatment effects relative to resting macrophages for H3K4 global methylation and H3K14 acetylation at 1 ng/mL and 10 ng/mL α-MSH and for H3K9 dimethylation at 30 pg/mL α-MSH. Low dose α-MSH induced demethylation and deacetylation for H3K4me and H3K19ac. The results suggest anti-inflammatory activity of α-MSH is through changing the H3 histone methylation and acetylation patterns, which decreases proinflammatory molecules and upregulates anti-inflammatory molecule expression by macrophages.

Computational and Mathematical Sciences

Spatial Dynamics of Neuronal Systems

Student Presenter: Jared Grossman
Faculty Mentor: Gabriel Ocker (CAS Mathematics and Statistics)
UROP Award

When two neurons interact, one neuron releases a spike, which allows information to be transferred in the brain. In the primary visual cortex of the brain, some neurons encode an angular sensory variable. We modeled these neurons using Leaky Integrate-and-Fire (LIF) neurons on a ring. In this model, the neurons can be in one of three different states: no activity, spatially homogenous activity, or a bump of activity centered around a specified angle. The question that arises is when do each of these states occur? To analyze this, we used a partial integro-differential equation that serves as a mean field theory for this network. This equation describes the rate of these spikes as a function of spatial location and time. We analyzed solutions to this equation and compared them against simulations to show that the activity state is determined by the initially applied voltage and strength of coupling between neurons. This type of analysis can be used to explain observed phenomena in the brain such as hysteresis: a history dependence of the activity state. Hysteresis has been linked to both unconsciousness and short-term memory. Continued analysis of this model could explain why hysteresis occurs in terms of conditions in the brain. The next step with this analysis involves changing both the coupling function and changing spatial domains to two-dimensional space to alter our description of the brain tissue containing these neurons.

Predicting Tremor from Subthalamic Nucleus Spectral Powers

Student Presenter: Zhandong Jiao
Faculty Mentor: Emily Stephen (CAS Mathematics and Statistics)
UROP Award

Parkinson's Disease (PD) results in involuntary shaking (tremors) linked to neural activity in the subthalamic nucleus (STN). In particular, evidence suggests tremors are associated with rhythmic neural activity in the subthalamic nucleus (STN). Some patients have electrodes implanted to reduce tremors by applying electrical stimulation in the STN. However, frequent stimulation could lead to neural tissue damage, so being able to find specific STN signals that are correlated to tremors is crucial because it will improve the accuracy of treatments. In our study, spectral powers in six frequency bands are recorded from micro/macro STN electrodes and epoch-averaged along with tremor amplitude data before regression. Then, a linear model that accounts for each of the six frequency bands (θ , β , γ-low , γ-mid , γ-high , vhf) is trained, where power values are taken as input to generate predictions for tremor values. The model showed that up to 33% (R-squared value of 0.33) of tremor variance can be explained by spectral powers, with a significant correlation (0.6 correlation value out of 1) in the γ-high band. The significant quantitative results as well as our visual analysis of the data suggest potential for refining PD treatments by utilizing the strong correlations between STN neural signals and tremors. Our findings highlight a new opportunity to enhance PD treatment accuracy by targeting specific STN neural signals, paving the way for future therapeutic innovations.

Developing an image-processing model that can be used to analyze classroom placement in K-12 schools.

Student Presenter: Lavya Midha
Faculty Mentor: Patricia Fabian (SPH Environmental Health)
UROP Award

Classroom placements in a school play an important role in determining the indoor environmental quality (IEQ). Our project focused on creating an image-processing model for Boston Public Schools that would read the floor plans for each floor for every school and create spatial polygons representing classrooms for future analyses. After reviewing methods to image-process a floor plan to turn into a dataset we selected GeoPandas in Python to create a spatial dataset. We then ran the code to generate a raw geo-dataset, and cleaned the data to get a separate spatial polygon for each classroom. In addition, we developed a distance based algorithm to group classrooms. We then assigned classroom IDs, calculated unscaled areas, identified classrooms near outside walls, and assigned ordinal directionality. Our work resulted in two datasets, one for grouping and the other with classrooms as separate polygons with their ID, area, edge detection, and ordinal direction(s). Finally, we documented the protocols. Future applications for this work will include classifying classrooms across schools in an entire school district, creating a classroom distance matrix, and looking at how classroom features correlate with IEQ.

Enhancing Multi-Threaded Workflows in Secrecy

Student Presenter: Vineet Raju
Faculty Mentor: John Liagouris (CAS Computer Science)
UROP Award

Secrecy is a cryptographically secure Multi-Party Computation (MPC) system. MPC systems allow multiple-data owners to perform computation while keeping inputs private. Secrecy enables general-purpose MPC computation in the cloud. The communication layer serves as a bottleneck for practical MPC systems. To achieve reasonable execution time it is critical to ensure exchanging data is optimized and parallelizable in order to amortize both network I/O and operation cost. For the communication layer, the goal is to consume maximum available bandwidth with as few computation threads as possible. Implemented in Message Passing Interface (MPI), which is a user-space double-copy based interface, for any given socket operation at least two expensive system calls are required. For high throughput network communication, system calls induce the CPU to context-switch wasting cycles. To improve performance, we decided to use io_uring, which is a kernel system call interface for asynchronous I/O. Using io_uring we are able to remove the need for context-switching as we can keep buffers shared between the kernel and user space, no longer performing system calls to copy these buffers from application space into user space. In multi-threaded workflows at smaller-sized buffers (from 4k-16k size), with low-thread count we are able to achieve ~2x throughput in bytes/second, and in larger-sized buffers (131k), we are at ~25% higher throughput. These results allow Secrecy to compute larger datasets, enhancing its viability as a practical system. Additionally, the new layer also provides better abstraction that would now allow future improvements to the execution model, further improving system performance.

Jump Process Simulation Algorithms for Modeling Biological Systems with Memory Optimization

Student Presenter: Caiwei Zhang
Faculty Mentor: Samuel Isaacson (CAS Mathematics)
UROP Award

When an unknown antigen infects an individual, it is a question how strongly the body's immune system will respond to the viral infection. Quantifying the strength of the immune system's reaction to antigens can aid biologists and pharmaceutical companies in understanding the severity of different viruses. In this project, we constructed and optimized a numerical method that can fit jump process models of antibody-antigen interactions to experimental surface plasmon resonance (SPR) assay data, allowing the quantification of different antibodies' reaction efficacies. To further improve the memory usage of the surrogate that underlies the model, we designed an exponential series for fitting surrogates by piecewise interpolation, using variable projection methods to speed up the optimization process. This resulted in a 33x reduction in on-disk memory usage. We also adopted a global derivative-free optimizer that consistently gives the best, most robust, fits of the interpolated model compared to other derivative-free and derivative-based optimizers. This project was launched as preparation for extending our methodology in modeling biological systems to bispecific antibodies, where we will discover and update our model to account for the heterogeneity of the antibody binding to each antigen.

Engineering

Assessing the Utility of AlphaFold Protein Models for Drug Design

Student Presenter: Rohin Bajaj
Faculty Mentor: Diane Joseph-McCarthy (ENG Biomedical Engineering)
UROP Award

AlphaFold is a novel deep learning AI software developed by DeepMind that has recently achieved a significant advance in our ability to predict protein structures accurately from their amino acid sequences. Given this breakthrough, there is interest in assessing the utility of AlphaFold protein models for use with a variety of computational drug design approaches. The overall goal of the project is to assess the accuracy of molecular docking of ligands to AlphaFold-generated protein models vs. X-ray structures of the proteins. To accomplish the goal, we first obtained AlphaFold models for the proteins in a published benchmark set for which both an apo (unbound) and small molecule ligand bound structure(s) exist. For each protein, we docked the corresponding small molecule ligand(s) to the unbound structure for that protein using the Glide docking method. We assessed how well docking to the unbound structure reproduced the known protein-ligand complex by calculating the RMSD between the ligand position in the bound structure and that in the docked structure. Finally, the docking results were compared to those obtained using AlphaFold models and shown to be similar. Overall, if AlphaFold models can be employed for molecular docking for a wide variety of proteins, including those not readily amenable to structure determination, the range of drug targets that can be pursued using structure-based computer-aided design methods will be significantly expanded.

Scaling Channel Count in Fibers using Topological Confinement

Student Presenter: Isabelle Boegholm
Faculty Mentor: Siddharth Ramachandran (ENG Electrical and Computer Engineering)
Clare Booth Luce Award

There is an increasing demand for more optical communication channels but except for space, the degrees of freedom have been exhausted. Different spatial modes can be used as distinct communication channels, similar to how different frequencies of radio waves give us different radio channels. The practical applications of spatial division multiplexing in a given fiber are dependent on the overall mode count. Unlike conventional bound modes that propagate due to total internal reflection, topologically confined modes (TCMs) propagate due to a centrifugal barrier. TCMs experience less mode coupling than bound modes, making them desirable for scaling the channel count. It has been shown that an increase in the overall mode count of a fiber corresponds to enhanced topological confinement. Due to topological confinement, a total mode count of 68 modes can be achieved for 25m. However, the limit to the scalability of these modes is unknown. Here we show that with higher orbital angular momentum we can enhance the topological confinement, achieving a record total mode count of 80 modes for 25m of fiber. This was accomplished by using a fiber with a larger ring core size. This is 40 times more channels than commercial single mode fibers in use today. Our results suggest that the overall mode count can likely be further increased by enhancing topological confinement, which can be done using larger ring core size. Fibers that have more channels for communication have the potential to allow us to transmit more information.

Early Functional and Behavioral Outcomes of Ischemic Stroke in Young Mice

Student Presenter: Piergiulio Bressan
Faculty Mentor: David Boas (ENG Neurophotonics)
UROP Award

The behavioral changes that arise consequently to an ischemic stroke are highly variable and their correlation with functional activity is still uncertain. To study this link in mice it is necessary to combine high quality functional imaging of the brain with simultaneous evaluation of the impaired behavior through a specific task, intended to mimic the commonly used cylinder test. In this study we focused on the early functional and behavioral outcomes of ischemia in mice, evaluated through blood flow measurements paired with quantitative analysis of the performance in the behavioral task; imaging with Laser Speckle Contrast Imaging at multiple timepoints happened simultaneously to the execution of the task, allowing us to study the correlation between the two. We noticed a significant decrease in performance in the task in the week immediately after the stroke, but a partial recovery was observed at later timepoints. We also observed a concomitant change in the distribution of blood flow during the task. The quick increase in blood flow, typically seen in the anterior primary motor cortex during the lever press task, was transiently and partially shifted to a different cortical area in the two weeks following the stroke. Despite the persistent cellular damage caused by the stroke, the blood flow appeared to revert to its original area at later timepoints, but further investigation will be needed to ascertain this. The postischemic behavioral outcomes evaluated in this study could lead to further research on the topic, eventually improving the understanding of the ischemia itself.

Establishing a Model of Tendon Explant Overuse

Student Presenter: Henry Chow
Faculty Mentor: Brianne Connizzo (ENG Biomedical Engineering)
UROP Award

Tendinopathy is a degenerative tendon condition characterized by pain, tenderness, and joint stiffness. This condition arises from repetitive strain and cumulative microtrauma within the tendon matrix. We aimed to create a model of overuse in tendon explants to understand the progression of microdamage accumulation. Previous research has indicated that a 3% cyclic strain best represents physiological conditions and maintains tendon health. Therefore, we hypothesized that strain levels above the physiological range (7% and 9% cyclic) were sufficient to induce microdamage without causing a complete tendon rupture. Tendon explants from four-month C57BL/6 mice were cultured in a custom-built mechanical loading bioreactor. Explants were cyclically loaded to 3%, 7%, or 9% maximum tissue strain for one hour and then rested at 0% strain for six hours. This loading protocol was conducted four times per day for seven days. We then assessed fiber structure and organization in each group using Second Harmonic Generation imaging. We found that both 7% and 9% cyclic strain led to an accumulation of microdamage in the form of angulated, kinked tendon collagen fiber formations. However, fiber analysis demonstrated that the overload strain conditions exhibited no significant differences in width, length, straightness, and alignment of fibers compared to tendons under physiological loading conditions. Currently, we are exploring alternative metrics and methods to better characterize the damage observed. Studying the progression of microdamage accumulation in tendon structures may offer valuable insights for future research, helping to identify potential targets for intervention and develop strategies to prevent or treat tendinopathy.

Detection and Correction of Out-of-plane Motion in 2D DIC

Student Presenter: Aidan Donovan
Faculty Mentor: Emma Lejeune (ENG Mechanical Engineering)
UROP Award

Digital image correlation (DIC) is a popular experimental method used to measure full-field deformation in materials. In brief, DIC works by capturing snapshot images as the material deforms and comparing reference points between an initial and subsequent images. In general there are two main methods of capturing images: two-dimensional (2D) and three-dimensional (3D) DIC. 3D DIC requires at least two cameras at a stereo angle while 2D DIC uses a single camera system. While 3D DIC is not impacted by out-of-plane motion and provides more accurate data, it is more expensive than 2D DIC. On the other hand, 2D DIC can introduce artificial deformations induced from the sample being out-of-plane with the camera field of view. This project aims to minimize the out-of-plane effect in deformation fields obtained from 2D DIC. To this end, we created a Python based framework utilizing the OpenCV library to deal with the key issues of the current DIC setup in the Lejeune Lab. The framework includes a custom autofocus algorithm to ensure optimal image quality, a checkerboard calibration method to ensure camera alignment, and a minimum area rectangle algorithm to ensure sample alignment. Additionally, the code also automatically creates a mask of the final image through image segmentation which is used to identify the region of interest for DIC analysis. The software will be made available through a public Github repository so that the Lejeune Lab and others can use or modify the code for their own purposes.

Engineering Uterine Fibroid Organoids: A preliminary study with MCF7 spheroids.

Student Presenter: Ricardo Fernandez
Faculty Mentor: Catherine Klapperich (ENG Biomedical Engineering)
UROP Award

Uterine fibroids are benign tumors that can cause gynecological issues and represent significant healthcare costs worldwide. We believe that by using organoids, three-dimensional cell models, we can better understand fibroid physiology. We developed and implemented a proof-of-concept study with MCF7 cells, a breast cancer cell line, to culture a simple three-dimensional model known as spheroids. We adjusted variables like cell seeding counts and captured observations on their morphology. The cells were first cultured in flasks and transferred to 96-well plates for spheroid growth. Within a plate, our cell counts ranged from 1000-6000 in 1000 cell increments and were grown for 5 days. We stained the spheroid nuclei with DAPI and the cytoskeleton with rhodamine phalloidin for confocal imaging. We used ImageJ to calculate aspect ratio and circularity, values closer to 1 were more spherical. Our data revealed no clear relationship between cell count and sphericality. Our results can be partially attributed to the presence of fibers in some spheroids causing cells to grow around them, therefore promoting deformation. We believe that manual culturing is responsible for the variability in our spheroids. Future steps will be to automate spheroid culturing to improve consistency, minimize error, and increase throughput. Automated and manual culturing for MCF7 spheroids will provide a proof-of-concept system for growing uterine fibroid organoids.

Engineering Microenvironment-Responsive Nanobodies for Non-Invasive Detection and Monitoring of Diseases

Student Presenter: Aidan Holmes
Faculty Mentor: Liang Liang Hao (ENG BME)
UROP Award

Disease specific diagnostics allows for new and efficient ways to detect certain heterogeneous diseases. The tumor microenvironment upregulates proteases that cleave synthetic DNA sequences as disease 'biomarkers', allowing for detection in biofluidics. For this study, protease activatable biomarkers were investigated for early detection of renal cell carcinoma (RCC), which accounts for the majority of kidney tumors. The basic design for the protease activatable biomarker is a targeting nanobody for an upregulated protein conjugated to a protease cleavable sequence. The Cancer Genome Atlas clinical RCC data was turned into a list of extracellularly expressed proteases with matching FRET probe sequences in lab stock. Literature search confirmed disease specific upregulation of CA9 protein in RCC and CA9 nanobody binding efficiency. CA9 nanobody production involved genetic insert design on a plasmid design software and performing cloning techniques to produce CA9 nanobodies for conjugation. Throughout the protein production process, a mouse RCC cell line was cultured at 37 C and 5% CO2 and divided for in vitro testing of CA9 targeting. Protein production yielded successful transformation of CA9 nanobody into competent E. Coli cells, confirmed by Sanger sequencing. Culturing transformed E. Coli led to CA9 nanobody production by column purification techniques and a stock of CA9 nanobody for conjugation. Next steps include a CA9 fluorescent assay to confirm CA9 expression in vitro and conjugating substrates to form a nanobody substrate complex. After the biomarker is applied in vivo for RCC, perhaps other heterogeneous diseases with irregular protease activity would benefit from this diagnostics design.

Deep Learning for Blood Pressure Estimation

Student Presenter: Jivesh Jain
Faculty Mentor: Darren Roblyer (ENG Biomedical Engineering)
UROP Award

Nearly half the population in the United States is suffering from hypertension. A device called Sphygmomanometer is the current gold standard for non-invasive blood pressure monitoring, but it doesn't provide continuous blood pressure readings. For continuous blood pressure estimation, various studies have constructed machine learning algorithms which use photoplethysmography ([PPG] which is an optical technique for detecting blood volume changes) and electrocardiograph (ECG) signals as inputs. In our laboratory, we have already shown that the blood flow index ([BFi] which gives information about vascular blood flow) is more correlated with blood pressure than PPG signals. Also, ECG and PPG signals require separate mechanical devices for their extraction which makes the blood pressure estimation process inconvenient whereas BFi and PPG signals can be extracted from the same optical set up. In this study, we used different deep learning techniques to estimate blood pressure for 30 subjects and then 10 repeat subjects using BFi and PPG waveforms. This study used highly variable blood pressure data because the subjects were asked to do exercise while their BP was being recorded. Several deep learning techniques like multilayered perceptron, recurrent and convolutional neural networks were used. We realized that for these techniques, hyper parameter tuning is essential and can significantly improve results. Also, since we used BFi and PPG waveforms, only one optical set up was needed for taking measurements and hence this made the blood pressure estimation process more practical and brought us one step closer to forming a portable blood pressure monitoring system.

Effects of post-mortem interval on myelin integrity in rhesus monkey brain tissue

Student Presenter: Allen Jang
Faculty Mentor: Irving Bigio (ENG Biomedical Engineering)
UROP Award

Studying myelin degradation and its relationship to dementia in human brains can be challenging, as brain tissue is often collected and preserved at varying times after death, which causes the myelin to break down independent of the effects of neurodegenerative disorders. This study investigated how post-mortem brain degradation affected myelin over time in rhesus macaque monkeys using high resolution optical imaging to quantify myelin degradation. This will inform future research in human brains. Immediately after euthanasia, brain tissue from the occipital lobe was cut into four thin slices, which were placed into 4% periodate-lysine-paraformaldehyde fixative solution at 0, 24, 48, and 72 hours after collection. The fixed tissues were imaged using polarization-sensitive optical coherence tomography to measure the relative retardance of the tissue and degree of scattering, then cut on a vibratome into 30μm thick sections. Tissue sections were mounted on charged gel-coated slides and imaged using quantitative birefringence microscopy to obtain high resolution images of the myelin, which were annotated for defects. The measured retardance of white matter tissue significantly decreased after the 24-hour sample, matching the expected decrease in birefringence due to loss of myelin integrity. A significant increase in light scattering was also found from the 0-hour to the 24-hour sample in both gray and white matter tissue, likely due to accumulation of myelin debris. Future studies of myelin degradation associated with neurodegenerative diseases should limit procuration of human brain samples to a window of 0-24 hours post-mortem, as significant degradation is expected after 24 hours.

Effects of Nucleoside Imbalance on Glial Cell Proliferation

Student Presenter: Jacob Labovitz
Faculty Mentor: Timothy O'Shea (ENG Biomedical Engineering)
UROP Award

Following neural injury, glial cells are stimulated to proliferate to provide support to the healthy tissue by isolating the region of damage and preventing the spread of the injury. While this proliferation serves to effectively protect the remaining healthy tissue, it is insufficient to repopulate the region of damage. Therefore, it is critical to understand how to regulate and stimulate glial proliferation. Nucleoside metabolism is an essential aspect of cell growth and replication. Imbalances in individual nucleoside levels can disrupt proliferation, leading to abnormal growth and a halt in cell division. Previous work in the O'Shea lab utilized a nucleoside-based polymer as a treatment for neural injury. In this work, we observed that the nucleoside-based materials appeared to limit the proliferation of glial cells locally, suggesting that these materials could be used to regulate glial proliferation in vivo. We hypothesize that inducing a nucleoside imbalance will modulate glial proliferation levels in a controllable and tunable manner. Using an astrocyte culture, we tested a broad spectrum of nucleosides at varying imbalances in vitro. Thus far, results show a nucleoside specific effect, tunable with nucleoside concentration, giving us the ability to increase or decrease proliferation in comparison to a control. Ongoing studies continue to investigate concentration-dependent effects, and will progress into studies focusing on cell migration before a transition into in vivo work.

Development of Tumor-On-A-Chip Model to Study Breast Cancer-Macrophage Crosstalk

Student Presenter: Nikhil Lahiri
Faculty Mentor: Joe Tien (ENG Biomedical Engineering)
UROP Award

Triple-negative breast cancer (TNBC) is an aggressive subtype of breast cancer with limited therapeutic targets. In TNBC, tumor cells are able to proliferate and migrate by evading and manipulating immune cells, such as macrophages. Macrophages exhibit functions that depend on external stimuli. Previous work has shown that naïve macrophages exposed to conditioned media from TNBC cells converts them into a phenotype that enhances the invasion of TNBC cells. However, the culture models used in this work do not resemble the 3D structure of the vasculature-extracellular matrix interface in vivo. More generally, little work has been done on directly incorporating macrophages into 3D models of TNBC. Here, I have developed a 3D in vitro model to study macrophage-breast tumor crosstalk. First, I resuspended macrophage precursor cells, called monocytes, into collagen gels. After polymerizing the monocyte laden gels, I differentiated them in situ to convert them into naïve macrophages. I found these macrophages to be viable and responsive to polarization reagents. Following an approach used by the Tien Lab, I modified the model to incorporate breast tumors. This work will set the foundation for studying how macrophages affect tumor progression in TNBC.

AI4HPC: AI-based Scalable Analytics for Improving Performance, Resilience, and Security of HPC Systems

Student Presenter: Yin-Ching Lee
Faculty Mentor: Ayse Coskun (ENG Electrical and Computer Engineering)
UROP Award

High-performance computing (HPC) systems play a critical role in pivotal domains such as drug discovery, quantum mechanics research, and COVID vaccine investigations. However, their operational efficiency can be compromised by occurrences of anomalies, posing significant challenges to advancements in these critical areas. PeacLab developed a supervised anomaly diagnosis framework that detects anomalies in HPC systems. To make our supervised framework publicly available, I developed AI4HPC, a web-based application that lets users explore diagnosis results using our ML model. Users can choose a sample dataset or upload their own multivariate time-series telemetry data. Both options involve offline training, deployment, and data preprocessing. For custom datasets, we assess the feature overlap between training and uploaded dataset. If the training dataset has different features after the intersection, we need to retrain the ML model based on the intersected columns. Then the retrained model provides anomaly diagnosis, otherwise, we would use the offline-trained model. User-friendliness is paramount as the uploaded dataset's requirement should be minimized and the inference time should be short. I iteratively reduced the training dataset and removed columns until achieving a 0.9 F-1 score. This experimentation aims to minimize the training dataset's size and ensure that even with few intersected columns, the model can provide an accurate diagnosis.

As a result, AI4HPC is deployed through AWS and was showcased at the Design Automation Conference (DAC). Our research group is actively advancing an unsupervised learning framework for detection in production systems. Integrating these developments into the website's framework is a future goal.

Analysis of Inflammatory Biomarkers in a Sleep Study on Major Depressive Disorder

Student Presenter: Joseph Licata
Faculty Mentor: Laura Lewis (ENG Biomedical Engineering)
UROP Award

Major depressive disorder is a heterogeneous disorder, composed of multiple subgroups with overlapping symptoms and etiology. One emerging subgroup of major depressive disorder is defined by cluster of abnormal inflammatory biomarkers, such as elevated levels of inflammatory substances in the blood. In this study I analyzed levels of blood inflammatory markers, such as C-reactive proteins (CRP) and Interleukin-6 (IL-6), to test whether the subjects in our major depressive disorder group had the inflammatory subtype of depression. I also analyzed a brain-based measure of glial reactivity as a proxy for brain inflammation, using myo-inositol levels measured from a magnetic resonance spectroscopy sequence collected directly after the blood samples. We collected data from subjects on two visits: one visit after a night of good rest, and one visit after a monitored night of sleep deprivation. I found that 6 of the 35 total subjects that had well rested visits had high CRP levels, and 4 of these 6 individuals had significantly higher than average levels of the IL-6 marker. There was no observable correlation between the blood markers of inflammation and myo-inositol levels. I further analyzed the relationship between each subject's sleep history prior to the sample collection and CRP levels. I found that subjects who slept less than 7.5 hours had higher CRP on average than subjects who slept more than 7.5 hours before their well-rested visit. Overall, my work suggests that some individuals in our major depressive disorder group do show signs of having an inflammatory subtype of the disorder.

Investigating the Effects of Audio Stimulation and Deep Brain Stimulation on Mouse Locomotion

Student Presenter: Audrey Lindsay
Faculty Mentor: Xue Han (ENG Biomedical Engineering)
UROP Award

Unstable gait is a major concern of most Parkinson's patients, and increases in severity over time. This study investigated the effects of both audio stimulation and deep brain stimulation (DBS) on locomotion in mice. Specifically, this study utilized an open field during audio stimulation to observe the effects of stimulation on locomotion in a more natural setting. In order to investigate the effects of audio stimulation, the mice were filmed from below in an open field to capture their motion while audio pulses were played at different rates. In order to investigate the effects of DBS, the mice were filmed from the sides on a pinned ball during stimulation. The video was then analyzed using Deep Lab Cut to mark the paws in each frame, and the data was run through MATLAB scripts to visualize the mouse's gait. In mice where an effect from the audio was observed, the speed decreased during audio stimulation. This effect was stronger when the audio pulses were at 4hz, and weaker during 2hz pulses. The effects of DBS on mouse locomotion have not been quantifiable so far in my investigation. However, in the future, I hope to use the open field assembly to further investigate the effects of DBS on mouse behavior. The open field allows the mice to move freely and with natural behavior, so any effects observed in the open field would be more applicable to what we would expect in a clinical setting.

Blood Flow Oscillations in Post-stroke Recovery

Student Presenter: Emily Long
Faculty Mentor: David Boas (ENG Biomedical Engineering)
UROP Award

Vascular oscillations are low-frequency oscillatory dynamics in the hemodynamic signal, which are proved to have important diagnostic values for post-stroke recovery in human patients. In mouse models, vascular oscillations are usually reported within the 0.1 to 0.3 Hz band. Previous investigation has revealed that the power of these slow frequency hemodynamic oscillations are positively correlated with behavioral outcomes after ischemic stroke in preclinical mouse models. The present study investigated the mechanistic relation between vascular oscillations and capillary stalling, the temporary arrest of capillary blood flow due to physiological changes including leukocyte-endothelium adhesion. Reductions in capillary stalling in the peri-infarct region have previously been found to improve post-stroke behavioral outcome in mice. Here, vascular oscillations were hypothesized to improve recovery by reducing capillary stalling events, thereby increasing perfusion to the stroke region. Measurements of vascular oscillations in cerebral blood flow and capillary stalling were gathered using laser speckle contrast imaging (LSCI) and optical coherence tomography (OCT), respectively. While vascular oscillations are conventionally measured in blood oxygenation dynamics by intrinsic optical imaging (IOSI), the same trend of vascular oscillation power variations were also seen in LSCI blood flow index (BFI). Both BFI and stalling statistics displayed the general trend of peaking at Day 2 post stroke and gradually returning to baseline on Week4. A strong negative correlation between BFI and capillary stalling was observed on Day2 post-stroke. Further analysis can be done to determine the physiological reasons driving the stalling events and to link BFI powers directly to the behavioral outcomes.

Fluidic System Integrated with a Soft Bleeding Sensor for Colonoscopy

Student Presenter: Arnav Mankad
Faculty Mentor: Sheila Russo (ENG Mechanical Engineering)
UROP Award

Colonoscopies are crucial for identifying colorectal cancer in patients; however, internal bleeding may occur during the procedure due to perforations, hemorrhaging, polyps, or diverticula. A soft sensor is in development that uses light to detect bleeding as the endoscope traverses the colon. However, the colon contains mucus that can get trapped in the sensor's microfluidic channel and hinder blood detection. For this project, a filtration system was developed which contains a vacuum pump that enables the suctioning of blood through the sensor along with a saline flushing pump with the ability to clear clogged mucus from the microchannel. The rates of vacuum and flushing were optimized to ensure that the sensor has enough time to process the blood in its channel and that the removal of mucus from the colon does not delaminate the sensor. It was also important to consider larger chunks of fluid that may persist in the sensor after filtration. After observing that the average loss from blood is higher than that from clear fluids, a new graphical user interface (GUI) was developed that normalizes smaller losses to zero. By eliminating outliers, the GUI provides the surgeon with more reasonable data. During ex vivo testing in an animal colon, there were zero false detections in fifteen trials by three novices, demonstrating that the system and GUI work efficiently together and improve the functionality of the blood sensor. In the future, the system's clinical efficacy will be further evaluated by performing in vivo testing in a pig.

Priming cells for increased survival and glia-repair in hemorrhagic stroke lesions

Student Presenter: Emily McCarthy
Faculty Mentor: Timothy O'Shea (ENG Biomedical Engineering)
UROP Award

Stroke is one of the leading causes of death and disabilities across the globe. Hemorrhagic stroke is a type of stroke caused by the rupture of a blood vessel which has no treatment. For the past century cell grafts have been explored as a potential treatment for stroke however, grafted cells are dramatically impacted by their environment. Our previous studies have shown that both neural progenitor cells (NPC) and immature astrocytes (ImA) grafts survive poorly in hemorrhagic lesions due to the presence of complex cytostatic cues derived from serum which may induce an EMT (epithelial to mesenchymal transition)-like program in the grafted cells. Therefore, we are interested in developing clinically-relevant conditioning strategies for cell grafts in hemorrhagic lesion environments to enhance glia repair. In our approach, we first determined how serum in vitro affects proliferation of NPC and ImA. We then probed the cell's response to serum after treatment with the Transforming Growth Factor Beta (Tgf-β) receptor inhibitor, SB-431542, which is also an established EMT inhibitor. Our results show that serum significantly decreases proliferation in both cell types. Results also show that SB-431542 pre-treatment had a positive effect on proliferation rates, but wasn't able to fully mitigate the cytostatic effect caused by serum. Further studies include identifying components of serum that cause the cytostatic effect using fractionation methods. This will allow us to understand how to effectively apply conditioning strategies to cells before grafting into hemorrhagic lesions.

Digital Logic Design for Residue Number System to Binary Number System Conversion

Student Presenter: Suhani Mitra
Faculty Mentor: Ajay Joshi (ENG Electrical and Computer Engineering)
Clare Booth Luce Award

Analog computing has shown to have the potential for accelerating deep neural network (DNN) inference. To utilize this, we must often convert between the analog and digital domains with high-bit precision converters. Since these converters can consume lots of power, there is a need for minimizing power consumption while maintaining high accuracy and the integrity of the converter. The residue number system (RNS), where an integer is represented by its residues from a set of coprime moduli, enables us to perform low-precision operations in parallel to address this, then compose a high-precision digital output. While using RNS, however, we must convert data between the binary number system (BNS) and RNS. As such, these conversions must be efficient so as to make this tradeoff worthwhile in the overall system. To identify the most optimal RNS-BNS conversion design, several existing RNS-BNS conversion methods were evaluated, implemented in Verilog HDL. The widely implemented Chinese remainder theorem (CRT), CRT modified with Barrett reduction, special set, and look-up table-based conversions were the primary methods analyzed. After RTL code implementation, SiliconCompiler synthesis was used to further understand the performance-cost tradeoffs each method posed. The synthesis revealed that the traditional CRT conversion was the most efficient method in terms of power consumption and area. This method also offered the most flexibility in terms of input values. With these findings, we can aim to accelerate DNN inference by facilitating the use of RNS in DNNs.

Implantable Radiofrequency (RF) coil development for ultra-high resolution fMRI of awake mice with 14 Tesla MRI scanner

Student Presenter: Sohail Mohammed
Faculty Mentor: Chen Yang (ENG Electrical and Computer Engineering)
UROP Award

Awake mouse fMRI presents a promising avenue for noninvasive investigation of functional connectivity, delving deeper into associated functional regions that remain hidden under anesthesia. The key to achieving successful awake mouse fMRI lies in head fixation, ensuring the mouse's stability during scanning. Purpose-designed radiofrequency (RF) coils, tailored for utilization at the proton frequency for 14T (600MHz), can be used as a headpost for the head restriction of awake mice. In addition, surgical implantation of the RF coils directly attached to the skull minimizes susceptibility arising from air/tissue interfaces and motion-related B1 variability (due to motion-induced RF coil loading alteration). It should also be noted that the implanted coils exhibit a substantial enhancement in signal-to-noise ratio (SNR), while simultaneously imposing minimal physiological disruptions, thereby enabling the acquisition of ultra-high spatiotemporal MRI scans at 100μm isotropic resolution. This ultra-high resolution fMRI of awake mouse brains enables mapping vessel-specific hemodynamic responses, e.g. vasomotion (slow oscillation of arteriole diameter changes), which can be involved in the glymphatic waster clearance. This single-vessel fMRI method allows the detection of impaired vasodynamics in degenerative brains of transgenic mouse models, including Alzheimer's disease. Moreover, this methodology holds the promise of broadening its scope to encompass x-nuclei MRI (e.g. 23Na). enabling novel biomarker detection of early brain injury. The preclinical advanced MRI methodlogy development will significantly advance our comprehension of brain function, paving a translational potential for humain brain mapping.

Measurement of Cartilage Crosslinks using Raman Spectroscopy

Student Presenter: Shakaani Nasankar
Faculty Mentor: Michael Albro (ENG Mechanical Engineering)
UROP Award

Cartilage is a low-friction, load-bearing tissue allowing for smooth joint locomotion. The cartilage matrix consists of glycosaminoglycans within a type II collagen network, important for its structural integrity and lubrication. The outstanding tensile properties and resiliency of the collagen matrix are modulated by the presence of biochemical crosslinks that arise from post-translational modifications to collagen fibrils. Perturbations of collagen crosslink density can contribute to tissue pathology—crosslink loss is a precursor to tissue breakdown, while excessive crosslinks can make collagen brittle and prone to fatigue failure. Raman spectroscopy is an inelastic light scattering technique, providing a spectral optical “fingerprint” of tissue molecular building blocks, for in vitro assessments or in vivo-based diagnostics of tissue composition. Here, I explored the capability of a Raman needle probe to measure the content of advanced glycation end-product (AGE) crosslinks in cartilage, a major crosslink in the collagen matrix. AGE crosslinks were induced in bovine cartilage explant tissue specimens through an established model system of long-term incubation with 500mM ribose for up to 18 days. The Raman Amide I peak was subjected to deconvolution with four Gaussian-Lorentzian subpeak distributions (subpeaks 1610, 1640, 1670, and 1690 cm-1). Results demonstrated that subpeak ratios (1670/1640 and 1670/1610) significantly decreased with ribose exposure ($p<0.05$), suggesting the ability of this analysis to predict AGEs in cartilage. In future work, we aim to correlate Raman subpeak ratios to direct measures of AGE content to establish Raman probe analysis as a non-destructive preclinical and clinical technique for analyzing cartilage composition.

Development of Patterned 2D Platform to Study Human Induced Pluripotent Stem Cell Derived Cardiomyocyte Behavior In Vitro

Student Presenter: Hawa Ndiaye
Faculty Mentor: Jeroen Eyckmans (ENG Biomedical Engineering)
Newbury Center Award

Cardiac diseases are the global leading cause of death. Due to the fact that human cardiomyocytes do not readily regenerate, the field is looking towards in vitro grown, cell-based approaches to understand and treat cardiac diseases. In this study, we aimed to develop a 2D platform to study how human induced pluripotent stem cell derived cardiomyocytes (hiPSC-CMs) interact with each other in a single monolayer. In the heart, cardiomyocytes are highly aligned and coordinated. This helps generate maximum force to pump blood through the body. Therefore, we used micro-contact printing to pattern fibronectin on polydimethylsiloxane (PDMS) substrates in order to control cardiomyocyte attachment and alignment. We developed multiple stamp patterns to test which patterns best aligned cardiomyocytes. We seeded hiPSC-CMs onto stamped substrates and imaged the cells using immunofluorescence microscopy. From this study, it became apparent that hiPSC-CMs seeded on rectangular patterns had more consistent morphology than those seeded on line patterns. Furthermore, adding lines to the rectangles better aligned cardiomyocytes than solid rectangles. With these results, we could use this platform to study how iPSC-CMs integrate with each other. This work has the potential to improve our understanding of how hiPSC-CMs behave with each other and how they may function in cell-based therapies for cardiac diseases.

Establishing a Model of Graded Cellular Senescence in Tendon Explants

Student Presenter: Takaya Niibori
Faculty Mentor: Brianne Connizzo (ENG Biomedical Engineering)
UROP Award

Cellular senescence is a biological process associated with the functional deterioration of tissues that occurs with aging. Senescence can be induced in vitro through various stimuli that cause cellular stress or damage, including the drug doxorubicin (DOX). My study investigates how different exposure times and DOX concentrations influence senescence induction, measured via cell proliferation. In vitro senescence induction is an essential technique to explore senescence biomarkers and uncover the role of senescent cells. Our lab uses a unique explant culture technique for studying tendon cell biology within the native ECM. In this study, we harvested flexor digitorum longus (FDL) tendon explants from young male mice. To induce varying degrees of cellular senescence, the tendons were treated with DOX at different concentrations (0-1000nM) and exposure times (0-168 hours). On day 7, we evaluated the extent of senescence induction with 24-hour radiolabeling using 3H-thymidine for cell proliferation. Our findings show a significant decrease in cell proliferation occurs within 48-hours of 200nM DOX treatment. Additional exposure past 48-hours did not cause further declines in cell proliferation. Increasing moderate DOX concentrations (50, 100, 200nM) show declines in cell proliferation, but rising high DOX concentrations (500, 1000nM) increase cell proliferation, potentially indicative of quiescence rather than senescence. This data suggests 100nM DOX treatment for 72-hours leads to the lowest cell proliferation. My results hold significance due to their potential to establish a graded model of induced cellular senescence in tendon explants. Our future work will utilize qPCR to further characterize the senescent profile.

Delivery of Genetic Cues for Increased Anti-Tumor Immunity

Student Presenter: Julia Nowak
Faculty Mentor: Michelle Teplensky (ENG Biomedical Engineering)
UROP Award

Immunotherapy treatments are an effective strategy to target cancer cell growth, as they reprogram a patient's own immune system to combat cancer. However, these drugs, typically monoclonal antibodies including Keytruda, OPDIVO, or Tivdak, are unstable and fragile. Developing improved delivery mechanisms for immunotherapeutics will enable better targeting, distribution, and extent of their delivery, key factors to increase effectiveness of existing and future therapies. This summer, the goal was to identify agents for delivery, and harness a new delivery vehicle – metal organic framework (MOF) nanoparticles – to encapsulate and protect biomolecules. MOFs are highly stable porous nanostructures, whose unique cage-like structure allows modulated cargo absorption and release, unlike other drug delivery systems. I identified and synthesized various oligonucleotide genetic cues that have been shown in literature to diminish the expression of a programmed death ligand (PD-L1) that cancer cells overexpress and abuse to confuse the immune system. I successfully developed an encapsulation protocol that maximizes the amount of oligonucleotide within the MOFs. I hypothesized that MOF stability and slow degradation within the body allows for greater amounts of immunotherapeutic treatments to successfully reach cancer cells. I observed a dose threshold at which I am able to achieve knockdown of PD-L1 in mouse melanoma cancer cells. This success will lead to continued development of both this drug delivery system and related platforms within my advisor's lab, where the delivery of newly designed immunotherapeutic treatments can continue to be tested.

Mechanosensitive Ion Transport in Nanoparticle-blocked Nanopores

Student Presenter: Joscelynn Palen
Faculty Mentor: Chuanhua Duan (ENG Mechanical Engineering)
Clare Booth Luce Award

The cell membrane plays a crucial role in facilitating key processes in living organisms, such as hearing in mammals and cellular volume regulation, by regulating ion transport into and out of cells through nanochannels. Mechanosensitive ion channels immediately respond to changes in external pressure and transform their channel configurations to perform critical biological functions, but this type of pressure-sensitive ion transport has not been artificially replicated yet. We present a nanoconfinement involving a hydrophilic nanopore with diameters ranging from 100 nm to 500 nm blocked by 510 nm-diameter carboxylated polystyrene (PS–COOH) nanoparticles using electrical and mechanical stimuli. When a voltage is applied, the negatively-charged nanoparticles are electrokinetically driven towards the nanopore with the same charge polarity. We applied pressures up to 7 atmospheres (atm) in order to mechanically drive nanoparticles further towards the entrance of the nanopore, creating a gate that would open or close depending on the pressure exerted. Using these two methods of nanoparticle-trapping, we were able to measure the average change in ionic current through the pore as the pressure increased. Plotting the current response for each chip, we discovered a linear trend between the current and the cubic root of the pressure in kilopascals (kPa), indicating that the nanoparticle actually makes contact with the edge of the nanopore and rotates around it according to its relationship with pressure^1/3. This system demonstrates a reversible and efficient gating strategy that could be useful in applications like drug delivery and cell communication.

Immunofluorescence characterization of polarized macrophages

Student Presenter: Abderrahman Rhmari Tlemcani
Faculty Mentor: Joe Tien (ENG Biomedical Engineering)
UROP Award

Macrophages, a type of immune cell, play an important role in regulating the migration and invasion of breast cancer cells and in promoting breast cancer metastasis. Clinical studies have shown that the abundance of tumor-associated macrophages (M1 and M2) in breast cancer tissue is an independent factor for poor prognosis. Therefore, it is important to distinguish whether different types of macrophages help or hinder the progression of breast cancer. M1 macrophages recruit other immune cells and are usually considered anti-tumor, whereas M2 macrophages are involved in tissue repair and are often considered pro-tumor. Various markers can be used to distinguish M1 and M2 macrophages, including iNOS or NF-κB for M1 macrophages and CD206 for M2 macrophages. My project aimed to characterize the macrophages that we use in the Tien Lab's breast microtumor model to confirm that we can produce both M1 and M2 macrophages. I first optimized our staining protocol to produce stains of our macrophages on coverslips. I then started characterizing the macrophages by staining for different macrophage markers.This characterization should help us determine how M1 and M2 macrophages affect the invasion and escape of tumors in our breast microtumor model and allow us to compare any of our results to other findings in the literature about M1 and M2 macrophages.

IoT Based Vibration and Sleeping Position Sampling for Animal Monitoring

Student Presenter: Noah Robitshek
Faculty Mentor: Ramaraja Ramasamy (UGA Engineering)

This project set out to create a product that could measure an animal's heart rate recovering from surgery. In contrast to traditional methods such as an EKG, our product is non-invasive and can be attached to the underside of an animal cage. To sample the data, we integrated an ESP32 and an internal measurement unit (IMU) sensor to collect data from a sleeping animal. Then, the data is sent via a Wi-Fi signal to a time series database called InfluxDB. Finally, we connected a graphical dashboard to display the data. After numerous tests, our device can detect the vibrations of a beating heart, but more work will be needed to see the exact heart rate and variability. While this product can be suitable for detecting the heart rate, we plan to adapt this project to implement a sleep posture tracker that will allow researchers to study a human's sleeping position.

Highly Sensitive and Robust Soft Capacitive Pressure Sensors

Student Presenter: Hanna Schlegel
Faculty Mentor: Tommaso Ranzani (ENG Mechanical Engineering)
Clare Booth Luce Award

Capacitive sensors have a simple design that take advantage of the electrical energy stored in an electric field that forms between two conductive plates acting as electrodes. The main problem faced by current soft sensors is their reduced sensitivity when under high stress loads. For this project, the dielectric material used between the two capacitor plates was manipulated to increase the dielectric constant to promote sensitivity even under high stress loads. To produce an optimal dielectric material, multiple recipes containing differing ratios of Ecoflex 00-30 (EF30), carbon black (CB) and sodium chloride granules (NaCl) were used. EF30 is a silicone commonly used in soft robotics and wearables, however it has a relatively low dielectric constant, making it a poor choice for the desired sensitivity. By adding sodium chloride to uncured EF30, allowing the silicone to cure and then dissolving the granules, I was left with a porous architecture with which capacitance sensitivity greatly increased. Adding CB, which is often used to strengthen rubber tires, into the uncured EF30 also led to a similar result of increased sensitivity. The greatest improvement in sensitivity, though, was found by reducing the dielectrics cross sectional area. As the sensors with a porous combination of EF30 and CB got thinner, I saw measurements that showed around 11 times more sensitivity. Through this project, I have manufactured a highly sensitive soft capacitive pressure sensor which I plan to integrate with wearable designs and other soft robotics surgical devices including an endovascular balloon.

Mapping the architectural differences of the extracellular matrix generated by senescent and normal cardiac fibroblasts.

Student Presenter: Varun Shah
Faculty Mentor: Jeroen Eyckmans (ENG Biomedical Engineering)
UROP Award

Doxorubicin is a powerful and highly effective anti-cancer drug prescribed to many patients. However, dose-dependent toxicity limits the usefulness of the treatment given that doxorubicin-induced cardiomyopathy claims a significant number of lives among cancer survivors every year. Although prior research has implicated detrimental changes in the nucleus and mitochondria of cardiomyocytes, understanding the exact mechanism of doxorubicin-induced cardiotoxicity and cardiac failure remains an open challenge. Generation of reactive oxygen species by doxorubicin is known to induce senescence in mammalian cells and the accumulation of these senescent cells over time can result in the remodeling of the extracellular matrix in the surrounding tissue. We hypothesize that the accumulation of doxorubicin-associated senescent cells leads to reorganization of the extracellular matrix and tissue in the surrounding regions of the heart, thereby compromising the mechanical and functional properties of the tissue. To investigate this, we developed an in vitro, 3D microtissue model using primary human cardiac fibroblasts. Micropillar devices were fabricated using polydimethylsiloxane (PDMS) and they seeded with normal or doxorubicin-treated cardiac fibroblasts embedded in a collagen-fibrin gel. The microtissues were then ablated using a pulsed, nanosecond laser, following which tissues were tracked using live microscopy. The microstructure and organization of the ECM were elucidated using immunofluorescence staining on a spinning disk confocal microscope. Unraveling the role of senescence in doxorubicin-induced cardiomyopathy may revolutionize post-treatment care, reduce animal testing reliance, and expand its relevance in regenerative studies.

Semi-Autonomous Driving of a Soft Robot for Bronchoscopy Procedures

Student Presenter: Armaan Vasowalla
Faculty Mentor: Sheila Russo (ENG Mechanical Engineering)
UROP Award

Lung cancer is the deadliest cancer due to difficulty in being able to biopsy lung tumors which generally form deep in the lung periphery. This project aims to reduce complications in bronchoscopy procedures with a soft robot that enables navigation into deeper sections of the lung through its millimeter-scale diameter. The robot has three functions within the lung: bend in one direction to steer, stabilize within a branch, and deploy a needle. The robot is autonomously driven from outside the lung by a stepper motor and Universal Robotics 5e Robot Arm, which allows it to traverse into the lung as well as rotate within the lung giving it full three-dimensional steering. An algorithm to control robot driving was developed to allow the robot to traverse the lung using a pre-programmed path as well as a camera to inform path correction as during the driving process. The manufacturing process of the soft robot was developed to consistently reduce impurities and air bubbles in the molding process resulting in an overall 2.5 mm diameter robot. The results from this summer will be used to inform the continued development of the system with an end goal of a working, semi-autonomous soft robotic bronchoscope.

Design and Implementation of Replaceable Shape Memory Alloy Artificial Muscles for Soft Robot Limbs

Student Presenter: Ilyoung Yang
Faculty Mentor: Andrew Sabelhaus (ENG Mechanical & Systems Engineering)
UROP Award

Soft robots have gained prominence for their inherent benefits in physical interaction with sensitive objects, particularly when using high-strength artificial muscles such as shape memory alloy (SMA) wires to create motion. However, these artificial muscles have a limited lifespan and therefore are impractical for prolonged use. This project presents an approach to address this challenge by introducing a modular design that allows removal and replacement of fatigued SMAs, quickly and reliably, without affecting the soft robot limb's performance characteristics. The proposed solution uses a module, constructed from silicone rubber cast in a 3D-printed mold, to which an SMA is attached on both ends and slides into an existing design. In this method, the robot's body is preserved and does not need to be remanufactured each time a muscle replacement occurs. Prototypes and tests show that SMA wires in this design can be replaced within a 5-minute timeframe, a stark contrast with prior processes that typically span several days to a week. With this ability to separate the actuation method from the soft robot limb, mechanical failure or damage to the SMA artificial muscles is no longer a hindrance to implementing soft robotic limbs in autonomous interaction with the environment.

Classifying Brainstem Cells That Receive Motor Cortex Input

Student Presenter: Anne Marie Zambon
Faculty Mentor: Michael Economo (ENG Biomedical engineering)
UROP Award

Although both are responsible for motor control, the motor cortex (MCtx) and brainstem perform distinct functions. For example, MCtx is involved in planning movements, while brainstem executes lower-level functions like breathing. To carry out planned movements, the MCtx sends signals to the brainstem via synaptic connections, but the specific cell types in the brainstem that receive this input are unknown. By delivering an anterograde transsynaptic virus into the ALM of the MCtx, we were able to label cells in the brainstem that receive synaptic input from the MCtx with GFP. To identify the brainstem cell types labeled in these experiments, we performed multiplexed fluorescence in situ hybridization (mFISH) to visualize the RNA expressed by these cells. We carried out multiple rounds of mFISH to label the transcripts of 12 genes, and used image registration to align the images. We then employed machine learning models to segment each cell, and to annotate each cell as expressing or not expressing each mFISH-labeled gene. By knowing the expression patterns across the, we were able to classify our mFISH-labeled cells into transcriptomic types. This allowed us to test the hypothesis whether there are distinct cell types receiving motor cortex input.

Photothermal Spectroscopy for Characterization of Phase Transitions in Smart Materials at Submicron Scale

Student Presenter: Yiwen Zhang
Faculty Mentor: Michelle Sander (ENG Electrical and Computer Engineering, Biomedical Engineering)
UROP Award

Characterization of thermoresponsive polymers in time and space is essential for designing high- level controlled drug delivery and for evaluating the efficacy of translational synthetic biomaterials. Yet, to consistently monitor the volumetric phase transitions in polymers with respect to external stimuli remains a challenge due to spatial and spectral limitations in imaging techniques. Here, we demonstrate a label-free mid-infrared photothermal spectroscopy system for chemical identification based on inherent vibrational bond signatures on poly (N-isopropylacrylamide) (PNIPAM) thin films. The system consists of a quantum cascade laser that targets the vibrational resonances and a near-infrared (980 nm) diode laser probe. In combination with boxcar measurements, photothermal spectroscopy can depict structural heterogeneities inside the film at submicron spatial resolution and can capture transient thermal profiles of polymer films at different timescales. Our work shows that photothermal spectroscopy can capture PNIPAM gels' properties including phase, structure and thermal diffusion properties. This can be relevant for photothermally induced stimuli that can trigger drug binding and release in hydrogel at low baseline to enhance the accuracy and efficiency of drug delivery in a controllable manner.

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