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**CrowdSearch, A better way to view how long a wait is on campus**

**David Kraus**, Computer Science, **Aidan LeBlanc**, Computer Science, **Ryan Lin**, Computer Science, **Ope Abegunde**, Computer Science

This project aims to develop a web application that enables users to report and view real-time crowd levels across the university campus. With the increasing need for efficient space utilization and the failings of previous systems, this system provides a solution to help students and faculty make informed decisions about navigating campus spaces.
Previous studies have explored various crowd-monitoring techniques, often relying on sensor-based or camera-based systems. However, user-reported data offers a cost-effective and privacy-conscious alternative. Our project builds on existing crowd-sourcing models by integrating real-time reporting with a user-friendly interface designed for campus environments.
The application is developed using a full-stack web framework, incorporating frontend technologies for intuitive user interaction and a backend for data management. Users can submit crowd level reports, which are aggregated and displayed on a campus map. The system employs data validation techniques to mitigate inaccurate reports and optimize reliability. Future enhancements may include machine learning models to predict crowd trends.
We anticipate that this application will enhance campus mobility and resource planning by providing a real-time crowd monitoring tool. The project has potential applications beyond the university setting, including large public events and urban planning initiatives.

Faculty Project Mentor: Shuai Xu, Department of Computer and Data Sciences

Capstone Instructor: Shuai Xu, Department of Computer and Data Sciences

**Redesigned Vaccine Carrier: Minimizing Cold Chain Disruption in Rural Uganda**

**Menaka Wijeratne**, Biomedical Engineering; **Riddhi Srinivasan**, Mechanical Engineering; **Layasri Ranjith**, Biomedical Engineering; **Samuel Haugen**, Biomedical Engineering; **Anushka Abhilash**, Biomedical Engineering; **Ann Shen**, Biomedical Engineering; **Jordan Gray**, Engineering Physics; **Andre Lozano**, Biomedical Engineering; **Krupa Venkatesan**, Biomedical Engineering; **Sruthi Potluri**, Cognitive Science; **Ratchana Ramesh Pandi**, Biochemistry; **Elmaz Abliazova**, Biomedical Engineering; **Aarushi Jain**, Biomedical Engineering; **Sharvi Agrawal**, Cognitive Science; **Mau Koishida**, Biomedical Engineering; Dr. Andrew Rollins, Department of Biomedical Engineering; Dr. Janet McGrath, Department of Anthropology

Currently, only 55% of Ugandan children are fully vaccinated by the age of 2 (BMC Health Services Research) against vaccine preventable diseases. The World Health Organization (WHO) has committed to tackling this deficiency through investing in healthcare outreach campaigns and supporting volunteer organizations, but fieldwork and collaboration with Makerere University (Kampala, Uganda) have demonstrated that the "last-mile" of vaccine delivery remains a significant challenge. The journey of transporting vaccines for outreach services in rural areas can be difficult due to poor infrastructure which leaves vaccines susceptible to the elements and human error - which currently available systems do not commonly address. The vaccine carrier that has been developed by the CWRU-Makerere collaboration addresses the three main limitations of currently-available vaccine carriers: (1) when opened, the carrier exposes all the vaccines at once to heat; (2) it has no effective mechanism for healthcare workers to periodically determine the temperature and thus the efficacy of the vaccines without opening the carrier; (3) it lacks effective organizational methods to prevent vials from breaking during transportation, and efficiency in retrieving vials from within the carrier. Via thermal modeling and literature reviews, the CWRU model has been designed with novel inclusions of silicone-lined racks, an insulated workstation, magnetic closures and a solar-powered external temperature readout. These features minimize human error and outside factors' impacts on vaccine delivery, improve hygienic delivery, and maximize ease of access for healthcare workers.

Faculty Mentor: Dr. Andrew Rollins, Department of Biomedical Engineering

## FootSafe Wheelchair Sensor System

**Kai Abitbol-Pierce**, Electrical Engineering

Persons with SCI who lack sensation of limb position are at risk for serious injury when driving power wheelchairs (PWCs) if their lower limbs become mispositioned. To prevent these avoidable lower limb injuries, we developed a real-time foot position sensor system to be used with a user alerting smartphone app. The system, called FootSafe, consists of an array of force and infrared distance sensors to measure the foot pressure on the footplate, and foot position in 3D space above the footplate. The collection of this data is coordinated by a microcontroller and processed by a foot detection algorithm which determines when the foot is in an unsafe location. This allows the user to be alerted when they need to reposition their feet to prevent injury.

Project Mentor: Dr. Mary Kristina Henzel (dept of Spinal Cord Injury, VA Medical Center),
Capstone Instructor: Dr. Steve Majerus

**Solvation Dynamics in Choline Chloride-Based DESs with Nile Red Spectroscopy**

**Haya Abusafieh**, Department of Chemistry; **Rathiesh Pandian**, Department of Chemistry; **Clemens Burda**, Department of Chemistry

In recent years, deep eutectic solvents (DESs) have gained widespread attention due to their unique physicochemical properties, making them a promising alternative to conventional organic solvents and ionic liquids. Their low volatility, high thermal stability, and environmentally benign nature distinguish them from traditional solvents, offering potential applications in green chemistry. Understanding the chemical properties and solute-solvent interactions of DESs is crucial for assessing their viability in industrial and laboratory settings. In this study, various common industrial solvents were combined with choline chloride, which served as the hydrogen bond acceptor, to form DES mixtures. To evaluate the polarity of these DESs, Nile Red, a solvatochromic dye sensitive to changes in solvent polarity, was employed as a fluorescent probe. Using UV-visible spectroscopy and fluorescence spectroscopy, this study aimed to enhance the understanding of how DESs interact with solutes at a molecular level, contributing to the broader effort of developing sustainable solvent systems for industrial applications.

Project Mentor: Dr. Clemens Burda, Department of Chemistry

Capstone Mentor: Dr. Drew Meyer, Department of Chemistry

**Open-Source Accessible 3D Force-Feedback Haptic Interface**

**Luke Adelman**, Engineering Physics; **Arimael Avalos**, Electrical Engineering; **Kurt Drath**, Electrical Engineering

Haptic interfaces that combine a force-feedback device with real-time simulation software have wide-ranging commercial, amateur, and research applications. Currently available 3D force-feedback haptic interfaces are high-cost and use proprietary software, forming a large barrier of entry for new developers of haptic applications. The few open-source haptic devices that attempt to reduce this barrier are one dimensional or are poorly documented, making them inaccessible for potential new developers that do not have a strong technical background or adequate amount of time to develop their own force-feedback robot. In this project we designed an open-source and accessible 3D force feedback haptic interface. The interface consists of a delta-parallel mechanism with motors to provide 3D force-feedback and a software driver to connect the device control firmware to simulation software on a user computer. Our approach is based on the 3D Hapkit, an open-source project from Johns Hopkins which combines three one-dimensional Hapkits, a device designed at Stanford. While the design is viable, the 3D Hapkit comprises accessibility and precision. It requires custom PCBs that are discontinued and a high-end 3D printer for hardware components. In combining the three Hapkits, their design includes redundant components and artifacts that slow down the control system. Our design focuses on improving the weak points of this design, including faster processing with a dual-core microcontroller, increased durability and manufacturability with component redesigns, and reduced cost by using off the shelf parts accessible to any interested hobbyist. Our biggest new addition is a software driver interface between our physical device and an open-source physics simulator, Chai3D. We constructed our haptic device and tested it with several force-feedback demo simulations. We provide design files, a parts list, manufacturing and assembly instructions, and software documentation to enable new developers to construct their own haptic interface and easily develop new simulations.

Project Advisor: Zonghe Chua, PhD, Assistant Professor, Department of Electrical, Computer and Systems Engineering, Case School of Engineering

Capstone Instructor: Gregory Lee, PhD, Assistant Professor, Department of Electrical, Computer, and Systems Engineering, Case School of Engineering

**Reassessing the effectiveness of Water Fluoridation in an increasingly skeptical public**

**Sam Lathrop,** Economics and Business Management**; Mitch Adkins**, Economics

With growing skepticism about man-made substances and added “chemicals” in consumer products, fluoride has become a topic of controversy. The public health policy that introduced water fluoridation nearly a century ago aimed to reduce childhood cavities, but its effectiveness has recently been questioned. This study evaluates the impact of water fluoridation on childhood cavity rates to determine whether these policies remain beneficial. Using panel data and state and time fixed effects to control for time-invariant state characteristics, we analyze the relationship between fluoridation rates and childhood cavity prevalence. We hypothesize that higher fluoridation rates are associated with significantly lower childhood cavity rates, indicating a strong negative correlation. Based on our research, previous findings support this hypothesis showing that water fluoridation remains an effective public health measure for preventing cavities in children. The results indicate that current fluoride policies are achieving their intended goals and should remain in place unless new, compelling evidence suggests otherwise. Calls to remove fluoride from public water systems should be carefully examined in light of this data. Local governments making decisions about water fluoridation should consider our findings alongside existing research before altering policies. Removing fluoride without strong scientific justification could lead to unintended public health consequences, particularly for low-income communities with limited access to dental care. We encourage policymakers to rely on robust, evidence-based research when making decisions regarding fluoride regulation. Additionally, we urge the scientific community to critically evaluate the broader implications before recommending the removal of fluoride from public water supplies. As new research emerges, continued assessment of fluoridation’s effectiveness will be necessary to ensure that public health policies are guided by science rather than public misconceptions.

Project Mentor: Professor Mark Schweitzer, Department of Economics

**Determining the Monosynaptic Inputs of Respiratory Thoracic Motor Neurons**

**Aambar Agarwal**, Neuroscience and Psychology; **Minshan Lin**, Department of Neurosciences; Dr. Polyxeni Philippidou, Department of Neurosciences

Breathing is a critical process for life. A population of thoracic motor neurons (MNs) innervate the intercostal muscles, which facilitate breathing. However, the inputs that drive thoracic MN activation are largely unknown. This project will map neuronal populations that directly project to respiratory thoracic MNs in mice. To determine these inputs, an mCherry-tagged rabies-based tracing strategy was used to label the monosynaptic inputs of thoracic MNs that innervate the intercostal muscles of mice. Brainstems and spinal cords were sectioned and stained for Choline Acetyltransferase (ChAT), which labels MNs, and GABA and glycine, which are inhibitory neurotransmitters, via immunofluorescence to identify inputs and classify them into inhibitory and excitatory. Sections with mCherry-positive cells were quantified using the software Imaris. These results will define the location, distribution, and identity of thoracic MN monosynaptic inputs and provide insights into the pathways driving respiration in mammals.

Project Mentor: Dr. Polyxeni Philippidou, Department of Neurosciences

Capstone Instructor: Dr. Ashley Nemes, Department of Neurosciences

**Through the Eyes of the Exiled: How Miguel Ángel Asturias's Work has Shined Light on Crimes Against His People**

**Carlos Aguilar Castaneda**, Chemistry and Spanish

Miguel Ángel Asturias, Guatemalan writer and Nobel Literature Prize Laureate, is celebrated for his powerful depictions of injustice. It is through his literary work that he has shined light on multiple problems in his community. From political oppression to indigenous identity, Asturias was very outspoken on the wrong doings against "su pueblo". It was due to his opposition to the authoritarian period in Guatemala that he was exiled, which then influenced his literary works. We see his presentation of such themes through his novels *Hombres de Maíz* (1949) and *El Señor Presidente* (1946). These novels reflect examples of the exploitation of the Mayan indigenous community as well as the political dictatorship respectively. Additionally, his short stories like *Leyendas de Guatemala* (1930) and *Week-end en Guatemala* (1959) have also shown impactful moments of such themes.

In his time in exile, Asturias exchanged ideas with other Latin American authors such as Pablo Neruda, Gabriel García Marquez, and Alejo Carpentier, heavily influencing their works.. Simultaneously, we see Asturias influence on the Latin American Boom through his stories, contributing to Magical Realism. His use of fusion using myths of the Mayan community with politics allowed for a new way to examine themes of oppression and identity in the same literary work.

It is through analysis of his work and his relationships with other Latin American authors that we are able to see the presentation of such legacy and how his works of art shine light on the crimes against people through indigenous exploitation and political oppression. His exile only deepened his commitment to writing for his people, leaving a positive mark on Latin American literature.

Project Mentor: Jacqueline Nanfito, Department of Modern Languages & Literature

**ClosetAI: An Outfit Recommendation iOS App**

**Teddy Bryant** Computer Science, **Kani Ahmed** Computer Science, **Ved Arora** Data Science and Analytics, **Montgomarie Essex** Computer Science, **Zachary Greenberg** Computer Science **Daniel Kelly** Computer Science, **Joseph Rhodes** Computer Science, **Dominic Sais** Computer Science

Choosing an outfit can be time-consuming and often frustrating, especially when navigating evolving fashion trends, dress codes, and social expectations. To simplify this process, we developed *ClosetAI*, an iOS application that leverages artificial intelligence to help users effortlessly curate stylish and appropriate outfits. Our system allows users to upload images of their clothing which are then analyzed through AI-driven classification. The app identifies colors, patterns, and clothing categories, creating a structured digital wardrobe. Our algorithms then generate personalized outfit recommendations based on factors such as formality, weather conditions, and individual style preferences. *ClosetAI* also provides users with insights into their style preferences and wardrobe utilization through data analytics, helping them identify their most worn pieces, overlooked items, and potential additions to enhance their wardrobe. By integrating AI-powered image recognition and recommendation systems, *ClosetAI* bridges the gap between fashion expertise and everyday convenience. *ClosetAI* explores the application of machine learning in personal styling, demonstrating AI's potential to enhance fashion accessibility.

Project Mentor: Shuai Xu, Computer and Data Sciences

Capstone Advisor: Shuai Xu, Computer and Data Sciences

## Infrared Absorption Sensor for Gas Application

**Liban Ahmed**, Electrical Engineering with a focus on Circuits; **Trang Nguyen**, Electrical Engineering and System and Controls Engineering

Infrared (IR) sensing technology provides a non-contact method for detecting gas concentrations in the environment. This project uses a thermopile sensor to measure $CO_2$ levels by analyzing infrared absorption patterns. The thermopile sensor converts incident infrared radiation into a voltage proportional to the temperature difference between its hot and cold junctions. A decrease in voltage indicates less infrared light reaching the sensor, which results from $CO_2$ absorption. Traditional $CO_2$ sensors often rely on nondispersive infrared (NDIR) technology, which can be costly and require frequent calibration. This project explores an alternative approach using a thermopile sensor to detect $CO_2$ absorption at 4.26 μm, applying the Beer-Lambert Law to estimate gas concentration. If successful, this method could provide a more accessible and energy-efficient solution for air quality monitoring. To accurately monitor gas concentration, the chosen infrared source emits at the appropriate wavelength and intensity to ensure reliable absorption measurements. Given the low voltage output of the thermopile, an instrumentation amplifier is employed to enhance sensitivity. The processed data is then analyzed to track $CO_2$ variations over time, providing insights into air quality dynamics. This project aims to develop an efficient, low-cost, and portable solution for environmental monitoring in enclosed spaces.

Faculty Project Mentor: Daniel G.Saab, Department of Electrical, Computer, and Systems Engineering.

Capstone Instructor: Gregory Lee, Department of Electrical, Computer, and Systems Engineering.

## Applying a Plasma-Activated Silver Salt Ink to Aerosol Jet Printing

**William Chang,** Department of Chemical Engineering; **Tauheed Ahmed,** Department of Biomedical Engineering; **Christian Zorman**, Department of Electrical, Computer, and Systems Engineering; **Allison Hess-Dunning**, Department of Biomedical Engineering, VA Northeast Ohio Healthcare System; **Janet L. Gbur**, Department of Materials Science and Engineering

Additive manufacturing is a promising method for fabricating conductive sensors in medical applications, primarily due to their ability to print on flexible and uneven substrates. Inkjet printing (IJP) and aerosol jet printing (AJP) are non-contact additive manufacturing methods capable of large-scale manufacturing of metal electrodes. However, common inks that utilize IJP and AJP contain metal nanoparticles that require thermal curing to remove solvents and sinter the particles, limiting compatibility with low temperature substrates and inhibiting sensor sensitivity. It was shown previously that a silver salt ink composed of $AgNO_3$, ethylene glycol, and DI water printed with IJP can use a plasma reduction process instead of thermal curing. Low pressure plasma reduction converts Ag+ ions to Ag, forming a solid film while subjecting prints to less intensive temperatures and producing viable sensitivities to $H_2O_2$. However, it was found that the conversion is limited by print thickness, compromising print adhesion to the substrate. There is potential for more sophisticated sensors to be developed using AJP, which offers greater print resolution in thickness over IJP.

This project utilizes AJP and plasma activation to apply the silver salt ink from the previous study to a polyimide substrate in the form of dumbbell shaped circuits. The goal is to model conductivity over print thickness. Our hypothesis is that as thickness of prints increase, the conductivity will also increase but will lead to a lower conversion of Ag proportionally. Each print was imaged using digital optical microscopy. A laser profilometer was used to characterize the thickness of the printed dumbbells. The print's resistance was characterized with the four-point probe technique. Future work will involve identifying and maximizing the proportion of Ag in prints while within a desired conductivity range.

Project mentors: Dr. Janet L. Gbur, Department of Materials Science and Engineering, Dr. Allison Hess-Dunning, Department of Biomedical Engineering

**Plasmonic Enhancement of Photothermal Conversion Efficiency in Gold-Nanoparticle Hydrogels**

**Mai S. Rashwan**, Chemistry; **Abed M. Al-Sheikh**, Chemistry; **Harihara Baskaran**, Chemical & Biomolecular Engineering; Clemens Burda, Chemistry

This study explores the enhanced photothermal conversion efficiency exhibited by citrate-capped gold nanoparticles (Au NPs) dispersed within an agarose gel matrix; various concentrations (0.2–2.5 nM) and sizes (6 nm, 14 nm, and 48 nm) of Au NPs were examined. Agarose, a biocompatible hydrogel, was utilized due to its ability to optimize uniformity of nanoparticles, eliminate agglomeration, and help stabilize the heat transfer properties of the system. To investigate the heat transfer behavior within these Au NP hydrogels, 785 nm laser-light-induced heating experiments were conducted. The results revealed a size- and concentration-dependent temperature increase compared to the plain gel. Our findings demonstrated that Au NP hydrogels exhibited a significant increase in the photothermal heating performance, particularly with larger-sized Au NPs and higher concentrations. As confirmed by absorption measurements, this effect was attributed to the plasmonic absorption of Au NPs and Mie scattering within the hydrogel network. Experimental measurements, combined with finite-element analysis simulations, further confirmed that the photothermal conversion efficiency of the Au NP hydrogels was primarily influenced by nanoparticle size and concentration. Thermal conductivity (TC) measurements of Au NP hydrogels remained constant across the tested concentration range. These findings highlight the potential for optimizing photothermal conversion efficiency in energy-related applications, such as solar cells, or biomedical nanomaterials to help improve laser-precision and efficacy in targeted radiosurgical therapies.

Faculty Mentor: Clemens Burda, Department of Chemistry

## Investigating Neutrino Mass Using Cyclotron Radiation Emission Spectroscopy

**Almuqtada Alyasiri,** Physics and Mathematics

Neutrinos, among the most abundant yet elusive particles in the universe, play a crucial role in fundamental physics. Their small but nonzero mass has profound implications for our understanding of the Standard Model, cosmology, and astrophysics. Project 8 is an international collaboration employing Cyclotron Radiation Emission Spectroscopy (CRES) to achieve a direct and precise measurement of the neutrino mass. The project is currently in Phase III, with the final Phase IV aiming for a mass sensitivity of approximately 40 meV through the use of atomic tritium. My role in Project 8 focused on developing and implementing a bead-pulling system to test the resonance properties of the caterpillar cavities, which are integral to CRES measurements. This system allows for precise characterization of cavity performance, ensuring readiness for high-precision electron energy measurements in Phase IV. The bead-pulling system consists of a motorized apparatus designed to move a dielectric bead through the cavity while analyzing frequency shifts using a Vector Network Analyzer (VNA). By integrating Arduino-based controls, I will automate data collection, improve measurement accuracy, and explore potential optimizations for future experimental setups. This research experience has provided me with valuable skills in experimental physics, and instrumentation. By contributing to the advancement of neutrino mass measurements, this work supports broader scientific endeavors, including neutrino oscillation studies and the search for physics beyond the Standard Model.

Faculty Project Mentor: Dr. Benjamin Monreal, Department of Physics

## Exploring Gun Culture in Cleveland and Increasing Rates of Youth Violence: A Literature Review

**Gabriella Alba**, Anthropology

This literature review examines the relationship between gun culture and youth homicide rates (ages 15–24) in Cleveland, a city currently experiencing a surge in firearm-related youth violence. By synthesizing existing research, this review explores how gun culture manifests in urban settings and its potential role in shaping youth experiences with violence. Additionally, it investigates the systemic factors—such as structural inequality, socioeconomic disparities, and institutional failures—that contribute to this crisis, disproportionately affecting Black communities. While prior research has examined gun culture broadly, there remains a gap in understanding its impact on youth of color in urban environments. This review aims to bridge that gap, offering a deeper analysis of how systemic violence and unmet basic needs may be fueling youth involvement in gun-related homicides. Furthermore, it explores potential solutions to address this crisis in Cleveland, emphasizing trauma-informed practices and community-driven initiatives that provide resources to alleviate systemic injustices.

Faculty Project Mentor: Sharon Milligan, Social Work, Mandel School of Applied Social Sciences

Capstone Instructor: Sharon Milligan, Social Work, Mandel School of Applied Social Sciences

**Comparison of the Effects of Plasminogen Activator Inhibitor-1–Specific DNA and RNA Aptamers on Cell Adhesion**

**Hamza Ali, Biology;** Dr. Khalequz Zaman; Dr. Yolanda Fortenberry

The serine protease inhibitor plasminogen activator inhibitor-1 (PAI-1) plays a vital role in the regulation of both cell adhesion and migration through its interaction with the extracellular matrix protein vitronectin. PAI-1 prevents integrin-mediated cell attachment to vitronectin, thereby inhibiting cell adhesion and migration which are key processes in vascular remodeling and disease progression. Increased levels of PAI-1 are correlated with pathological conditions such as atherosclerosis and restenosis, where impaired smooth muscle and endothelial cell function accelerates vascular dysfunction. Previous research has demonstrated that RNA aptamers (WT15 and SM20) targeting PAI-1 can bind near its vitronectin-binding site and prevent PAI-1 from disrupting the integrin-vitronectin interactions, which ended up leading to increased cell adhesion. In the current study, we aim to investigate whether a DNA aptamer version of WT15 exhibits similar biological effects in a cell adhesion assay using human umbilical vein endothelial cells (HUVECs). Cells were seeded onto vitronectin-coated plates to promote adhesion, followed by the addition of PAI-1 to disrupt this interaction. DNA aptamer WT15 was added alongside PAI-1 in experimental groups to assess its ability to preserve cellular adhesion.Compared to RNA aptamers, DNA aptamers have previously been found to be advantageous through increased stability and easier synthesis. Considering this, they may indeed serve as a more practical or effective alternative for therapeutic applications. We hypothesize that the DNA aptamer WT15 will restore HUVEC adhesion to vitronectin in the presence of PAI-1, similar to its RNA counterpart, in a dose-dependent manner. If confirmed, these results would support the feasibility of DNA aptamers as viable tools for mitigating the pathological effects of elevated PAI-1 levels in vascular diseases. Preliminary results are inconclusive, but continuation of the procedure with more DMSO usage to better dissolve crystals in the MTT assay could provide a new set of data that supports the hypothesis.

Faculty Project Mentor: Dr. Yolanda Fortenberry, Department of Biology

Capstone Instructor: Dr. Yolanda Fortenberry, Department of Biology

**From Quantum Gyroscopes to Quantum memories : Relaxation dynamics of strongly-coupled nuclear spins**

**Omar Ali**, Physics

We study the role of system-environment interaction symmetry in modulating relaxation dynamics of nuclear spins that are strongly-coupled to an environmental electronic spin via the hyperfine interaction via a qubit-fluctuator model. We highlight how a competition between the longitudinal and transverse components of the hyperfine coupling modulates the induced nuclear relaxation dynamics, revealing a parameter regime where the polarization lifetime of nuclear spins is significantly longer than the electronic relaxation lifetime despite their strong coupling. In this regime, a relatively strong longitudinal (secular) coupling, which leads to rapid dephasing of coherences of individual nuclear spins, makes the induced relaxation lifetime of nuclear spins longer as if it were weakly coupled to its electronic environment, despite the interaction strength being much larger than the nuclear spin energy splitting. We discuss two applications of the discussed model. The first is predicting the relaxation lifetime of a nuclear spin coupled to NV-center under a rotating magnetic field in a proposed quantum rotation sensing protocol. In the second one, we show how such a strong longitudinal coupling can protect coherences in two-spin collective dephasing Decoherence-Free-Subspace (DFS) by suppressing other modes of decoherence that the collective-dephasing subspace is not robust against

Project Mentor: Paola Cappellaro, Research Laboratory of Electronics, Massachusetts Institute of Technology

## RoomMe

**Addison Miller,** Music and Computer Science; **Amir Aliyu,** Computer Science; **Chaehyeon Kim.** Music and Computer Science, **Yashaira Longras,** Computer Science

RoomMe is an online platform that connects CWRU residential communities, dormitories, and roomates. We observed a lack of convenient communication for larger residential communities, complicating community announcements, coordination of events, etc. Creating a centralized platform for communication and coordination of chores, events, grocery lists, etc. could prove useful for the CWRU community. The app has two main components: the frontend and the backend. We used React as the primary frontend framework and NodeJS for the backend server logic. MongoDB, a no-SQL database, is used for storing user and community data. The backend serves pages to the frontend, which is rendered by the browser. We deployed the application using heroku and allow users to log in with their CWRU SSO information.

Faculty Project Mentor: Shuai Xu, Department of Computer and Data Sciences

Capstone Instructor: Shuai Xu, Department of Computer and Data Sciences

**A Two-Cohort Assessment of the Nord Family ESP Summer Bridge Program: A Focus on Success Skills and Sense of Belonging**

**Manal Alkabani**, Psychological Sciences; **Dave Ki**, Psychological Sciences; Dr. Rita Obeid, Department of Psychological Sciences; Arthur Evenchik, Office of the Dean of the College of Arts and Sciences; and Dr. Stephen E. Haynesworth, Department of Biology

Summer bridge programs across the U.S. have been shown to be effective in helping college students from underrepresented and minoritized backgrounds prepare for college. The Nord Family Emerging Scholars Program (Nord Family ESP) at Case Western Reserve University (CWRU)[1] [2] [3] [4] , which provides academic support and advising to students who have graduated from under-resourced high schools, has conducted an annual summer bridge program since 2011. Originally designed for commuters, the bridge program added a residential component in 2023.

This research evaluated the impact of the 2023 and 2024 Nord Family ESP summer bridge programs (n = 18) on students' sense of belonging and success skills, such as collaborative study and time management.

A mixed methods research design was used, combining quantitative surveys and qualitative interviews. Comparisons of pre-test and post-test quantitative data showed significant improvements in several areas, including sense of belonging and time management skills. Similarly, qualitative interviews revealed improvements in students' success skills, sense of belonging to CWRU, and understanding of college life.[5] [6] Overall, the findings align with previous research demonstrating the benefits of summer bridge programs in promoting student success in higher education.

Project Mentor: Dr. Rita Obeid, Department of Psychological Sciences,

Capstone Mentor: Dr. Rita Obeid, Department of Psychological Sciences
Faculty Sponsor: Dr. Stephen Haynesworth, Department of Biology

## Analysis of Soleus H-Reflex and Impairment in Post-Stroke Individuals

**Sandra Allen-Fernandez**, Biomedical Engineering

Every year about 795,000 people in the United States have a stroke. Individuals who survive often experience chronic motor impairments, such as changes in gait, difficulty with coordination, and muscle weakness and/or stiffness. One common condition post-stroke is hyperreflexia, a component of spasticity defined by exaggerated muscle stretch reflexes. Clinically, spasticity is tested for using the Modified Ashworth Scale (MAS) where clinicians subjectively rate resistance to movement on a standardized scale. Within research, hyperreflexia can be measured quantitatively using reflexes evoked by peripheral nerve stimulation with responses measured using electromyography (EMG). A commonly used method to perform this is Hoffman's reflex (H-reflex), the electric analog to the tendon jerk reflex. Previous research indicates that an exaggerated or increased H-reflex magnitude corresponds with a higher severity of hyperreflexia. The goal of the study was to determine if H-reflex magnitude is related to other clinical measures of impairment within people with post-stroke gait impairments. This study uses H-reflex data collected from the soleus muscle of 17 participants. The soleus H-reflex was elicited using transcutaneous electrical stimulation of the tibial nerve. The raw EMG data was filtered in MATLAB using signal processing techniques to extract the maximal H-reflex peak-to-peak amplitude. Values from each participant were then correlated to clinical measures including gait speed and hyperreflexia severity. Results from this study will provide insight into the relationship between soleus hyperreflexia and functional ability.

Faculty Project Mentor: Dr. James Sulzer, Department of Physical Medicine and Rehabilitation

## Hereditary Breast and Ovarian Cancer in Marginalized Communities

**Lisbeth Almonte,** Biology

Hereditary Breast and Ovarian Cancer (HBOC) is caused by mutations in the BRCA1 and BRCA2 genes, which play an important role in DNA repair. While these mutations increase the risk of breast and ovarian cancers, their impact extends beyond genetic susceptibility, contributing to healthcare disparities that disproportionately affect marginalized populations. Despite similar mutation rates across racial and ethnic groups, disparities in diagnosis, treatment access, and survival outcomes persist, particularly for Black and Hispanic women. These populations often experience delayed diagnoses, lack of access to genetic counseling and testing, and inadequate healthcare resources, making it harder to get timely care. Additionally, the financial burden of genetic testing and the lack of culturally competent healthcare providers make these inequalities even worse. New treatments/ therapies like PARP inhibitors and liquid biopsies could help with treatment and early detection, but making them available (equitable) to everyone is a challenge. This review highlights the need for fair healthcare, including better access to genetic counseling, testing, and treatments for underrepresented groups. It also stresses the importance of diverse clinical trials to create treatments that work for everyone. Ultimately, to address and reduce the healthe care gaps in HBOC, we need policy changes, better community education, and more funding for research focused on minorities, with the goal of closing the gap in cancer care and survival outcomes.

Faculty Project Mentor: Nancy Dilulio, Department of Biology

**Review of Antimicrobial Mechanisms of Small Molecules Against Uropathogenic Escherichia coli**

**Isabela Alvarez Harris**, Chemical Biology

Uropathogenic Escherichia coli (UPEC) is a leading cause of urinary tract infections (UTIs), particularly due to its ability to form biofilms and enter a quiescent state. Quiescent UPEC cells, often in the form of persisters, are metabolically inactive but capable of reactivating. Quiescence makes treatment challenging as dormant bacteria cannot be eradicated by antibiotics that target biosynthetic processes. This literature review investigates the antimicrobial mechanisms of small molecules that target UPEC's quiescent forms, aiming to identify strategies for combating UPEC's persistent and dormant populations.Three categories of molecules will be reviewed: amino acids, clinically approved pharmaceuticals, and phytochemicals. The review explores different mechanisms employed by the small molecules in this category against UPEC, including biofilm inhibition, oxidative stress induction, metabolic reactivation, and disruption of key cellular processes such as iron metabolism and membrane integrity. The synthesis of this information may provide insights into potential therapeutic strategies, including reactivating quiescent UPEC cells to make them more susceptible to conventional antibiotics or inhibiting the biofilm formation that supports their dormancy. While conclusive results regarding their combined effects are still under investigation, the review highlights their promise as components of future treatment regimens for persistent UPEC infections.

Faculty Project Mentor: Dr. Matthew Bertin, Department of Chemistry

Capstone Instructor: Dr. Matthew Bertin, Department of Chemistry

**The Host Ranges of a biofilm-tropic Pseudomonas aeruginosa bacteriophage**

**Amani Alvi**, Sociology

Pseudomonas aeruginosa is responsible for 10% to 20% of hospital-acquired infections. These infections are challenging to treat via antibiotics due to its ability to form protective multicellular clusters known as biofilms. We have previously discovered that the exopolysaccharide Psl plays a crucial role in biofilm matrix formation and is also required for infection by the P . aeruginosa bacteriophage Clew-1. In this study, we aim to determine the host range of Clew-1 across 96 strains of P . aeruginosa using biofilm assays and fluorescent live/dead staining. By evaluating Clew-1's ability to infect diverse strains, we seek to assess its potential as a therapeutic agent against biofilm-associated infections. Understanding Clew-1's host range and its impact on biofilm formation may offer valuable insights for developing bacteriophage-based treatments to combat antibiotic-resistant P .aeruginosa infections.

Project Mentor: Dr. Arne Riestch, Microbiology

**Evaluating the affinity of GluK2 and APP containing synaptic complexes**

**Sara Albergaria**, Neuroscience and Dance; Dr. Nami Tajima, Department of Physiology and Biophysics

Kainate receptors (KARs) are ionotropic glutamate receptors widely expressed in the brain. They play key roles at synapses, including mediating excitatory synaptic transmission, modulating synaptic excitability, and regulating presynaptic neurotransmitter release. Overall KARs help maintain the balance between excitation and inhibition, and contribute to synaptic plasticity, influencing processes such as long-term potentiation (LTP) and long-term depression (LTD).
KAR subtypes vary depending on subunit composition, anatomical location, and developmental stage. Furthermore, they interact with multiple auxiliary and modulatory proteins at synapses, which influence their function and regulation. Dysfunctional KAR signaling has been implicated in neurodevelopmental disorders, epilepsy, and neurodegenerative diseases, making them potential therapeutic targets. Recent studies have identified an interaction between amyloid precursor protein (APP) and KARs, which may mediate pre- and postsynaptic associations. Given APP's critical role in Alzheimer's disease (AD), understanding APP-KAR interactions could provide insights into the molecular mechanisms underlying synaptic dysfunction in AD and aid in drug development. This project aims to characterize the detailed interactions between APP and KARs. To achieve this, I co-expressed recombinant proteins in HEK293 cells, purified the complex using affinity chromatography, and analyzed complex formation using Western blotting, native SDS-PAGE, and biophysical techniques. These analyses demonstrated the direct, high-affinity interaction between APP and KARs.

Project Mentor: Dr. Nami Tajima, Department of Physiology and Biophysics

Capstone Instructor: Dr. David Friel, Department of Neurosciences

**Effects of Social Media Engagement on Political Polarization Across Age Groups**

**Nikki Amir Dastmalchi**, Economics, Biology; **Suhani Nog,** Economics

Social media has become a battleground for political discourse, with concerns about its role in deepening ideological divides. From debates over a potential TikTok ban to past political controversies, digital platforms increasingly shape how we engage with politics. This study investigates the relationship between our independent variable of social media engagement and the dependent variable of political polarization across different age groups. We explore whether increased exposure to political content reinforces pre-existing beliefs or facilitates ideological shifts, and how they differ between generations. We are measuring political polarization through two models – the first using a self-reported scale, and the second using a composite measure to account for self-reporting bias. We are using data from the American National Election Study (ANES) Social Media surveys conducted pre- and post-2020 elections, as well as post-2022 midterms. The study uses an established online survey panel. Compared to previous literature, we analyze the impact and interaction of age groups in our data. Our research reveals that younger generations are more susceptible to social media influence, so we expect a greater shift in ideological extremity with increased engagement in those generations. We hypothesize that higher social media engagement is positively correlated with greater political polarization, with this effect differing by age group. The findings of this study have significant implications for understanding the role of social media in shaping political polarization across generations. If the results confirm that higher social media engagement is associated with greater political polarization, this would suggest that digital platforms may contribute to ideological entrenchment rather than fostering diverse political discourse. Such findings can inform policymakers and platform regulators on the need for interventions that promote exposure to diverse perspectives, such as algorithmic adjustments that counteract echo chambers or digital literacy initiatives aimed at improving critical engagement with online political content.

Project Mentor: Professor Jenny Hawkins, Department of Economics

**Investigating the stress response kinase DLK in the SOD1-G93A mouse model of neurodegenerative disease**

**Alisha Anand,** Neuroscience; Dr. Catherine Collins, Department of Neurosciences, CWRU School of Medicine

Dual Leucine Zipper Kinase (DLK) is a mitogen-activated protein kinase kinase kinase (MAP3K) that regulates neuronal stress responses. Through downstream signaling, DLK has been shown to have dichotomous roles in promoting circuit repair and axonal regeneration, while also causing neurodegeneration, synapse loss, and axonal degeneration. Interestingly, DLK has also been shown to promote neurodegeneration in amyotrophic lateral sclerosis (ALS) and Alzheimer's disease mouse models. However, limited understanding of activators and downstream effectors of DLK signaling has made it difficult to therapeutically target. Dysregulation of the autophagy pathway has been shown in ALS disease models, and preliminary observations have shown a potential relationship between autophagy and DLK. This project focuses on elucidating the relationship between DLK and autophagy within a mouse model of ALS disease. We used the transgenic $SOD1^{G93A}$ mouse model which was designed with a mutant human SOD1 gene and is driven by the endogenous human SOD1 promoter. SOD1 neurons exhibit phenotypes of autophagic stress, as measured by the autophagic proteins p62, gabarap, and lamp1. We asked whether the knockout of DLK in motor neurons altered these cellular phenotypes in any way. Here we show a decrease in p62 intensity with loss of DLK across disease conditions at both P30 and P120, suggesting that DLK signaling does have a relationship with the autophagic receptor p62. Additionally, we found that knockout of DLK decreases the percentage of round body-like accumulations per cell that colocalize with gabarap. These findings suggest that DLK plays a role in autophagy functioning, and potentially affects protein degradation in both wild-type and ALS animals. We plan to further investigate gabarap and lamp1 colocalization in animals absent of disease pathology. Through understanding DLK signaling and autophagy interaction we can gain crucial insights into ALS pathology and potentially identify new therapeutic targets.

Project Mentor: Dr. Catherine Collins, Department of Neurosciences, CWRU School of Medicine

Capstone Instructor: Dr. Jon Niemi, Department of Neurosciences, CWRU School of Medicine

## AI-Powered Graduate Student Success Prediction System

**Jacob Anderson,** Computer Science; **Weiyang Chen,** Computer Science; **Zeyu Chen,** Computer Science; **Taylor Grossenbacher,** Computer Science; **Handong He**, Computer Science Yanming Hua, Data Science

This project presents an intelligent system for predicting graduate student success using both structured and unstructured application data. To address the challenges of sparse, inconsistent inputs—such as missing GRE scores or vague recommendation letters—we integrate traditional statistical models with advanced AI techniques. The system combines linear regression, Optical Character Recognition (OCR) based document processing, and large language model (LLM) feature extraction to build a Bayesian Belief Network, enabling nuanced reasoning over both quantitative and qualitative factors. By transforming raw application materials into a unified attribute profile, our approach delivers interpretable and data-driven predictions to support more equitable and effective graduate student consulting.

Project Mentor: Vincenzo Liberatore, MS, PhD, Department of Computer and Data Sciences.

Capstone Instructor: Shuai Xu, PhD, Department of Computer and Data Sciences.

## Reducing Sharps Waste Volume by Separating Non-Sharp Components

**Ricardo Anesi,** Department of Materials Science and Engineering, CWRU**; Ian Suddarth,** Department of Materials Science and Engineering, CWRU; Dr.John Lewandowski, Department of Materials Science and Engineering, CWRU;

A significant amount of waste, in both mass and volume, that enters global landfills comes from medical environments. The effects of waste disposal on the environment are not limited to the disposal location, as waste must be transported from origin to disposal, and includes previous transport along the manufacturing process from raw material to finished product. Sharps are a type of waste common in healthcare environments that are often hazardous, requiring special care in storage and transportation. Common control methods for sharps often produce a number of items that take up a much larger volume than would be expected based on the volume of each object. A typical example of a medical sharp is the common syringe and needle. While only the needle itself is sharp, it is common practice for the whole syringe to be disposed to lessen the occurrence of injury during recapping. We propose that the impact of syringe sharps on waste volume can be lessened by separating the item into a sharp and non-sharp portion. In the case of syringe sharps, this reduces the volume of waste created by reducing the dead space in containers associated with this waste stream. Additionally, it opens the possibility of easier recycling of the two primary material components by producing two single or near-single material waste streams. The recycling device would function by cutting or shearing the syringe sharp to separate the primary polymer component from the metallic needle, enabling disposal of the latter as normal sharps, but taking up far less volume per unit item disposed.

Project Mentor: Dr. John Lewandowski, Department of Materials Science and Engineering

**Next-Generation Gold Nanoparticle Cancer Therapeutics: Synthesizing Indocyanine Green Side-Chain Variants for Optimal Target Protein Binding**

**Sofía Añón Bagatini**, (B.S. in Neuroscience); Zoey Lockwood -Department of Neuroscience, Case Western Reserve University; Clemens Burda- Department of Chemistry, Case Western Reserve University

The National Institutes of Health (NIH) approximated that over two million new cases of cancer were diagnosed in 2024, with a little over 600,000 patients having ultimately succumbed to the disease. Concurrently, indocyanine green (ICG) and its fluorescence have proven to be effective in the characterization of solid tumors and metastatic lymph nodes. We aim to synthesize and explore several ICG side-chain variants to design an optimal ICG conjugate for targeted protein binding to these tumors. The synthesized molecules will be conjugated to gold nanoclusters (AuNCs). Recent research has shown there is a significant temperature increase (> 50°C) when ICG absorbs near-infrared (NIR) light of 808 nm, which has been proven to destroy cancerous cells. The treatment described has high potential to both improve and save patients' lives.

Faculty Project Mentor: Dr. Susan Burden-Gulley, Department of Biology

**Analysis & Visualization Platform for Atmospheric Propagation Research**

**Andrej Antunovikj,** Computer Science; **Mengyun Huang**, Computer Science;**Maya Malavasi**, Computer Science; **Avry Rechel**, Computer Science

Our project is developing software to supplement a platform for measuring low-power radiofrequency data transmissions in varying weather conditions, mimicking SmallSat-to-ground communications. This work is adjacent to a project done by a radio research group at Case WesternReserve University, in collaboration with the NASA Glenn Research Center Amateur Radio Club (callsign NA8SA); the expected outcome is an experimentally-tested recommendation to the CubeSat community for data transmission frequencies and modes that would optimize digital signal speed and accuracy in varying ground station conditions. Our group's goal is to facilitate this work as much as possible via our software platform, which will take the data sent to it by the various automated collection systems, clean and filter it, and display the data in appropriate graphs and visualizations, allowing us to spot correlations between the error rate and the atmospheric data.

Faculty Project Mentor: David Kazdan, Department of Electrical, Computer and Systems Engineering

Capstone Instructor: Shuai Xu, Computer and Data Sciences

## Identity Negotiation in the Armenian Diaspora

**Sophia Arnold,** Anthropology

The formation of the modern Armenian diaspora—while a continuous process with perpetual waves and dips—can largely be attributed to the mass deportation and genocidal killing performed by the Ottoman Empire during World War I. As of 2020, there are an estimated 0.5-1 million United States residents self-identifying as having Armenian, or partial Armenian, heritage. The following project examines the negotiation of ethnic identity performed by second, third, and fourth generation members of the Armenian diaspora living within the United States. This work draws upon anthropological theory of the construction and maintenance of identity in conjunction with qualitative data concerning the lived experiences of immigrant descendants. The primary factors of identity negotiation, as explored in this project, are experiences of shared and generational trauma resulting from the Armenian genocide, the resilience—or lack thereof—of ethnic forms such as language reproduction, and an ever-growing reliance on genetic testing within the context of America's biomedical society as identity is transformed into a technical science rather than a cultural construct. Ultimately, this project speaks to the tensions, complexities, and multifaceted nature inherent to identity creation and preservation within an ever-increasing group of immigrant descendants.

Faculty Project Mentor: Bridget Haas, Anthropology

**Racial and Ethnic Disparities in the Return-To-School Transition Post-Traumatic Brain Injury in Adolescents**

**Mariangel Arrieta**, Sociology

Traumatic brain injury (TBI) is a leading cause of disability among adolescents, often resulting in cognitive, emotional, and physical challenges that complicate their return to school. While prior research highlights disparities in healthcare access and outcomes based on race and ethnicity, little is known about how these disparities affect school reintegration post-TBI. Understanding these differences is crucial for developing equitable educational and healthcare policies to support all students in their recovery and academic success. This study aims to examine racial and ethnic disparities in the return-to-school (RTS) transition among adolescents post-TBI. Specifically, it focuses on differences in the type of medical care sought that consider indicators of healthcare and socioeconomic status. A retrospective quantitative analysis was conducted with 114 students in grades 8-12 at the time of their mild TBI/concussion. The sample included 84 students from BrainSTEPS, a formal RTS program, (63 white, 21 non-white) and 30 students from Ohio, where there is no RTS program available, (23 white, 7 non-white). Key variables analyzed were the type of medical care sought (specialized TBI care vs. general care such as emergency rooms) and in-school lunch access (free/reduced vs. full-price as a proxy for socioeconomic status). Findings indicate a general racial and ethnic disparity between groups, with non-white students being less likely to receive specialized TBI care and more likely to qualify for free or reduced lunch. These differences suggest systemic barriers to healthcare access that may contribute to prolonged recovery times and more challenging school reintegration. This research calls attention to the need for policy interventions that address disparities in TBI recovery and school reintegration. Expanding access to specialized medical care, increasing school-based support programs, and addressing socioeconomic barriers to healthcare could help reduce these disparities. Future research should explore additional social determinants of health and their impact on post-TBI outcomes.

Project Mentor: Dr. Angela Ciccia, Department of Psychological Sciences

## PollPal

**Leonardo Astorga**, Data Science and Analytics; **Parv Bhardwaj,** Computer Science; **Jacob Hall,** Computer Science; **Gautam Khandige**, Computer Science; **Tom Than**, Computer Science; **Michael Warner**, Computer Science; **Stephen Yen**, Data Science and Analytics; **Max Zweiback**, Computer Science

PollPal is an innovative web application designed to enhance users' real-life experiences by recommending to them venues such as restaurants and other entertainment locations based on individual preferences. Leveraging a machine learning algorithm, PollPal provides users with personalized suggestions, which they can respond to with a simple "yes" or "no" vote. These constant user inputs contribute to the continuous refinement of the recommendation engine, allowing it to deliver increasingly accurate and relevant venue suggestions. This helps construct a key feature of PollPal: its dynamic rating system, where user feedback directly influences a venue's internal rating. This approach ensures that venue ratings are continuously updated to reflect current user sentiment. Additionally, aggregated data from user interactions contributes to a collaborative model of filtering, further enhancing recommendation accuracy for all users. PollPal also offers valuable insights into regional venue preferences and market trends, making it a useful tool for viewing what is gaining traction in a local area. The project involves the design and implementation of a scalable web application with an intuitive user interface, supported by a robust backend system for data management and AI model deployment. Upon comprehensive testing and user studies, the effectiveness of PollPal's recommendation algorithm and rating system will be examined, and will provide insights into the viability of adaptive recommendation systems in enhancing user satisfaction and engagement. PollPal represents a novel approach to venue discovery beyond common applications, offering personalized and data-driven recommendations with a strong focus on communities. This research contributes to the fields of artificial intelligence, machine learning, and user experience design, with potential applications in various recommendation-based platforms.

Capstone Instructor: Shuai Xu, Department of Computer and Data Science

## A Multi-Sample Prostate Core Needle Biopsy System

**Jube Augustino,** Biomedical Engineering; **Jennifer D'Silva,** Biomedical Engineering;**Octavio Guzman,** Biomedical Engineering; **Esmeralda Qiang,** Biomedical Engineering

Prostate cancer is one of the most common types of cancer, with approximately one in nine men being diagnosed in their lifetime. Prostate cancer progresses gradually, but aggressive forms can metastasize quickly, highlighting the need for effective diagnostic methods. Existing methods allow for the collection of only one sample per insertion. Therefore, requiring numerous insertions making the overall procedure inefficient and causing great discomfort, bleeding, and risk of infection to the patient. We are designing a multi-sample needle biopsy system aiming to address these issues by decreasing the number of insertions while still collecting the same number of samples. This system entails a shuttle-like mechanism with spring-loaded (outer and inner) needles, a storage cartridge, and an external shell to stabilize. The outer needle remains inside the prostate while the inner needle travels to and from the prostate collecting cores and depositing them in a storage compartment attached on the device. This system aims to reduce the number of biopsy needle insertions, enhancing ergonomics, improving diagnostic efficiency, and minimizing post-procedural pain & discomfort.

Project Mentor: Colin Drummond, Biomedical Engineering

**Quantifying Porosity and Permeability of UV-Crosslinked Decellularized Heart Matrix**

**Anna Avila**, Biomedical Engineering, CWRU; Dr. Samuel Senyo, Department of Biomedical Engineering, CWRU

This study investigates methods to quantitatively determine the degree of porosity of crosslinked hydrogels via permeability analysis. The degree of porosity in crosslinked hydrogels affects molecular transport, which is crucial for applications such as drug delivery and tissue engineering. In this project, we assessed porosity using permeability experiments with molecules and particles of varying sizes (e.g., FITC-dextran, polystyrene beads). In addition, we assessed how varying crosslinking density affects permeability and molecular transport within the hydrogels. Previously, we have designed an extracellular matrix (ECM)-hydrogel therapy for cardiac tissue regeneration where improvements in cardiac regeneration were observed. Using ECM from the hearts of pig donors, we synthesized decellularized heart matrix (DHM) and functionalized it with methacryloyl groups to make DHMMA. We are establishing DHMMA as a biomaterial with tunable physical properties, such as stiffness and degradation rate, for cardiac tissue engineering applications. Currently, we are interested in using DHMMA for other applications, such as drug delivery and 3D cell culture. Therefore, the characterization of DHMMA porosity allowed for a better understanding of its internal structural properties, which are challenging to quantify.

Project Mentors: Dr. Samuel Senyo and Valinteshley Pierre, Department of Biomedical Engineering, Case Western Reserve University

**The War on Drugs: The Effect of Legalization of Medical Marijuana on Opioid Prescription Rates.**

**Nicolas Lende**, Economics, Classic; **Oscar Badillo Barrera.** Economics, Psychology

Between 2019 and 2022, opioid-involved overdose deaths in the United States increased from 49,860 to 81,806, marking a rise of approximately 64%. The legalization of medical marijuana has gained attention as a potential tool to address this crisis by reducing opioid prescriptions. To examine the relationship between the prescribing rate of opioids and the legalization of marijuana. Using data from the Centers for Disease Control and Prevention (CDC) from 2010 to 2023, we analyze opioid prescription rates across ten different states with varying levels of marijuana legalization (illegal, medical-only, and recreational). We utilize a difference in difference regression model to assess the relationship between marijuana laws and opioid prescribing behavior while controlling for factors such as opioid-related deaths, dispensary presence, rural versus urban settings, poverty, race, income, and health insurance. Preliminary findings suggest that states with legalized medical and recreational marijuana experience lower opioid prescription rates, supporting the hypothesis that medical marijuana may serve as a substitute for opioids. This study also explores the role of dispensary availability, demographic factors, and regional characteristics in influencing opioid prescribing patterns. The results have implications for policy, suggesting that expanding access to medical These inspire several policy and public health outcomes. If the substitution effect between cannabis and opioids holds, then policy makers could consider expanding access to marijuana dispensaries, and particularly aim for counties where opioid use is prevalent. In many states that have legalized, a drug tax has been placed on dispensaries that generate additional revenue for public policies like public health initiatives. A portion of this program could be used to create avenues for opioid treatment such as methadone clinics or other harm reduction strategies.

Project Mentor: Mark Schweitzer, Department of Economics

**Analyzing the Impact of Berryessa Extension of BART**
**On Demographics in Adjacent Neighborhoods**

**Nia Badley,** Department of Economics; **My Nguyen,** Department of Economics, CWRU

The Bay Area Rapid Transit (BART) Berryessa Extension in San Jose represents a significant public transit investment, yet its demographic impacts on surrounding communities remain understudied. This research examines how the extension influences population characteristics such as population growth, income levels, racial composition, educational attainment, in the adjacent neighborhoods from 2010-2023. Previous research by AlQuhtani and Anjomani (2021) found variable population density changes around transit stations in Dallas-Fort Worth, while Lee and Lee (2018) documented that Seoul's subway expansion strengthened central business districts rather than decentralizing growth. Evidence suggests that census tracts within a half-mile of BART stations have nearly twice the number of households per acre compared to farther areas (BART, 2024), and neighborhoods near stations tend to have higher median incomes, raising gentrification concerns. Using U.S. Census and American Community Survey data with ZIP Code Tabulation Areas (ZCTAs); a geographic product of the U.S. Census Bureau created to allow mapping, display, and geographic analyses of the United States Postal Service (USPS) Zone Improvement Plan (ZIP) Codes dataset, as our geographic unit of analysis. We apply a Difference-in-Differences approach to compare demographic changes in areas affected by the extension against similar unaffected areas, with Propensity Score Matching to identify appropriate comparison areas. We hypothesize positive estimates for demographic variables, particularly increased population density and income levels near new stations. This research contributes valuable insights for urban planning and housing policy as San Francisco proceeds with the $12.75 billion BART Silicon Valley Phase II extension, potentially helping policymakers implement measures to balance transit benefits with equitable community preservation.

Faculty Project Mentor: Professor Schweitzer, Department of Economics, CWRU

## Understanding Post Traumatic Stress in Suicide Bereavement

**Seobin Baeg**, Biology

Statistically, each suicide leaves 135 people on average who knew the individual. Given this math, out of 135 million in the United States, approximately 5.5 million are mourning the suicide of someone they knew personally each year- not a small number. Yet many suicide bereaved report shame, fear of stigma, and lack of support for their plights. Recent research suggests that those who suffer from bereavement from trauma experience a complicated grieving process that is often comorbid with post-traumatic stress disorder. Given the nature of the death of the deceased, this critical review intends to examine specific factors that correlate with the unique vulnerability that suicide bereavement poses to post-traumatic stress and long-term grieving. In total, 11 articles were identified through a search for the keywords "suicide bereaved" or "suicide survivor" with "PTSD." in the APA PsychNet database. A review of these articles suggests that time since death loss is an alleviating factor but that the presence of guilt and blameworthiness make the individual more vulnerable to suffering from psychological stress symptoms. The unexpectedness of the death, frequently seen in suicide bereavement was correlated with psychological symptoms. However, the field is very new, necessitating more research on grieving and post-traumatic stress on suicide bereaved, as well as on their general well-being.
Project Mentor: Dr. Amy Przeworski, Department of Psychology, Case Western Reserve University

Capstone Instructor: Dr. Amy Przeworski, Department of Psychology

## Tunify

**David Cho,** Computer Science; **Ritu Havaldar,** Computer Science; **Eliana Matos,** Computer Science; **Jacob Bair,** Computer Science; **Tommy Hareford,** Computer Science; **Max Katzman,** Data Science

Music recommendation algorithms often rely on past listening history or curated playlists, but these methods may not fully capture a user's evolving taste or mood. *Tunify* explores a more user-driven approach by allowing individuals to input a small number of songs they enjoy, then generating personalized recommendations using metadata from the Spotify Music API. This project asks: *How can we create a lightweight and intuitive music recommendation system that uses minimal input to generate relevant suggestions?*

Rather than tracking long-term listening behavior, *Tunify* uses song-level metadata - such as genre, tempo, and mood - to identify patterns among the songs a user selects. The goal is to return other songs with similar characteristics, allowing users to discover music in a more intentional and interactive way. This approach emphasizes simplicity, privacy, and user control, contrasting with more complex or opaque recommendation engines.

The project is still in development. We are currently testing the capabilities of the Spotify Music API to understand what classification data is consistently available, and how well it reflects meaningful musical attributes. Our next steps involve experimenting with basic logic for comparing songs and assembling early recommendation outputs. Through this process, we hope to learn what kinds of features are most useful for lightweight, input-driven recommendations.

Faculty Project Mentor: Not applicable (Capstone Project)

Capstone Instructor: Shuai Xu - Department of Computer and Data Sciences, CWRU

## Medication Management for Polypharmacy Patients

**Siddharth Balakrishnan**,Biomedical Engineering; **Keren Hu**,Biomedical Engineering; **Atreya Sridharan**, Biomedical Engineering; **Angela Tsang**,Department of Biomedical Engineering

Polypharmacy, which is defined as the concurrent usage of five or more medications by a single patient outside of hospital settings, is a growing challenge in healthcare. Currently, polypharmacy affects around 25% to 47%, increasing with age starting from individuals around 60. It is an issue that disproportionately affects older individuals because many of them have multiple chronic conditions (MCC). Diseases that are common in polypharmacy patients include arthritis, heart disease, diabetes, and hypertension. Polypharmacy can contribute to various adverse outcomes including adverse drug events, drug interactions, decreased medication adherence, increased hospitalization, and elevated healthcare costs. Current polypharmacy management strategies are focused on deprescribing as a follow-up to medical review and reconciliation. There are very few technologies related to medication management that support polypharmacy patients. The task of managing a wide array of medications, monitoring side effects and contraindications, planning medication schedules, and adhering to the schedule is mentally burdensome to the patient; in addition, the risks of mismanaging medications are not only costly but also potentially life-threatening. This project will use an interdisciplinary approach to identify medication management challenges and develop a new solution in the form of a smartphone application that helps reduce adverse health events in patients outside of the hospital setting. The application aims to provide polypharmacy patients and their caretakers with a medication management solution that can identify contraindications, create a personalized calendar, and send reminders.

Project Mentor: Professor Matthew Williams, Department of Biomedical Engineering; Professor Colin Drummond, Department of Biomedical Engineering

**Utilizing CaMPARI to visualize Calcium ion binding in Drosophila with NOCFLY protein deficit**

**Ashvika Bandaru**, B.A in Biology and Medical Anthropology, Case Western Reserve University

Nocfly is a novel gene involved in female receptivity in Drosophila melanogaster that encodes a predicted potassium ion channel-binding protein similar to human KCNIP1-4. NOCFLY contains an EF-hand domain that binds to calcium, which allows voltage-gated potassium ion channels to open. To analyze the functional role of nocfly in Drosophila, we designed a loss-of-function experiment to test its requirements in behavioral function and in neuronal firing. In my previous summer research, we knocked-down NOCFLY using the UAS-GAL4 system to express UAS-nocfly RNAi in two different types of neurons using the Cha-Gal4 and Elav-Gal4 drivers. These Experimental flies displayed significant motor deficits when tested for negative geotaxis behaviors. To further investigate whether calcium ion concentrations are affected by the knockdown of NOCFLY , we used a calcium sensor that can be photo-activated in freely behaving flies to permanently label firing neurons in response to a stimulus at a desired time point. This system relies on the expression of CaMPARI2, an engineered fluorescent protein whose green-to-red photoconversion depends on simultaneous light exposure within 400 nm wavelength and elevated calcium ion concentration. Utilizing an experimental line of flies with the CaMPARI2 protein will allow me to test if the loss of NOCFLY protein affects the concentration of calcium ions in a neuron before an action potential.In Cha-Gal4-UAS-CaMPARI2 flies exposed to food as a smell stimulus, we observe the photoconversion from GFP to RFP in the antennal lobe. These flies will be used as a positive control to compare to Cha-Gal4-UAS-CaMPARI2-UAS-nocflyRNAi flies. We expected to find a decreased conversion of CaMPARI2 GFP into RFP due to a reduced calcium ion movement in the absence of NOCFLY . These results will be analyzed by obtaining fluorescent signals from the antennal lobe and employing a one-way ANOV A test to analyze if control and experimental groups are significantly different.

Project Mentor: Dr. Claudia Mizutani, Department of Biology, Case Western Reserve University

## Monitoring Application for Pediatric Dysphonia

**Rachel Barker**, Biomedical Engineering; **Veebha Havaldar**,Biomedical Engineering; **Justin Storn**,Biomedical Engineering; **Nehal Garg**,Biomedical Engineering; Colin Drummond, Matthew Williams, Department of Biomedical Engineering, Case Western Reserve University

Pediatric dysphonia is a vocal condition which mainly affects children between the ages of five and ten. One of the most common forms of the disease, which is considered inflammatory, is vocal fold nodules. This interferes with glottic closure and vocal fold vibration necessary for speaking. This disease can be life-threatening if the voice change is associated with difficulty in swallowing or breathing. Pediatric dysphonia varies widely in severity, with some children growing out of the condition with age and others requiring surgery. Pediatric dysphonia can lead to chronic voice changes that can limit a child's success in school as well as their social and professional opportunities later in life. Currently, pediatric dysphonia is only assessed by clinical specialists, limiting accessibility of care and prolonging diagnoses. To help clinicians gather data for pediatric dysphonia patients, a noninvasive monitoring application is being designed. This will help to assess changes in severity over time and analyze vocal patterns, allowing for better evaluation of the disease by the user and their clinicians. Preliminary work consisted of a Matlab application which demonstrated vocal analysis from a recorded voice sample. Current work is on an Android application which will perform jitter, shimmer, and harmonic to noise ratio calculations on a recorded or uploaded voice sample. The application will also calculate a severity score to provide a child-friendly measure of progress. This severity score will be a moving average based on the correlation of pathological value thresholds to dysphonia symptoms. The application's collection of quantitative data will allow users and clinicians to make assessments of changes in patient condition and dysphonia severity over time.

Project Mentor: Dr. Eppell, Associate Professor of Biomedical Engineering and Otolaryngology/Head & Neck Surgery

## Heat Transfer in Granular Materials

**Zoe Bataille,** Mechanical Engineering

Granular materials are a system composed of discrete solid particles in which forces are dominated by interaction between particles. Heat transfer in granular materials is useful to describe some natural phenomena and is important to a wide array of industries. However, due to the inherent particularities of the stresses and contacts at play in a particulate system, the modelling of heat transfer in granular materials has been a challenge. Computational simulations describing the simplest case of heat transfer in granular material, conduction through the solid particles, are quantitatively accurate making them useful tools for testing existing theories. To analyze conduction through a granular bed, a heat transfer functionality was added to a pre-existing MATLAB code using the Thermal Particle Method (TPD). The Discrete Element Method, already implemented to the code, models each individual particle in the system, therefore including heterogeneities of stresses and contacts, and calculates their position, velocity and the forces acting on them. The TPD builds off this model to calculate individual particles' temperature. A dynamic temperature distribution of the whole system is obtained at the particle level. The effect of differing material properties and of the deviation in particle size on heat transmission was analyzed.

Project Mentor: Steve Hostler, Department of Mechanical and Aerospace Engineering

Capstone Instructor: Majid Rashidi, Department of Mechanical and Aerospace Engineering

## Wearable Swim Stroke Efficiency Calculator

**Andrew Cedar**, Computer Engineering; **Alessandro Meucci**, Computer Engineering; **Jiro Batt**, Mechanical Engineering

Competitive swimming demands the optimization of technique, strength, and efficiency, as swimmers must minimize drag and maximize propulsion in the medium of water. Optimizing each stroke involves precise coordination, timing and force, yet most feedback returned to swimmers is observational feedback or basic lap time data. Henceforth most feedback received by swimmers is general and overlooks nuances of technique and coordination, limiting a swimmer's ability to reach their potential.

Sports such as American football, golf, and tennis have all implemented wearable technology in the pursuit of individualized, tracked data. Athletes using wearable technology have commended the effect in which a personalized improvement program has made on their technique and overall performance. While swimming data tracking exists in smart watches, only basic data is recorded such as lap times and stroke counts.

The proposed project addresses this market gap through developing a novel wearable device designed to measure and analyze the force exerted by swimmers during their strokes. This device, worn on the wrist or palm, will utilize advanced sensors such as accelerometers, gyroscopes, and force sensors to capture precise data on stroke dynamics. The wearable device should be able to track force output at specific positions as well as measure stroke paths.Through monitoring the force applied during each phase of a swimmer's stroke, the tracker will provide actionable insights into stroke efficiency and power generation, helping athletes refine their technique for improved performance. Data will be transmitted by some means to highlight metrics like peak force, stroke consistency, and energy expenditure.

This innovation is aimed at bridging the gap between subjective coaching feedback and objective performance metrics. Unlike existing swimming trackers that focus on lap counts or swim duration, the swim force tracker provides feedback on the biomechanical aspects of swimming. It is intended for competitive swimmers, coaches, and recreational athletes seeking to enhance their skills. By combining wearable technology with biomechanic analytics, this project aspires to redefine how swimmers improve.

Project Mentor: Steve Majerus, Department of Electrical, Computer and Systems Engineering

**Days, Lost Opportunities: Does the Presence of Communities in Schools Reduce Chronic Absenteeism?**

**Julia Bauer**, Mathematics, Economics; **Nathaniel Page,** Economics

An enormous body of literature tries to understand the root causes of poor school attendance as well as the interventions that can effectively remedy the problem. Poor school attendance is a major impediment towards educational progress and is associated with increased rates of high school dropouts, lower lifetime earnings, increased criminality, and adverse health outcomes. Communities in Schools (CIS) is the largest and most prominent organization in the country fighting to combat chronic absenteeism. CIS works directly with schools to provide integrated student support and resources. In our research, we explore the impact of CIS on chronic absenteeism, graduation rates, and other educational outcomes for the public and community schools they served in. Our data focuses on the organization's interventions in the state of Ohio and spans from 2016-2024. We source our data from the Ohio Department of Education database and the CIS website. We contribute to the literature by uniquely studying the state of Ohio and updating the observation period. We employ a propensity score model to match and evaluate the **Lost** effect of CIS in Ohio over the observed time span. This model estimates the probability of CIS intervention in a school based on the school's observed characteristics, then compares the treated and untreated schools with similar probabilities. We hypothesize that CIS intervention will decrease chronic absenteeism, increase school attendance, and increase school test results, based on previous literature and a model of positive intervention. Our results have important implications for education policymakers as they decide how to best allocate resources to fight one of the largest impediments to educational progress in the United States.

Project Mentor: Professor Mark Schweitzer, Department of Economics

**Characterizing the Effects of *De Novo CTNNA2* Missense Mutations in Lissencephaly**

**Kayleigh R. Bauer**, Biomedical Engineering, Case Western Reserve University

Neuronal migration during gestation is crucial for neurodevelopment as the process lays the groundwork for proper gyration, or folding, of the cerebral cortex that enables the brain to carry out an array of complex functions. In the case of abnormal neuronal migration, lissencephaly, a group of disorders characterized by reduced and abnormal gyration, can arise. During migration, neurons travel along radial glial cells, relying on extracellular signals to guide proper movement. Molecularly, this occurs through a dynamic process of actin assembly and disassembly at neuronal growth cones. Monomeric actin (G-actin) is polymerized and disassembled by both positive regulators such as formins and the Arp2/3 complex and negative regulators such as αN-catenin, encoded by the *CTNNA2* gene. The αN-catenin protein plays a unique role in mediating this process by competing with Arp2/3 to bind with actin at the αN-catenin actin binding domain (ABD). Previous research has shown that biallelic loss of *CTNNA2* results in Arp2/3 overactivity and excessive actin branching. Whether the same effect occurs in *de novo* missense mutations in *CTNNA2* is not yet known. I hypothesize that mutant cells, not just knockouts, display Arp2/3 overactivity and excessive actin branching. To test this hypothesis and characterize the effects of patient *CTNNA2* mutations, I utilized a combination of molecular cloning and biochemistry techniques to model patient mutations. The effects of each mutation on polymerization, relative to wild type *CTNNA2*, were characterized using an actin polymerization assay and demonstrates novel effects of *CTNNA2* function.

Project Mentor: Andy Y. Chen, Lucie Y. Ahn, Ashleigh E. Schaffer Department of Genetics and Genome Sciences, Case Western Reserve University School of Medicine, Cleveland, OH

## Morphometric Scanning for Medical Applications

**Juan C. Beaver**, Computer Engineering, **Ryan Coneway**, Systems and Control Engineering, **Karungi Kabaseke**, Electrical Engineering

Accurate 3D modeling of human limbs is critical for biomechanics, medical diagnostics, prosthetics design, orthopedics, rehabilitation, and personalized healthcare. However, traditional surface scanning methods like high-cost optical systems and laser scanners present barriers including limited accessibility, high expense, and restricted portability. This research addresses these limitations by developing a proof-of-concept for a portable and cost-effective imaging system. This system captures a limb's surface images through a camera's rotational movement around one endpoint in a full 360-degree arc.

The primary aim is to determine the most accurate surface reconstruction technique for generating detailed anatomical limb meshes. Additionally, the study evaluates the effectiveness of Digital Image Correlation (DIC) speckling in improving surface feature recognition and overall reconstruction quality. Multiple advanced 3D surface reconstruction methods are comparatively assessed using captured image datasets, with evaluation criteria specifically focusing on mesh accuracy and fidelity in representing anatomical structures. Preliminary expectations suggest that certain advanced surface reconstruction methods will significantly outperform traditional approaches in terms of mesh accuracy, potentially offering a practical and accessible alternative to more expensive surface scanning technologies. The results of this project aim to guide the selection of optimal reconstruction techniques suited for clinical use and resource-limited environments.

Faculty Project Mentor: Zonghe Chua, ECSE, Case Western Reserve University

Capstone Instructor: Gregory Lee, ECSE, Case Western Reserve University

**Pupil Dynamics as a Non-Invasive Biomarker for Autism Spectrum Disorder in the PTENY68H/+ Mouse Model**

**Frederick Bell**, Tenesha Connor, Miguel Maldonado, Kemal Ozdemirli, Macit Emre Lacin, Murat Yildirim, Department of Neuroscience, Cleveland Clinic Lerner Research Institute, Cleveland, OH, USA Department of Neuroscience, Case Western Reserve University, College of Arts and Sciences, Cleveland, OH, USA

Autism Spectrum Disorder (ASD) affects approximately 5 million individuals in the United States and remains one of the most complex and heterogeneous neurodevelopmental disorders, for which there are currently no objective, universally accepted biomarkers.
Recent studies have implicated the PI3K/Akt/mTOR signaling pathway as a significant driver of ASD risk. Among the genes in this pathway, phosphatase and tensin homolog (PTEN) plays a key role in suppressing mTOR activity and regulating cell growth. Loss-of-function mutations in PTEN are established risk factors for ASD in both humans and animal models. In parallel, ASD has been associated with dysregulation of the autonomic nervous system, leading to changes in arousal markers such as pupil diameter and heart rate variability—making these features potential candidates for non-invasive ASD biomarker development.
In this study, we tested the feasibility of using pupil dynamics as a physiological biomarker for ASD using the PTENY68H/+ mouse model. Mice were head-fixed and trained to run freely on an air-suspended ball while being recorded. Videos of the pupil were processed using DeepVision, a deep learning-based software developed in our lab to track pupil diameter. The resulting time series were input into a Long Short-Term Memory (LSTM) recurrent neural network, which was trained to distinguish between wild-type and PTENY68H/+ based solely on their pupil dynamics. The trained model achieved high classification accuracy on previously unseen data, demonstrating that pupil behavior encodes genotype-specific information in a way that machine learning can reliably decode.
Our findings provide proof of concept that noninvasive pupil imaging can provide potential biomarkers. Moving forward, we aim to combine these behavioral readouts with large-scale cortical calcium and neurotransmitter imaging to characterize ASD phenotypes along the brain–behavior axis. This integrative strategy has the potential to uncover mechanistic insights into how genetic mutations alter neural activity patterns and autonomic function.

Project Mentor: Murat Yildirim, Department of Neuroscience

Capstone Mentor: David Friel, Department of Neuroscience

**Pediatric Pulse Oximeter for Low- and Middle-Income Countries**

**Amarachi Chukwumaeze,** Biomedical Engineering; **Ken Bella Jaro**, Biomedical Engineering; **Kai Abitbol-Pierce,** Electrical Engineering; **Danil Mosley,** Electrical Engineering; **Pranav Saran,** Computer Science and Computer Engineering; **Nischay Pothineni,** Systems Biology; **Ronit Ganguli,** Neuroscience; **Mina Holtzman,** Undecided Engineering; **Samhita Jonnalagadda,** Biomedical Engineering; **Hundana Allepalli,** Biomedical Engineering; **Adhvay Kumar,** Systems Biology

Pulse oximeters hold significant value in the diagnosis of many acute respiratory illnesses (ARIs) such as pneumonia, as they provide healthcare workers with the patient's oxygen saturation (SpO2) levels, a key indicator of respiratory health and function. However, current commercial pulse oximeters are either too large for pediatric use or not accessible for low-resource or low-income communities. Many commercial pulse oximeters also have a bias against people with darker skin tones with consistent overestimations in their SpO2 levels. This current lack of a sustainable and appropriate pulse oximeter for pediatric use in low-resource settings contributes to delayed diagnoses and treatment of respiratory diseases, resulting in disproportionately high child mortality rates. Thus, we are currently developing an affordable reflectance-based pulse oximeter and a corresponding app to display relevant patient data (heart rate, SpO2, and a photoplethysmogram). We also plan on curtailing the algorithm calibration and the testing of the device to accommodate a population of darker skin tones, as this is highly relevant to broadening the reach and serviceability of our pulse oximeter. The pulse oximeter has adjustable straps that will enable healthcare workers to easily measure a child's oxygen saturation levels by fixing it to a region such as the forehead, decreasing the effects of motion artifacts and improving the accuracy of the SpO2 readings. Our design also sends data wirelessly to a healthcare worker's mobile device, where results are displayed.

Faculty Mentor: Brecken Blackburn, Ph.D., Department of Biomedical Engineering

**Exploring the interplay between BRCA2 and Pol ι in driving genome instability**

**Ariana Bellare,** Department of Biochemistry, Case Western Reserve University

BRCA2 functions as a crucial tumor-suppressor protein with multiple roles in maintaining genome stability, largely through its involvement in homologous recombination for double stranded break repair and protection of the replication fork. There is increasing evidence that BRCA2 heterozygosity leads to haploinsufficiency, in which one functional BRCA2 allele is insufficient to produce the normal phenotype, resulting in increased risk for breast cancer development. Loss of BRCA2 function can lead to the activation of error-prone translesion polymerases. Pol ι is a highly error-prone Y-family translesion DNA polymerase involved in replication of damaged DNA regions. To investigate the interplay between BRCA2 haploinsufficiency and POLi, we performed gene silencing studies using small-interfering RNAs against BRCA2 and POLi in MCF10A cells, an untransformed human mammary epithelial cell line. Given POLi's role in replicating damaged DNA regions, we then evaluated 53BP1 accumulation via immunofluorescence in the silenced cells. 53BP1 is often used as a marker of unresolved replication stress. The results demonstrated a significant increase in 53BP1 under BRCA2 silencing compared to control conditions, as well as a significant decrease under dual knockdown compared to BRCA2 knockdown alone. These findings demonstrate that Pol ι may play a crucial role in driving genomic instability under BRCA2 loss, contributing to breast cancer initiation.

Project Mentor: Dr. Mihriban Karaayvaz and Dr. Kavya Vipparthi, Department of Genomic Medicine, Cleveland Clinic Lerner Research Institute

Capstone Mentor: Dr. Hung-Ying Kao, Department of Biochemistry

**Mapping the Vote: A Data-Driven Approach to Electoral Fairness**

**Madison McDaniels,** Data Science and Analytics, Computer Science, and Business Management; **Amelia Myhrvold,** Data Science and Analytics and Business Analytics and Intelligence; **Catherine Supron,** Data Science and Analytics; **Dale Berkove,** Data Science and Analytics

This research examines partisan gerrymandering in Ohio's congressional districts using advanced computational methods. Following the 2022 ruling of Ohio's electoral map as unconstitutionally gerrymandered, we develop precise mathematical metrics to evaluate partisan asymmetry and create alternative districting plans that enhance representational accuracy while meeting legal requirements. Despite redistricting reforms, manipulated boundaries continue to undermine democratic principles and diminish electoral power, especially for urban and minority communities.

Our approach combines GerryChain's Markov Chain Monte Carlo (MCMC) sampling with a custom Proximal Policy Optimization (PPO) reinforcement learning model to systematically improve district boundaries. The algorithm assesses plans against multiple criteria: population balance, geographic contiguity, compactness, and preservation of communities of interest. Using precinct-level electoral data and 2020 Census demographics, we quantify gerrymandering through a fairness coefficient derived from Monte Carlo simulations that measure deviations between actual and expected partisan outcomes.

Deliverables include optimized redistricting plans showing improved representational fairness and detailed analyses projecting 2024 election outcomes under these more equitable configurations. This work advances democratic theory by establishing robust metrics for gerrymandering and demonstrating how computational learning systems can create fairer electoral maps. The methodology offers a transferable framework for other jurisdictions facing similar redistricting challenges.

Project Mentor: Shuai Xu, Department of Computer and Data Sciences

**A data-driven investigation into olfactory dysfunction and Alzheimer's disease: insights from COVID-19 patients.**

**Valentina C. Bermúdez**, Neuroscience B.S.; **Kristy Miskimen**, Department of Population and Quantitative Health Sciences School of Medicine; **Yeunjoo Song**, Department of Population and Quantitative Health Sciences School of Medicine; **Audrey Lynn**, Department of Population and Quantitative Health Sciences School of Medicine; **Carly Rose**, Department of Population and Quantitative Health Sciences School of Medicine

Alzheimer's disease (AD) is a leading cause of cognitive decline in older adults, yet current treatments fail to prevent or cure the disease. Recent research suggests the potential role of olfactory dysfunction as an early warning sign for AD, leading to questioning how smell loss might foreshadow or influence disease onset. The first phase of this project focuses on a genomic analysis of 69 expanded loci identified as risk regions for AD and related dementias. A total of 1,870 protein-coding genes were found to be present in these risk regions. Among these, 47 genes were directly involved in olfactory function. This finding presents the possibility that olfaction-related mechanisms could be tied to neurodegenerative pathways, encouraging deeper exploration into how they might contribute to the progression of AD.The second phase of the study utilizes the National COVID Cohort Collaborative (N3C) database to investigate whether persistent olfactory dysfunction in COVID-19 patients is associated with an elevated risk or earlier emergence of AD-like cognitive symptoms, such as memory impairment. Since the onset of the pandemic, a significant proportion of individuals infected with SARS-CoV-2 have experienced prolonged or even permanent loss of smell, offering a large, well-documented sample in which to study olfactory disruptions. This project compares the cognitive health of COVID-19 patients whose sense of smell has been affected to those showing no signs of impaired olfaction. A link between olfactory dysfunction and cognitive decline in COVID-19 patients would give weight to the hypothesis that genes related to smell and AD risk contribute to a shared neuropathological process. By connecting large-scale genetic findings with clinical data, the project aims to validate olfactory dysfunction as a potential biomarker for AD risk. If confirmed, such a marker could facilitate earlier identification of individuals at risk and the development of more efficient treatments.

Faculty Project Mentors: Kristy Miskimen, Department of Population and Quantitative Health Sciences School of Medicine, Yeunjoo Song, Department of Population and Quantitative Health Sciences School of Medicine, Audrey Lynn, Department of Population and Quantitative Health Sciences School of Medicine

Capstone Instructor: David Friel, Department of Neurosciences, School of Medicine

## Wind Tunnel Flow Visualization

**Nathaniel Bernston,** Aerospace Engineering; **Preston Yen,** Aerospace Engineering

The purpose of this project is to design, manufacture, and test a flow visualization system for the Flotek 1440 Open System Wind Tunnel in Glennan 412 for future use in the EMAE 285 course. Utilizing a smoke generator, compressor, smoke fluid, and a 3D printed smoke rake system, smoke streamlines can be generated to show the flow behavior of airfoil designs and other geometries for varying free stream velocities. Additionally, the Vortex Panel Method was utilized in MATLAB to make theoretical streamlines for this system to compare the accuracy of the smoke system's streamlines. Results from the experimentation and the theoretical calculations show that the present smoke rake has difficulties displaying a streamline, and the vortex panel method's simulations show small defects in some of the streamlines. Currently, no comparison can be made for the experimental and theoretical streamlines, as a test for the wind tunnel hasn't been conducted with implementation of the airfoil.

Faculty Project Mentor: Dr. Bryan Schmidt, Department of Mechanical and Aerospace Engineering

Capstone Instructor: Dr. Majid Rashidi, Department of Mechanical and Aerospace Engineering

## Bioinspired Soft Swimming Jellyfish Robot

**Alison Berry**, Aerospace Engineering; **Riddhi Srinivasan**, Mechanical Engineering; Dr. Yi Jin, Department of Mechanical and Aerospace Engineering; Dr. Chase Cao, Department of Mechanical and Aerospace Engineering

Bioinspired swimming robots are an emerging technology with significant potential to enhance our knowledge of the world's oceans and the life that exists within. Extreme conditions in the deep seas make both human and machine exploration difficult; however, success can be found by developing robots containing features that are inspired by the animals that thrive in said environments. Jellyfish, being some of the most efficient swimmers in the animal kingdom through a jet propulsive mechanism, has inspired numerous robots. Robots using a variety of actuators have been developed, but rarely has a jellyfish robot used a piezoelectrically driven actuation system. In addition, robots with traditional motors and hard moving parts pose risks to undersea environments in the form of noise pollution and damage. Therefore, we introduce a numerical model of a soft jellyfish robot that uses piezoelectric actuators along with a mechanism to amplify their inherently low displacements.

The numerical model includes piezoelectric bimorph actuators that function as single clamped cantilever beams, a jellyfish bell constructed of soft materials, and beams equidistantly placed around the inner surface of the bell, with one end of each fixed to the free end of an actuator at the inner ceiling of the bell, and the other end fixed to the tip of the jellyfish bell. Each beam is balanced on a fulcrum fixed to the bell, creating a lever mechanism that forces the bell close when the piezoelectric applies a force to the end of the beam at the ceiling. The numerical model aims to optimize the geometry of the jellyfish prototype by calculating the actuation and propulsive capability of a possible dimensioning set. It is expected that following the completion of the model, the prototype will be built and tested in order to construct another numerical model for comparison.

Project Mentor: Dr. Changyong Cao, Department of Mechanical and Aerospace Engineering

Capstone Instructor: Dr. Majid Rashidi

**After the Storm: The Employment Effects of Natural Disasters in California**

**Manav Bhandary**, Finance and Economics **Janson Xu**, Finance and Economics

Although natural disasters severely impact local economies, their impact on industry-specific employment remains understudied. Understanding the relationship between natural disasters and employment can provide valuable insights for policymakers to strengthen California's labor market resilience. This paper analyzes the effect of natural disasters on employment across industries in California. We combine data on federally declared disasters from the Federal Emergency Management Agency (FEMA) with county-level employment data from the Quarterly Census of Employment and Wages (QCEW) from 2010 to 2024. We examine employment trends before and after disasters to determine which disasters have the largest impact on employment. We employ a Difference-in-Differences (DiD) approach using a Two-Way Fixed Effects (TWFE) model, controlling for both time and county fixed effects, to estimate the causal impact of natural disasters on employment in California and compare their effects, an aspect often overlooked in previous literature. Our key variables include employment rate by county, population growth, and GDP per capita, with expected negative effects on tourism, agriculture, and retail, but positive effects on construction employment due to rebuilding efforts. We hypothesize that earthquakes will have the largest overall employment effect because of the widespread infrastructure damage and long recovery periods, while floods will cause temporary disruptions, but have quicker employment recovery. Furthermore, we believe that construction employment may increase due to rebuilding efforts, while tourism, agriculture, and retail may suffer prolonged job losses, with variations based on disaster type and severity. This aligns with labor demand theory, which states that industries reliant on discretionary spending face employment declines because of the reduced demand. While our research focuses on California, our findings have broader implications for regions facing similar disaster risks. The results will help guide policy responses, resource allocation, and workforce development programs tailored to industry-specific recovery needs.

Project Mentor: Professor Mark Schweitzer, Department of Economics

Capstone Instructor: Professor Mark Schweitzer, Department of Economics

**Paper-Based Serum Protein Electrophoresis for Point-of-Care Multiple Myeloma Testing**

**Charlotte Bimson**, Physics; Charlotte Brunkalla, Rucha Natu, Oshin Sharma, Sulatha Dwarkanath, Peter Galen, Umut Gurkan

Multiple myeloma (MM) is the second most common blood cancer with increasing global incidence; the mortality burden falls primarily on low-resource healthcare systems due to the high cost of screening and treatment. To quantify MM risk and progression, clinicians use serum protein electrophoresis (SPEP) to monitor the monoclonal protein (M-protein) concentration indicated by high protein concentration in the gamma band. Capillary electrophoresis-based platforms are the gold standards in SPEP. However, these tests are time-consuming, expensive, and require sophisticated equipment and batch processing. This limits the availability of the tests in low-resource settings. We propose an accurate and accessible paper-based SPEP for point-of-care (POC) M-protein monitoring using an inexpensive and portable electrophoresis platform developed by Hemex Health, Inc. The platform consists of two main components: a microchip and a reader. The microchip houses a cellulose acetate membrane, buffer wells, and electrodes. To test a sample, serum is deposited on the membrane and a buffer-stain solution fills the wells; then, a constant voltage is applied over the microchip in the reader. Post, the test is destained and imaged. A protein intensity distribution is plotted and the relative intensity is determined from the distribution. Ongoing efforts are focused on optimizing the test parameters to improve test band definition and accuracy.

Project Mentor: Umut Gurkan, Department of Mechanical and Aerospace Engineering

## Reaction Control Wheel for Rocket Roll Control

**Chris Bishop**, Aerospace Engineering; **Owen Braun**, Aerospace Engineering; **Ryan Price**, Aerospace Engineering

Active stabilization of an amateur rocket is an area of interest to advanced hobbyists, collegiate teams, and anyone interested in maintaining precise attitude control of a rocket during flight. Numerous control options exist to mitigate in-flight disturbances depending on the desired level of precision and complexity, but few are well-documented for use at the hobby-grade level. The *Reaction Control Wheel for Rocket Roll Control* presents a relatively simple, and semi-modular solution for controlling the rolling motion (spin about the axis parallel to the direction of flight) of a 3" diameter rocket during the pre-apogee flight phases. The system employs the use of a reaction wheel aligned with the roll axis to control rotation caused by aerodynamic disturbances. The module is constructed from a variety of COTS components as well as several custom-made parts. System validation and PID control tuning was performed using a bench test stand prior to integration into a custom-built rocket. Data collected from an onboard camera and IMU during a low-altitude test launch indicated proper operation of the control system and minimal rolling during the powered and unpowered ascent phases. This report contains detailed documentation regarding the design, manufacturing, and test of the reaction wheel control system and its potential for use as a modular package with similarly sized rockets.

Project Mentor: Paul Barnhart, Department of Mechanical and Aerospace Engineering

Capstone Mentor: Majid Rashidi, Department of Mechanical and Aerospace Engineering

## Python-Powered Worm Robot for Sensor-Based Locomotion

**Allison Black**, Mechanical Engineering

Worm-like robots mimic earthworms' peristaltic movement to navigate challenging environments by deforming their bodies. This compliance, however, introduces challenges in tracking and control. Recent studies have shown that stretch and pressure sensors can reliably measure both forward and backward movements with low error, enhancing navigation in complex conditions. Although the robot's locomotion has been tested on a flat plane with a straightforward path, these results lay the groundwork for future experiments on more intricate terrains, including turning paths and inclines. Soft worm robots hold significant potential for cleaning, repairing, and inspecting pipes, where traditional robots might struggle.

This project aims to convert the robot's control system from an Arduino-based environment to a Python-based framework. While the locomotion model has already been developed in Python, the physical robot currently operates on Arduino. By integrating the two systems, the project will enable the exploration of various sensor configurations to refine and alter locomotion patterns, ultimately improving the robot’s performance in real-world applications.

Project Mentor: Roger Quin, Department of Mechanical and Aerospace Engineering

Capstone Mentor: Majid Rashidi, Department of Mechanical and Aerospace Engineering

**Stalling Production: The Ripple Effect of Steel Tariffs on U.S. Automotive Manufacturers**

**Luke Bobosky**, Finance, Economics; **Zach Chen**, Statistics, Finance

This study will analyze the impact steel tariffs have on domestic automobile manufacturing levels from 2000 to 2024. While steel tariffs have been implemented at various points in United States history, their impact on manufacturing sectors remains a topic for debate, and whether or not consumers face higher prices as increased costs are passed through to consumers. Steel tariffs have been implemented in 2002, 2018, 2024, and 2025 with current literature focusing on 2002 and 2018 tariff effects. We will be running a two regression analysis on time series data from 2000 to 2024, the data will include monthly tariff data, production, unemployment, inventory levels, lagged sales, recessions, strikes, and producer price index (PPI) to determine if there is a causal relationship between steel tariffs and the number of automobiles produced in the United States. Since steel tariff data varies by grade and stage of production, the first regression will predict tariffs' effect on PPI. This predicted value will be used in our second regression as our independent variable. We hypothesize that steel tariffs will lead to higher steel costs as manufacturers switch to domestic steel or pay the premium on foreign steel. While controlling for demand, our hypothesis concludes that domestic automobile manufacturers produce less during months with steel tariffs and pass the costs through to consumers. Compared to previous literature, our research differs by including a broader time range and analyzing the effects producers confront. Our findings will apply to all domestic automotive manufacturers and they will also have implications for the existing and upcoming tariff policies by the new administration. Our results will help manufacturers brace for the impact of steel and aluminum tariffs while providing insights for the government administration on the decision to implement additional tariffs.

Project Mentor: Mark Schweitzer, Department of Economics, Case Western Reserve University

## Agora: The New Student Marketplace

**Avalon Haney,** Computer and Data Sciences; **Stephen Hogeman**, Computer and Data Sciences; **Adriana Kamor**, Computer and Data Sciences; **Levi Ladd**, Computer and Data Sciences; **Sarah Mahmoud**, Computer and Data Sciences; **Jaiden Borowski,** Computer and Data Sciences; **Jennifer Puzey**, Computer and Data Sciences

After observing the current disorganized use of CampusGroups to sell items, the common struggle of finances for college students, and a lack of sustainable options, our team has come up with an alternative solution that builds community on campus through a college-focused marketplace application. Agora allows the campus community to advertise goods and services in the form of an online marketplace, promoting affordability and the reusability of items as well as empowering students to utilize their talents. Users can list items or skills they would like to sell along with their preferences on items or skills they would like to purchase. Once a user finds an item or service they are interested in, the user can save that posting and reach out to the poster if they wish to complete a transaction. The application's core feature is the browsing functionality, which involves a swiping-style mechanism. Users swipe left or right to either “dislike” or “like” an item or service being advertised in addition to a traditional search function, making users feel more engaged and excited to participate in campus commerce. Furthermore, filtering options via user preferences are also available to assist in narrowing the user’s marketplace feed. Focusing on the college demographic, user email addresses will be verified via student email addresses, ensuring a higher level of trust between users as well as keeping transactions localized to the campus.

Capstone Instructor: Shuai Xu, Computer and Data Sciences, CWRU)

## Comparing Floral Scent Compositions of Kadua affinis, Kadua cookiana, and Kadua foggiana using Gas Chromatography/Mass Spectrometry

**Debra Boutom**, Chemistry

The majority of flowering plants rely on animal pollination in order to outcross, as animals have the ability to accurately seek out inflorescences of the same species. Each species may employ a variety of strategies, including the utilization of visual and olfactory cues, to attract desired niches of pollinators. Kadua is a genus of 30 species in the Rubiaceae (coffee family) restricted to the Pacific, with most species endemic to the Hawaiian islands and pollinated primarily by insects. While the flowers of many species have a similar appearance (small and white), Kadua contains substantial variation in floral scent between species, likely reflecting corresponding variation in pollination strategies. To begin investigating this diversity, volatile organic compounds (VOC) were analyzed from three closely related Hawaiian species: K. affinis, K. cookiana, and K. foggiana. VOC were collected from wild and cultivated plants in Kauai, Hawaii, USA, using a dynamic headspace collection method and analyzed using thermal desorption and gas chromatography/mass spectrosometry (GCMS). Terpenes were the VOC class produced most abundantly by each species, and K. cookiana notably produced a significant variety of sesquiterpenoids. K. affinis samples, while having the lowest VOC variety of the three species, showed the most even distribution of peak areas in its primary scent composition. In contrast, the K. cookiana and K. foggiana samples both had significantly more VOC than K. affinis, with (+)-linalool and -ocimene alone making up the vast majority of the VOC abundance in their respective species. (+)-Linalool is commonly used to attract nighttime pollinators, particularly nocturnal moths (Raguso, 2016). □-ocimene, however, is more associated with bee pollination (Huang et. al, 2022). Both compounds were dominant in K. affinis samples and found alongside other strongly-smelling compounds, suggesting that K. affinis may be pollinated by a wider variety of insects than K. cookiana and K. foggiana.

Project Mentor: Elliot Gardner, Department of Biology

**Development and Optimization of a VTOL Hexacopter for Precision Payload Delivery in Wildfire Suppression**

**Caleb Brady**, Mechanical Engineering; **Mitchell Schultz**, Aerospace and Mechanical Engineering**; Lincoln Reiter**, Aerospace and Mechanical Engineering; **Joshua Paine**, Mechanical Engineering

This project presents the development of a hexacopter unmanned aerial vehicle (UAV) designed for precision payload delivery in wildfire suppression scenarios. The research aims to enhance aerial firefighting capabilities by optimizing payload capacity, endurance, and stability while ensuring modularity for field repairs.

The hexacopter is engineered to carry and deploy 8-ounce water bottles in a controlled manner, targeting early-stage wildfires. The propulsion system is designed to support a 25-pound maximum gross weight, with weight distribution strategies minimizing center-of-gravity shifts during payload drops. A MATLAB mission model script evaluates performance, integrating aerodynamic and propulsion system dynamics to optimize endurance and hover efficiency.

The electronics architecture prioritizes reliability, incorporating a Pixhawk 6X Pro Flight Controller, RTK GPS for high-precision positioning, and a custom companion computer for synchronized payload actuation. ESC telemetry aids in PID tuning, ensuring optimal stability and response. Finite element analysis and structural testing validate frame integrity, with the final design leveraging carbon fiber and 7075-T6 aluminum for an optimal strength-to-weight ratio.

Preliminary flight testing confirms the UAV's ability to maintain stable hover, execute controlled drops, and withstand wind disturbances. Further testing will refine mission performance and payload accuracy. This research demonstrates the potential of UAVs in autonomous firefighting, offering a scalable solution for early wildfire intervention.

Faculty Project Mentor: Majid Rashidi, Department of Mechanical Engineering, Case Western Reserve University

**The Design and Simulation of a Biologically Inspired Material For Use in a Space Debris Collecting Satellite**

**Joseph Schlager**, Mechanical and Aerospace Engineering; **Nicholas Brenner**, Mechanical and Aerospace Engineering

Abstract: Due to the increased importance of space satellites in modern life, it has become increasingly necessary to protect current and future satellites from damage due to space debris. The purpose of this report is to design and test a biologically inspired mesh material for a tensegrity structure proposed by Dr. Cao et al that will be attached to a satellite with the goal of removing small space debris from orbit. The targeted debris is between 1-10 cm in size, an anticipated mass between 1-10 kg, and traveling at a velocity relative to the removal satellite between 100-1000 m/s. The material will focus on achieving a high level of energy absorption capability while taking full advantage of Dr. Cao's existing tensegrity structure, which is designed to collapse inward under sufficient force and expand once sufficient kinetic energy has been absorbed from the debris. After exploring biological materials such as Abalone nacre and mussel bysuss we have elected to incorporate an orb weaver spider web into our mesh to take advantage of its energy absorption and distribution capabilities. Existing research demonstrates the web's ability to evenly distribute applied energy to all radial threads, regardless of the location of the applied force, which is ideal for the tensegrity structure application. To test this we will be modeling multiple web structures in Abaqus and performing simulations to optimize our design according to the required debris parameters supplied by Dr. Cao. The goal will be to develop a web structure capable of absorbing sufficient kinetic energy from collected space debris for safe debris removal. Once concept feasibility and optimization have been completed we will construct a physical prototype out of Kevlar for further testing and research.

Project Mentor: Dr. Chase Cao, Assistant Professor, Department of Mechanical and Aerospace Engineering, Case School of Engineering

Capstone Instructor: Dr. Majid Rashidi, Department of Mechanical and Aerospace Engineering, Case School of Engineering

## PTSD and Moral Injury: A Comparative Analysis of Intervention Models and Clinician Roles

**John Paul Brewster,** Psychology and Sociology

Clinicians in recent decades have witnessed an increasing number of PTSD survivors enduring unique symptomatology sets that go beyond the standard DSM-5 paradigm. These symptom sets are not exclusive to active or former combatants but also to civilians and potentially correlate with complex PTSD relating to a moral injury. Moral injury can be understood as a psychological wound resulting from one's willing, perceived, or forced actions that violated their own moral values. Understanding PTSD in relation to moral injury is imperative to building an effective treatment plan. This review seeks to identify efficacious factors within an integrated approach for the treatment of PTSD that considers moral injury's moderating role. Specifically, if the role of the intervention specialist, whether it be a clinician or chaplain, impacts the desired efficacy. A systematic literature review was conducted using the APA PsychInfo database. Three key terms, PTSD, moral injury, and intervention models, were used to search the database. Restrictions and filters such as articles within the last 10 years and empirical methodologies refined the search further. 12 articles that met this standard were reviewed. Results indicated that standard interventions for PTSD where the trauma is a consequence or relating to moral injury, are not effective. Rather, higher efficacy rates are seen with integrated approaches where PTSD and moral injury are equally considered and clinician intervention procedures are accordingly adjusted. Future research ought to examine how interdisciplinary efforts and clinician roles can support the growth of an integrated approach to treatment for other disorders.

Faculty Mentor: Dr. Amy Przeworski (PhD), Department of Psychological Sciences

Key Words: PTSD, moral injury, treatment, integrated interventions

## Cross-Modal Sensory Integration in Aplysia California

**Emily Brobst**, Bachelor of Science in Neuroscience

Previous research on Aplysia californica revealed sensitivity to chemical stimuli applied to the radular surface of the buccal mass, indicated by heightened B4/B5 activity recorded from buccal nerve 3. Recordings from the nerve showed consistent decreases in interspike interval and increases in spike count, with distal to proximal spikes indicative of sensory responses to stimuli. This study aims to corroborate and expand upon those findings by integrating extracellular recordings from the somas of the B4/B5 multiaction neurons with recordings from buccal nerve 3 to improve signal quality and specificity. Based on my previous work, I hypothesize that chemical and mechanical stimulation of the odontophore will elicit greater B4/B5 responsiveness than mechanical stimulation alone. Examining the responsiveness of these neurons may provide a more comprehensive understanding of cross-modal sensory integration and its role in feeding behavior in Aplysia.

Project Mentor: Hillel Chiel, Department of Biology, Case Western Reserve University

## Shape Memory Alloys in Non-Electrical Temperature Indicators

**Margaret Goldstein**, Engineering-Physics; **Erin Brose**, Materials Science and Engineering; **Naja Quatman**, Materials Science and Engineering; Professor John Lewandowski, Department of Materials Science and Engineering, CWRU

Shape memory alloys such as nitinol undergo a reversible temperature-dependent phase transition between two crystal structures, enabling the material to change shape. The mechanical change of a shape memory alloy wire, such as from a bent wire to a straight wire, is triggered by a temperature increase and can be used for non-electrical temperature indicators. Shape memory alloys have a strong temperature-shape dependence which can be utilized in an electrically independent temperature indicator. This project aims to use nitinol wires to provide a visual indicator for a variety of temperatures to be used in quality control applications. A benefit of using shape memory alloys for this purpose is that these temperature indicators can be manually reset, unlike their non-electric chemical counterparts. Nitinol specifically also has high corrosion resistance. These can be used in a variety of fields including pharmaceutical and food safety monitoring.

Project Mentor: Professor John Lewandowski, Department of Materials Science and Engineering, CWRU

**The Effect of RNA Synthesis Inhibition on the Localization of Periaxial Nucleolar Proteins.**

**Alyson Yuen**, Biology, CWRU; **Louisa Hagen**, Biochemistry, CWRU; **Vaishnavi Khandelwal**, Biology, CWRU; **Owen Browen**, Biochemistry, CWRU; Dr. Alan Tartakoff, Department of Molecular Biology & Microbiology

The long arm of chromosome 12 is localized in the nucleolus of the budding yeast, *Saccharomyces cerevisiae*, and includes ribosomal DNA (rDNA) repeats that are transcribed into ribosomal RNA (rRNA) by RNA polymerase I. In metaphase, the elongated rDNA (axis) is found in the mother domain, while the bud usually includes bulk chromatin. This axis is surrounded by an enclosing periaxial region. It includes at least three groups of proteins that contribute to rRNA synthesis: a) Chromatin remodelers, b) RNA Polymerase A (Rpa) subunits, and c) Small nucleolar ribonucleoproteins (snoRNPs). Chromatin remodelers alter the organization of nucleosomes to control transcription. Rpa synthesizes the rRNA. SnoRNPs produce covalent post-transcriptional rRNA modifications. In subsets of control cells, only modest amounts of these proteins were associated with bulk chromatin. To investigate the dynamics of these periaxial proteins, we inhibited RNA synthesis in strains expressing different representative green fluorescent protein (GFP) tagged periaxial proteins (the remodeler Pob3, the Rpa subunit Rpa190, and the snoRNP protein Nop56). In each strain, Htb2, a core histone, was tagged with the red fluorescent protein, mRFP in order to mark the rDNA axis. Three agents (thiolutin, rapamycin, and starvation medium) were used to inhibit RNA synthesis. Thiolutin inhibits yeast RNA polymerases. Rapamycin inhibits Pol I transcription and causes widespread downregulation of metabolism. Starvation medium lacks the carbon and nitrogen required for rRNA synthesis. After treatment with each inhibitor for 1 hour, we tabulated the distribution of each protein in the nucleolus versus bulk chromatin in replicate experiments. These data will be illustrated, allowing us to evaluate the hypothesis that the tagged proteins are mobile. These observations may also help explain why only about half of rDNA repeats are used at any moment in yeast and in higher eukaryotic cells.

Project mentor: Dr. Alan Tartakoff; Department of Molecular Biology & Microbiology, Case Western Reserve School of Medicine

## Women's Perceptions of Autonomy During Labor and Delivery

**Nyah Brown**; Anthropology

My research, based on interviews with five women, seeks to evaluate the degree to which women exert control over their birthing process. My paper will first discuss expectations versus reality pertaining to attitudes regarding unexpected events such as needing a C-section when desiring a vaginal birth. I will also discuss breastfeeding expectations of healthcare professionals which may not align with the goals of mothers, especially related to pumping breast milk. I will then discuss the high degree of medicalization of birth. Three out of five women were medically induced with pitocin, all utilized an epidural, and two delivered via C-section. The use of these medical interventions did not align with the want for natural vaginal delivery as those who underwent C-sections expressed discontent with the procedure. The epidural was seen as quite useful for alleviating labor pain in all women however, there were notable reflections on the want to attempt an unmedicated birth. I will also discuss how non-traditional birthing positions (non-supine) were utilized with the aim of progressing labor which often did not help. However, there were several notable instances in which mothers described a desire to feel more in tune with their bodies instead of relying on nurses when numbbed due to an epidural. Finally, I will discuss how the quality of hospital and care by physicians and nurses was highly correlated with a positive recollection of the overall experience. This will highlight the importance of access to quality care including: adequate staffing, the treatment by nurses, and the treatment of the mother as an individual with preferences.

Project Mentor: Liihong Shi, Department of Anthropology

## High Speed USB Power Delivery Hub

**Zach Brown,** Electrical Engineering**; Carter Graefnitz,** Electrical Engineering; **Jen Lawrence,** Electrical Engineering & Computer Engineering

This project focuses on developing a High Speed USB Power Delivery Hub capable of efficiently delivering power and data to multiple downstream devices. The goal is to design and implement a functional USB hub that supports Power Delivery negotiation while maintaining reliable high-speed data transfer. USB Power Delivery is a rapidly evolving standard with significant implications for modern electronics, enabling faster charging and more efficient power management. However, designing a robust hub involves overcoming hardware and firmware challenges, particularly in configuring USB hub integrated circuits for proper communication and PD negotiation. This project employs an iterative hardware and firmware development methodology, including circuit design, PDC assembly, and firmware programming. Troubleshooting involves testing hardware configurations, validating PD contracts, and refining the firmware to ensure consistent negotiation with downstream devices.

Expected outcomes include a fully functional USB PD hub capable of delivering stable power and supporting high-speed data transfer. This work offers practical insights into power management protocols, firmware development, and real-world hardware debugging, contributing to the advancement of USB PD technology in multi-device environments.

Faculty Project Mentor: Dr. Greg Lee, Department of Electrical, Computer, and Systems Engineering, CWRU.

Our Capstone Instructor: Dr. Greg Lee, Department of Electrical, Computer, and Systems Engineering, CWRU.

## A 20 Year Review of Homicide Gunshot Wound Deaths in Cuyahoga County, Ohio

**Suzanna Bruns**, Biochemistry ; Dr. Joseph Felo D.O.

In the most recent years, the number of homicide deaths has steadily increased. Firearms comprise a large percentage of these total homicide cases, and this number is seemingly rising in comparison to the past 20 years. With the increased usage of firearms in homicides, it has been noted that the number of gunshot wounds per victim is also on the rise. Many of these additional gunshot wounds have been reported as being non-fatal—not hitting major organs or vasculature but rather soft tissues and other non-vital structures. Through reviewing individual autopsy case files for each firearm victim in Cuyahoga County over the previous 20 years, the number of gunshot wounds per decedent was recorded. In addition, these gunshot wounds were determined to be fatal or non-fatal by tracking the bullet path through the body and noting which structures were injured. Age, race, and sex were also recorded for each decedent. Through statistical analysis, the average number of gunshot wounds per victim was tracked in addition to the average percentage of gunshot wounds determined to be fatal per victim. Analysis of these annual statistics may help to understand the rise in interpersonal violence in American metropolitan areas such as Cleveland, Ohio—especially regarding age, race, and sex. Each individual autopsy case file as well as the Annual Statistical Reports were provided by the Office of the Cuyahoga County Medical Examiner in Cleveland, Ohio.

Project Mentor: Joseph Felo, Department of Medicine

## Non-invasive Measurement of Jugular Vein Pressure

**Priya Jayakumar,** Department of Biomedical Engineering, CWRU; **Siva Bubby**, Department of Biomedical Engineering, CWRU; **Aria Patel**, Department of Biomedical Engineering, CWRU; **Erica Rice,** Department of Biomedical Engineering, CWRU

In 2022, about 700,000 people died from heart disease. To predict cardiac distress, clinicians can use the pressure measurement from the distended jugular vein. The most prevalent current noninvasive method for measuring jugular venous pressure includes a visual examination performed using two rulers, providing the mean jugular venous pressure in cm of H2O. The main challenges with this method are time sensitivity and accuracy. It takes time to not only properly position the patient, but also the rulers, as the physician visually determines the angle of the rulers and the location of the vein. Given the significant clinical value that jugular venous pressure (JVP) measurements have, it is important to have a method to quickly and easily measure JVP. The proposed device includes two bevel components (one horizontal and one vertical) with a locking mechanism. A bubble level will be attached to the device to ensure the horizontal component is parallel with the ground during measurements. The vertical component is an adjustable ruler that can be used to measure the distension of the jugular vein. Lastly, the locking mechanism allows the clinician to maintain the rulers' position and fold and unfold the device for portability purposes. This device offers a lightweight, efficient, and mobile method for the physician to more accurately and efficiently measure the JVP of patients in cardiac distress while causing minimal discomfort.

Faculty Mentors: Dr. Colin Drummond, Department of Biomedical Engineering, CWRU; Dr.

Matthew Williams, Department of Biomedical Engineering, CWRU

## Synthesis and Characterization of Phosphaazulenes

**Justin Bucsanyi**, Chemistry

Contemporary life revolves around substances that interact with light. Molecules that include conjugated systems – that is, alternating single and double bonds – are of great interest because they can absorb light. Absorbing this energy allows electrons to promote to excited states; when electrons return back to the ground state, they emit light. According to Kasha's rule, emission of a photon always comes from the lowest excited state. However, some molecules, such as azulene, do not follow this rule. Azulene is an isomer of the well-studied naphthalene but differs because it exhibits fluorescent properties. The highest occupied molecular orbital (HOMO) and lowest occupied molecular orbital (LUMO) for azulene have nodes on different atoms, allowing for fluorescence. The mechanism for this fluorescence occurs from the second excited state; thus, it breaks Kasha's rule. This allows for an array of new derivatives to be developed and characterized for their useful and unique photophysical properties with various heteroatoms, such as phosphorus.

Azulenes have applications that are well studied, such as lasers, light-emitting diodes (LEDs), and solar cells. On the other hand, phosphaazulenes are criminally unstudied molecules: their first synthesis was proposed by Märkl and Reindl in the 1990s. The literature fails to study them in more than a handful of papers, and their scope is limited. Additionally, no prior literature shows specific pi-conjugated systems that involve phosphorus carbon bonding (P=C).

To begin to synthesize these molecules, air-free synthetic techniques were utilized. Use of a Schlenk line will allow us to produce these air-and-moisture sensitive molecules in inert environments to ensure safety and purity. Work on the synthesis of these molecules has begun, but they have not been prepared yet; it is predicted that anti-Kasha emitters will have unique photophysical properties to be manipulated for materials in future projects.

Project Mentor: Dr. John Protasiewicz, Department of Chemistry

## Elucidating Degradation Modes in Silicon Architectures

**Sophia Buffone,** Andrew Lininger, Ina T . Martin, Department of Physics, Department of Materials Science and Engineering, Case Western Reserve University, Cleveland, OH 44106

Over the last decade, new photovoltaic cell architectures have been introduced that exhibit record efficiencies, in response to the increasing need for solar power. However, the implementation of new materials combinations within these structures introduces the potential for new degradation modes, raising concerns about their durability and reliability in the field. Silicon heterojunction (SHJ) solar cells are a highly efficient, next generation architecture, with unique materials including intrinsic hydrogenated amorphous silicon (a-Si:H) and a transparent conductive oxide (TCO), implemented to improve the cell's charge carrier transport. For this study, SHJ solar cells and witness planar c-Si/a-Si:H/ITO film samples will be used to better observe novel interfaces. To study degradation, samples are aged in accelerated weathering chambers that simulate components of outdoor conditions. These include a damp-heat (85℃ and 85% humidity) environment, an isolated UV exposure, and one which cycles between the two conditions. Characterization methods including Secondary Ion-Mass Spectrometry (ToF-SIMS), X-ray Photoelectron Spectroscopy (XPS), and Fourier-Transform Infrared Spectroscopy (FTIR) will be used to analyze changes in layer composition after aging intervals. Through these methods, I aim to improve understanding of degradation pathways in silicon heterojunction architectures exposed to environmental conditions, linking chemical changes to environmental stressors and device quality.

Project Mentor: Ina Martin, Department of Materials Science and Engineering

Capstone Instructor: Idit Zehavi, Department of Physics

## Fibrotic Gene Upregulation by TGF-β in LX-2 Cells

**Victoria Bulkowski**, Biochemistry

Non-alcoholic fatty liver disease (NAFLD) is a progressive liver disorder that begins with hepatic steatosis and can progress to non-alcoholic steatohepatitis (NASH), fibrosis, and ultimately cirrhosis. Fibrosis is characterized by excessive accumulation of extracellular matrix (ECM) components, primarily driven by the activation of hepatic stellate cells (HSCs), characterized by a phenotypic shift of HSCs from quiescent vitamin A-storing cells to ECM component producing cells. Transforming growth factor-beta (TGF-β) is a key regulator involved in the transcriptional upregulation of ECM-related genes during fibrosis. This research investigates the role of TGF-β in regulating two important fibrotic genes, COL1A1 and ACTA2. COL1A1 encodes the alpha-1 chain of the triple-helical structure of type I collagen, while ACTA2 encodes alpha-smooth muscle actin, a protein involved in cytoskeletal contractility, movement, and cell shaping. Together, upregulation of these genes reflects HSC activation and contributes to fibrotic tissue remodeling in the liver. Using the immortalized human HSC line LX-2, gene expression following TGF-β treatment was measured via quantitative real-time PCR (qRT-PCR), normalized to the housekeeping gene HPRT. Results showed a significant and moderately consistent upregulation of COL1A1, whereas ACTA2 expression was more variable across replicates. These findings support the role of TGF-β in promoting HSC activation and ECM remodeling, with a stronger effect observed in COL1A1. The variability in ACTA2 response highlights the need for further experimental improvement. Overall, this study reinforces the importance of TGF-β in hepatic fibrosis and identifies potential molecular targets for prevention and treatment of NAFLD.

Project Mentor: Danny Manor, Department of Nutrition

**ORMIS-PD: An Ontology-Based Clinical Decision Support System for Parkinson's Disease**

**Manu Bulusu,** Neuroscience; Pedram Golnari, Dipak Prasad Upadhyaya, Dr. Satya S. Sahoo, Department of Population and Quantitative Health Sciences

Currently used clinical criteria for diagnosing and characterizing Parkinson's disease (PD) is inconsistent and difficult to use due to its complexity and lack of a conclusive test. To address these challenges, we are developing a clinical decision support system, titled Ontology-based, Real-time, Machine Learning Informatics System (ORMIS-PD) that leverages artificial intelligence approaches including knowledge representation and machine learning to improve the accuracy and consistency of PD diagnosis and prognosis. The ORMIS-PD system captures patient information using the novel Parkinson Movement Disorder Ontology (PMDO) to standardize PD patient data with the goal of streamlined diagnosis/prognosis. At the core of ORMIS-PD is a Django-based web application that interfaces with a PostgreSQL database to manage patient records and clinical metrics. For the application back-end, we leveraged Django's Object-Relational-Mapping system for secure entry, storage, and retrieval of patient information, ensuring data integrity and efficient retrieval for downstream model training and prediction. Meanwhile, we used HTML, CSS, and JavaScript to create an intuitive and interactive front-end interface for healthcare professionals. Overall, this project aims to enhance clinical workflows by providing a streamlined, accurate, and scalable platform for PD diagnosis and prognosis. Our future work will involve the integration of machine learning algorithms to consolidate patient history with current clinical criteria to predict potential disease progression, allowing for more personalized and data-driven clinical decision-making.

Project Mentor: Dr. Satya S. Sahoo, Department of Population and Quantitative Health Sciences

Capstone Mentor: Dr. Ashley Nemes-Baran, Department of Neurosciences

## Cognitive Behavioral Therapy and Trauma

**Zack Bunnell**, Cognitive Science

Cognitive Behavioral Therapy (CBT) has emerged as a leading evidence-based intervention for individuals experiencing trauma-related symptoms. This project plans to research the efficacy of CBT in reducing the psychological effects of trauma, such as post-traumatic stress disorder (PTSD), anxiety, or depression. By analyzing both primary care data from clinical observations and secondary data from pre-existing literature, this study will assess CBT's impact across diverse populations and trauma types.

Current research indicates that CBT significantly decreases symptom severity in individuals with trauma histories. Different forms of CBT, such as Trauma-Focused CBT (TF-CBT) and Cognitive Processing Therapy (CPT), have shown many benefits in specific populations such as children and military veterans.

CBT is a valuable tool in the treatment of trauma. It offers structured and scalable solutions for mental health recovery. This work will emphasize the need for continued innovation and accessibility to ensure broader and more equitable delivery of trauma-informed care.

Faculty Project Mentor: Adam Croom, Department of Cognitive Science

## Mitigated Free Will

**Zack Bunnell,** Cognitive Science

In contemporary discussions surrounding criminology, understanding the dynamics that underpin criminal behavior remains to be a fundamental endeavor. Various factors such as poverty, education, and access to resources have long been labeled as significant determinants of criminal behavior. Due to the influence of these factors on behavior, the concept of free will emerges as an important consideration to take into account. From genes and hormones to culture and upbringing, various external elements can subtly or drastically affect what makes a person act upon certain stimuli, constraining the scope of our sense of "free will". Since this is the case, this project will discover how we can determine what is considered to truly be acting freely, without any constraint, in the context of criminality. Moreover, the role of consciousness in decision-making processes further complicates our understanding of "free will". Conscious awareness provides individuals with the platform to deliberate and reflect upon their actions, seemingly enabling the exercise of free will. This has caused researchers to attribute conscious awareness to the evidence of free will. While it is agreed upon that consciousness plays a deterministic role in behavior, it is the study's view that to fully understand conscious action, one must look to the subconscious mind to elucidate its cause. By examining the external factors that influence criminal behavior, we can re-evaluate our understanding of free will, giving us a more holistic understanding of criminal behavior that can inform future justice policies.

Project Mentor: Fey Parrill, Department of Cognitive Science

**A Genetic Analysis of Histone H3 and BRAF mutations in Pediatric Glioma Patients**

**Cierra Burchett-Norquist**- Department of Biology, College of Arts and Sciences

In pediatric cancer patients, 25% of new cancer cases are a result of high grade and low grade gliomas (pHGGs and pLGGs) within the nervous system. New biomarker research has revealed that many diagnosed pediatric gliomas are driven by Histone H3 and BRAF mutations that interrupt key genetic processes within DNA regulation such as Histone H3.3,H3.1, and BRAFV600E. Unfortunately, these tumor types and their specific mutations often result in deeming patients untreatable, or terminal due to their aggressive nature and treatment resistance. Despite this, new methods of therapy and diagnostics such as liquid biopsies are being implemented and studied to help manage the disease and provide alternative treatment plans for infected patients in a less invasive way. The understanding of the biological impact and implication of these mutations, as well as their diagnostic methods, and their relativity is important for developing precision medicine that targets childhood brain cancer in order to improve the prognosis of infected patients. In this presentation, the literature of underlying genetic changes of pediatric gliomas will be discussed in addition to highlighting new treatments and diagnostic technology being developed to disrupt tumor growth in pediatric populations as well as insights for the future of pediatric cancer care.

Project Mentor: Nancy Dilulio, Department of Biology, College of Arts and Sciences

## Audiokinetic Sculpture

**Abigail Burianek**, Mechanical Engineering and Aerospace Engineering; **Jordan Burnett**, Mechanical Engineering; **Sarah Gerber**, Mechanical Engineering and Aerospace Engineering

The Museum of Science in Boston contains a rolling ball sculpture known as the Archimedean Excogitation created by George Rhoads, who is famous for this type of sculpture. Inspired by his work in the Museum of Science, we wanted to design, manufacture, and assemble a rolling ball sculpture, more formally known as an audiokinetic sculpture, to be displayed on the Case Western Reserve University campus. Thus, we decided to base it on Sears think[box], a cornerstone of creativity for many students. The target deliverable is to create an audiokinetic sculpture that can be displayed and fully document the whole process. With that goal in mind, we began with prototyping. Research is what initiated this step, giving us an idea of how other audiokinetic sculptures operated. By doing this, we were able to take note of the size, materials, and mechanisms utilized. With this in mind, we drafted different systems that could be implemented while considering the limitations of this project. After that, several prototypes were produced, with materials like cardboard and paper, to allow for a three-dimensional analysis of the sculpture. Then, we began the design portion of the process by refining the sketches produced in the prototyping phase. We then selected the ball we would be using for the sculpture and created 3D models of track pieces based on the marble's size, allowing for easy comparison and alterations of track components. Once completed, manufacturing began. Materials were bought and techniques like laser cutting and welding were used to produce track components. After all the pieces were created, we made a case to hold the sculpture. Then, the sculpture was assembled and placed in the case for display, completing the physical deliverable of the project. Documentation was completed throughout the process, fulfilling the second part of the deliverables.

Faculty Mentor: Sunniva Collins, Department of Mechanical and Aerospace Engineering

Capstone Instructure: Majid Rashidi, Department of Mechanical and Aerospace Engineering

## Wind Tunnel Prototype and Testing Abstract

**Lucy Vanderbeck,** Mechanical Engineering; **Greg Burns,** Aerospace Engineering**; Joshua Tam,** Aerospace Engineering

This project includes the design, manufacturing, and preliminary analysis of a miniature, open-loop, aerodynamics wind tunnel prototype. Wind tunnels have played a crucial role in the advancement of aerodynamics since the 19th Century. Our project aims to demonstrate the feasibility of constructing a wind tunnel with standard equipment, a $200 budget, and 15 weeks time. The wind tunnel also serves as an educational tool, helping demonstrate aerodynamic principles such as streamlines, stall, and stagnation in a simple way. The wind tunnel consists of five main sections: the settling chamber, contraction cone, test section, diffuser, and fan unit. The contraction cone follows a modified Bell-Mehta polynomial curve to maximize uniformity and still be manufacturable from wooden panels. The test section is made of acrylic windows for clear visualization. A NACA 2412 and NACA 0012 airfoil were 3D-printed for aerodynamic testing. The entire manufacturing took place on Sears think[box]'s prototyping, manufacturing, and project floors. The prototype required several machines, including a table saw for the diffuser panels, a drum sander for the contraction cone panels, a miter saw for the frames, a laser cutter for the windows and honeycomb, and a 3D printer for the test airfoils. The contraction cone and diffuser panels were constructed from half inch plywood, while the test section frames and mounting structures were made from solid wood. Material selection was based on balancing feasibility and cost effectiveness. The exhaust fan unit was sourced from an external supplier. Final steps of this project were evaluating the wind tunnel's performance through velocity and pressure measurements using a pitot-static tube. These results were compared against other wind tunnels to assess flow uniformity and efficiency. Ultimately, this project demonstrates the potential for small-scale, budget wind tunnels to serve as effective tools in aerodynamic education and research.

Faculty Project Mentor: Majid Rashidi, Department of Mechanical and Aerospace Engineering

Capstone Instructor: Sharon Milligan, Mandel School of Applied Social Sciences

## Mental Health and Stress in Athletes

**Michael Butler:** Psychology BA, Cognitive Science BA

Past research suggests a correlation between active participation in varsity-level college athletics programs and underdiagnosis of various mental health issues, including depression, anxiety, disordered eating, and panic disorders. However, it is not conclusive as to why such a correlation exists. Thus, our study explores potential relationships between scores on measures of various mental health issues in high performing athletes and in non-athlete students. We hypothesize that the internal, external, and environmental stressors athletes face will be associated with greater demonstrated scores of mental health issues, as well as fewer mental health care seeking behaviors. This study utilizes a self-report survey consisting of academically-validated measures of depression (BDI), anxiety (GAD-7), disordered eating (EDE-Q), burnout (SMS), internalized stigma of mental illness (ISMI), administered to both student-athletes and non-athlete students. We also asked questions regarding pressure felt from coaches and peers that may create a barrier to seeking mental health support. We expect to see a relationship between being a collegiate athlete and increased psychopathology. We also expect to see that collegiate athletes are unlikely to identify their symptoms as representative of disordered mental processes, and due to pressure less likely to seek support for these issues. The present research includes a literature review and preliminary study.

Project Mentor: Amy Przeworski, Psychological Sciences, CWRU, Capstone Instructor
Jennifer Butler, Psychological Sciences, CWRU

**CWRUSTU**

**Noah Butler,** Computer Science, Economics; **Alex Wang,** Computer Science; **Mark Wani** Computer Science, Finance; **Brian Zhu,** Computer Science

The field of audio production has evolved significantly since the late 19th century, transitioning from mechanical sound capture to complex digital systems. While modern Digital Audio Workstations (DAWs) offer powerful tools for music production, they often present a steep learning curve and accessibility barriers, particularly for beginners. One key challenge is the transformation of recorded audio into MIDI data, a process that is essential for many production workflows but remains largely inaccessible to novice users. This project addresses the accessibility gap in music creation tools by developing an intuitive, web-based application that leverages artificial intelligence for audio stem separation and MIDI transcription. Using Demucs, an AI-powered model, we isolate individual components of a song—such as vocals, drums, and bass—into separate audio stems. These stems are then passed through a MIDI transcription pipeline using tools like JUCE and GarageBand, enabling users to experiment with and manipulate musical elements without needing advanced production knowledge.

The goal is to streamline the creative process for aspiring musicians and producers by offering an easy-to-use platform that reduces technical barriers. We expect the final product to facilitate greater engagement with music production and provide a foundation for future enhancements, such as real-time MIDI mapping and integration with MIDI controllers.

Faculty Project Mentor: Shuai Xu, Computer and Data Sciences

**Effect of efavirenz treatment on brain sterol and oxysterol content of C57BL/6J mice**

**Makaya Butts,** Neuroscience

Alzheimer's disease (AD) is a progressive neurodegenerative disorder. Currently, there are no disease-modifying treatments available. AD pathogenesis has been linked to disruptions in cholesterol metabolism. The enzyme CYP46A1 is particularly important because it converts cholesterols into 24-hydroxycholesterol (24-HC). Low-dose Efavirenz (EFV) administration has been demonstrated to increase CYP46A1 activity and promote cholesterol turnover, which is the main pathway to remove cholesterol from the brain. Using a healthy mouse model (C57BL/6J) mice, this study intends to investigate the role of CYP46A1 in AD to explore its therapeutic potential and offer crucial insights into the connection between neuroprotection, neurodegeneration, and cholesterol metabolism.

Building on earlier research in AD models, we examined brain tissue from EFV-treated and control mice. We measured 24-HC levels, total cholesterol, and markers of cholesterol biosynthesis, lathosterol, and desmesterol to evaluate cholesterol turnover and homeostasis. According to our results, 24-HC levels increased by 11% without a change in total cholesterol levels, indicating an accelerated cholesterol turnover. Furthermore, whereas desmesterol levels remained unchanged, lathosterol levels increased by 8%, suggesting an increase in neuronal cholesterol biosynthesis but not in astrocytic cholesterol biosynthesis.
These results suggest that efavirenz (EFV) enhances CYP46A1 activity not only in the AD mouse model (5xFAD) but also in the normal mouse model (C57BL/6J). However, more research is necessary to understand EFV treatment's molecular implications fully. We should include Western blot analysis to ensure the EFV treatment increased CYP46A1 levels and behavioral tests to investigate cognitive performance. Additionally, to fully understand the biological processes impacted by CYP46A1 activation and its potential as therapeutic implications, proteomics, acetyl-proteomics, and metabolomics should be integrated into the analysis.

Faculty Project Mentor: Natalia Mast, PhD, Department of Ophthalmology and Visual Sciences

## Safe at Home? Evaluating the Effect of COVID-19 Stay-at-Home Orders on Domestic Violence Incidents

**Joanna Chiu,** Finance and Economics; **Aanchal Nair,** Quantitative Economics, Business Information Technology and Cognitive Science

The COVID-19 pandemic led to nationwide mandates of stay-at-home orders across the country to limit the spread of the virus. Though the policies aimed to keep families safe, unintended costs became prevalent. We use the natural experiment of COVID-19 to test whether domestic violence increases when individuals spend more time together in the home and have less access to outside support systems. This research examines variations in COVID-19 stay-at-home policies on domestic violence calls in Minneapolis, Minnesota through a difference-in-differences model. This study analyzes domestic violence trends in Minneapolis, Minnesota, Omaha, Nebraska, and Iowa City, Iowa. Minneapolis mandated a stay-at-home order between March 2020 and May 2020 while Omaha and Iowa City never implemented a mandate throughout the pandemic. We use county data on daily U.S. state and territorial stay-at-home orders and daily domestic violence incidents from open-sourced crime datasets published by city police departments from 2016 to 2023. We aim to isolate the causal impact of COVID-19 stay-at-home mandates on domestic violence calls through fixed effects regression, difference in difference, synthetic control, and propensity score matching models. Control variables include daily weather conditions, COVID-19 cases, percent of the population who stay at home, dummy for weekend, dummy for school closure, and the total number of police reports that day. Due to extensive past literature, we hypothesize an increase in domestic violence calls in Minneapolis, with stay-at-home orders due to more time spent in enclosed environments and less access to outside support systems.

Project Mentor: Professor Jenny Hawkins, Department of Economics

## Investigating the Effects of Anti-Diabetic Medications on Oncogenic Promyelocytic Leukemia 1 Expression in Estrogen Receptor-Positive Breast Cancer

**Jackie Cai** (Biochemistry)**,** Hung-Ying Kao, PhD (Department of Biochemistry).

Breast cancer (BC) is one of the most prevalent malignancies worldwide, with estrogen receptor-positive (ER+) BC accounting for approximately 70% of cases. Epidemiologic studies link metabolic syndrome and type 2 diabetes to increased ER+ BC incidence and worsened prognosis. The anti-diabetic medications metformin and Glucagon Like Peptide -1 Receptor (GLP-1R) agonists have garnered interest in cancer research, as they have been shown to inhibit mTOR signaling, a key proliferative pathway in cancer progression. Metformin activates AMPK, an energy sensor that directly suppresses mTOR activity, reducing tumor growth. Similarly, GLP-1R agonists, including Semaglutide and Liraglutide, modulate the PI3K pathway and insulin signaling, whose downstream effects may suppress Akt phosphorylation and inhibit mTOR-driven tumorigenic processes.

Previously, our lab has identified Promyelocytic Leukemia 1 (PML1) as an oncogene for ER+ BC. We observe that PML1 knockdown inhibits ER+ BC tumor cell proliferation and high PML1 expression correlates with increased mTOR-mediated metabolic adaptation. Additionally, we observe a significant increase in PML1 expression in MCF7 breast cancer cells upon treatment of selective estrogen receptor degraders (SERDs) and CDK4/6 inhibitors, suggesting that PML1 upregulation may be a mechanism through which ER+ BC develops resistance to drug therapies. Our findings highlight PML1 as a potential target for overcoming endocrine and cell cycle inhibitor resistance in ER+ BC.

Thus, our study aims to explore the interplay between metabolism and therapy resistance by assessing the effects of metformin, Semaglutide, and Liraglutide on PML1 expression and ER+ BC progression. We propose treating ER+ MCF7 breast cancer cell lines with metformin and GLP-1R agonists to determine their impacts on PML1 expression, mTOR signaling, and endocrine therapy response. Our goal is to uncover metabolic mechanisms regulating PML1 and identify novel strategies to overcome hormone therapy resistance in ER+ BC.

Faculty Project Mentor: Hung-Ying Kao, PhD, Department of Biochemistry, Case Western Reserve University School of Medicine, Cleveland, OH, USA

Capstone Instructor: Vivien Yee, PhD, Department of Biochemistry and Case Comprehensive Cancer Center, Case Western Reserve University School of Medicine, Cleveland, OH, USA

**Flame Behavior under Varying Ambient Pressures Using a Combustion Chamber to Simulate Lunar Buoyant Conditions**

**Alexander Calabrese** Mechanical Engineering, CWRU; **Simon Cubas,** Mechanical Engineering, CWRU**; Ethan Hutchinson,** Mechanical Engineering, CWRU

The flame spread process is governed by the ambient pressure and gravity, parameters that vary in lunar and outer-space environments. This experimental study investigates how different pressure and flow conditions develop and affect the burning behaviors (flame spread and extinction) of a solid material. A combustion chamber is used to artificially manipulate the buoyant flow to mimic some aspects of the flow in reduced gravity environments, with the results providing insight into how material flammability can vary for use in future space missions. To achieve this outcome, a flow loop is used to condition the combustion chamber to the desired ambient pressure that enhances the buoyant flow boundary layer thickness, mimicking that in reduced gravity environments. Our burn experiments utilize polymethyl methacrylate (PMMA) material, performing both concurrent and opposed flow trials. MATLAB code is developed to post-process the flame images obtained in the experiments. The experimental findings (flame spread rate and burnt sample length) are compared between different ambient pressure conditions. In summary, as the ambient pressure decreases, the flame weakens and burns the sample less effectively than at higher ambient pressure.

Faculty Project Mentor: Dr. Ya-Ting Liao, Mechanical and Aerospace Engineering, CWRU

Capstone Instructor: Dr. Majid Rashidi, Mechanical and Aerospace Engineering, CWRU

## Syzygy: A Physics Simulation Language

**Hayden Caldwell**, Computer Science; **Callum Curtis**, Computer Science; **Jacob Leider**, Computer Science and Mathematics; **Jonas Muhlenkamp**, Physics and Computer Science

Physics simulation is an important tool both for education and research. Simulations allow students to visualize physical concepts in memorable ways and also serve purposes in advanced research applications in many fields. Current options for such simulators, however, are either primarily targeted toward the video game industry (e.g. Unity) or custom-built for single use cases within academia. Furthermore, these simulators either use a complex user interface for configuring systems or require their users to learn fully-fledged programming languages like C# or Python. This presents an unnecessarily steep barrier of entry for novices interested in creating their own physics simulations, whether for teaching others or for personal investigation. Our project, Syzygy, aims to reduce this barrier of entry and make simple yet highly customizable simulations accessible to people without strong programming backgrounds. Syzygy includes a physics simulation DSL (domain–specific language), a compiler, and visualization software. User input comes in the form of straightforward commands to create particles and forces within the simulation. Syzygy parses this user input into a JSON object, which is compiled into a simulation program that maintains and updates the state. Parsing and compilation are implemented through Python libraries and modules. A separate animation module displays the simulation. This visualization is then integrated into a web app user interface, which will provide users with a wide array of options for adjusting the view of their simulation.

Project mentor: Shuai Xu, Department of Computer and Data Sciences

## Comparing Experimental Centroid and Shear Center Responses to Theoretical Results

**AJ Campbell,** Mechanical Engineering; **Will Cassano,** Mechanical Engineering; **David Fleck,** Mechanical Engineering; **Gwendolyn Hayes** Mechanical Engineering; **(All are Mechanical and Aerospace Engineering)**

When a beam is subjected to lateral loads, it deflects laterally. Beam theory provides an equation for predicting the deflection of the beam based on the loading conditions. However, if the load is not applied through the shear center of the beam, the beam both deflects and twists, such that each point on a given cross-section deflects a different amount. This leads to the obvious question: Which point on the cross-section profile obeys the beam deflection equation? This project aims to determine experimentally, using a low-cost test rig, which point on the cross-section profile obeys the beam deflection equation. Our team started with initial research looking into the theory behind beam deflection, specifically cantilever beams. The team then designed a test rig aimed at targeting deflection in a way that could be measured. With some preliminary calculations, the team settled that a 1.5 ft beam with a 25 lb force applied at the end would produce enough deflection to be measured using a cell phone camera and image processing. The team did some preliminary testing with MATLAB image processing tools and determined that by placing dots on the beam and having a ruler in frame for scale, the team would then be able to use the MATLAB image processing toolbox to measure how much deflection is occurring. From there, we will compare with the theoretical equations to see whether or not there are discrepancies. Additional experimentation to characterize the warping of the cross-section will also be conducted.

Project Mentor: Richard Bachmann, Department of Mechanical and Aerospace Engineering

Capstone Instructor: Majid Rashidi, Department of Mechanical and Aerospace Engineering

## A Safe Haven: Evaluating the Role and Impact of Child Advocacy Centers in Supporting Children

**Elena Cangahuala,** Psychology

Child Advocacy Centers (CACs) play a critical role in supporting children who have experienced abuse and neglect by combining law enforcement, child protective services, medical professional, and mental health providers to create a coordinated, trauma-informed response. This literature review examines how CACs impact the recovery and well-being of abused children through their multidisciplinary approach and specialized services. It will explore the effectiveness of the multidisciplinary team (MDT) model in reducing trauma, improving forensic investigations, and facilitating access to specialized services such as forensic interviews, medical evaluations, and trauma-focused therapy. Drawing on both qualitative and quantitative research, this review analyzes the experiences of children and families involved with CACs, as well as statistical outcomes related to case processing, mental health recovery, and legal effectiveness. Additionally, it discusses the challenges CACs face, including resource limitations, interagency communication barriers, and disparities in service accessibility. While research highlights the positive impact of CACs in mitigating the effects of child abuse, ongoing policy development and further research are necessary to enhance service delivery and ensure equitable access for all children in need.

Faculty Mentor: Sharon Milligan, Mandel School of Applied Social Sciences

Capstone Instructor: Sharon Milligan, Mandel School of Applied Social Sciences

## A Hierarchical Graph Neural Network for Kinase-Substrate Association Prediction

**Allan Cao**, Philosophy and Computer Science

Protein phosphorylation is an important post-translational modification in cellular processes. While biotechnology advances have increased the amount of identified phosphorylation sites it is often the case that there is no information on which kinase has phosphorylated which substrate. Because of the high cost in experimentally validating kinase substrate associations, previous research has focused on developing deep learning models for site-specific prediction of kinase substrate associations. Furthermore, current knowledge of kinase-substrate associations is biased towards well-studied kinases that already have many phosphorylation sites associated with them. This study introduces a novel approach that uses a hierarchical graph neural network (HGNN) model. The proposed method utilizes Alphafold2 predicted protein structures and transforms them into protein residue graphs. These serve as a bottom-view of the HGNN, where the explicit tertiary structure and residue-level ESM-2 embeddings serve as edges and node features. The method then proposes a novel application of hierarchical graph neural networks by shifting the protein-protein interaction formulation of the prediction problem to a site-specific, subgraph based method and enriching the density of the subgraph by also extracting 2-hop neighbors of the relevant residues. Finally, the model incorporates a top-view "structural interactome" that incorporates the global landscape of kinase substrate interactions.

The study performs model comparisons with other state of the art site-specific models. It also analyzes overall prediction accuracy and the contribution of various versions of the model that use different structure edges and subgraph-extraction techniques. In order to evaluate the efficacy of the project in an applied research setting, the study reports a stratified Top Hit@k analysis that ranks and categorizes kinases depending on how well-studied they are. It also explores zero-shot learning approaches to generalize to kinases and phosphorylations that are not seen during Training.

Project Mentor: Dr. Mehmet Koyutürk, Department of Computer and Data Sciences

## Spinoza, Negri, and Networks of Technology

**Allan Cao**, Philosophy and Computer Science

Michael Hardt and Antonio Negri wrote Empire in 2000, where they argued that imperialism has transformed into a global, decentralized form of capitalism. They also argued for a collective, global democratic body called the multitude. These ideas eventually fell out of favor after a series of major geopolitical events and the advent of new forms of digital technology. However, Negri's work was strongly influenced by the 17th century rationalist philosopher Baruch Spinoza, whom Negri wrote about in his first major work The Savage Anomaly. The goal of this project is to draw upon the same tools of Spinoza as Negri drew upon in Empire to understand large networked and algorithmic systems as contemporary instances of "subjectivity without a subject." Negri grounds this understanding in biopolitical production which operates through knowledge, communication, and language in the process of social constitution. Understanding these systems in Spinozist terms like imagination, conatus, bodies, and mind allows us to see political potential in the affective aspects of social media, the attention economy, knowledge production in generative AI, and the proliferation of human/tech hybrids in cognitive/physical artifacts. This reinvigorates the multitude by advancing analysis on the process of subjectivization in digital technology as a constituent project.

Capstone Mentor: Dr. Laura Hengehold, Department of Philosophy

## Sit-to-Stand Mobility Aid

**Ana Cao,** Mechanical Engineering; **Henry Houston,** Mechanical Engineering; **Allen La Tournous,** Mechanical Engineering; **Maxum Staples,** Mechanical Engineering

This project focuses on the creation of a portable mobility aid device capable of assisting people in moving from a sitting position to a standing one. Devices currently available on the market are bulky, and prohibitively expensive. Additionally, the complexity of sit-to-stand devices limits the potential applicable use cases, due to inherent design choices, such as lift location, size, and lift methodology Our mission is to create an alternative that is easily accessible to people by making it light and portable, affordable, and battery-operated.

The body of our design is made of a fabric-like, flexible rubber that's assembled into a shape consisting of two parts: a rectangular base that lifts the user upward, and a wedge-shaped top that tilts them forward, aiding in the standing motion from the seated position. Inflated by a battery-operated air pump, the bladder is sealed using heat treatment at the seams, stitching, and seam tape. This design will meet all expected requirements, and deliver these results at a lower cost to consumers. Whether the individual employing this device is an elderly person with limited mobility or someone with a disability that affects their range of motion, our design is meant to be easily used by anyone, no matter their circumstances.

Faculty Advisor: Majid Rashidi, Mechanical Engineering Department, Case Western Reserve University

## A Meta-Analysis on the Effectiveness of Using Music Therapy to Reduce Anxiety in Adult Gastrointestinal Procedures

**Hannah Caraballo**, Cognitive Science

Procedural anxiety is a common feeling among adults scheduled to receive medical or surgical care. Existing research suggests that rather than using sedatives or medications, therapeutic approaches such as meditation, aromatherapy, or music therapy should be utilized. These relaxation methods avoid adverse drug effects and are often inexpensive ways of comforting patients. However, it is important to use the most effective strategy to prevent additional patient stress. Therefore, this meta-analysis outlines the overall effectiveness of music therapy (compared to a no-music control condition) as an intervention in reducing adult anxiety before and during gastrointestinal procedures. The procedures included in this study are colonoscopies, endoscopies, and flexible sigmoidoscopies. Following PRISMA guidelines, meta-analytic research was conducted to illustrate the efficacy of music therapy in the healthcare setting using randomized controlled trials collected from the Google Scholar search engine. Using a random effects model, the meta-analytic research found a small yet statistically significant effect for music therapy in reducing anxiety ($k = 7$, $SMD = -0.366$, $p = 0.018$). Anxiety levels can have an impact on patient outcomes as highly anxious patients may require more medication or procedure time. Effective music therapy can be a practical way of comforting a patient before and during their medical procedure to ensure a positive patient experience and recovery. This meta-analytic study will further discuss the strengths, limitations, and implications of the usage of music therapy in reducing adult anxiety in the healthcare setting.

Faculty Mentor: Adam Croom, Department of Cognitive Science

## Creating from Cognitive Science: Playwriting with Principles of Surprise Cognition

**Liv Carle**, Cognitive Science and Psychology

In the never ending battle against boredom, entertainment consumption and pursuit of surprise are two key players. The aim of this project is to gather and summarize a strong base of existing research on the intersection of surprise, narrative, and social cognition, and use those findings to create an original narrative work meant to stimulate cognition and evoke a surprise response in audience members. Mechanisms of surprise cognition will be examined through multidisciplinary studies that focus on attention, expectation, neurophysiology, language and organization, with specific focus on narrative structure. This information will then be used to inform and guide the creative process to produce an original narrative crafted to thoughtfully and intentionally stimulate cognition. For the purposes of this project, the form of a ten minute play has been selected as the ideal medium. Film is used more often in the current research due to its incredibly high accessibility, but since the focus of this project is the creative process rather than the viewing experience, live theater is prioritized for its immediacy, inherently social nature, and increased avenues for sensory activation. With the rise of technology and constant exposure to stimuli, many individuals have begun using excessive media consumption as a tool to reach mental disengagement and experience temporary relief from stress (Huff, 2022). The aim of this project is to gather research and create a novel work meant to activate sensory awareness, stimulate cognition, prompt reevaluation of expectations, provide a sense of interpersonal connection from shared experience, elicit a surprise response, and ultimately, to produce a shock to the system rather than numbing it.

Faculty Mentor: Vera Tobin, Department of Cognitive Sciences

## Chromium diffusion in iron meteorites

**Patricia Carrig**, Environmental geology, Environmental studies

The manganese-chromium radionuclide decay system is a commonly used dating tool for early solar system objects, and aids in the study of the age, size, impact history, and cooling rates of the differentiated parent bodies of iron meteorites. The age recorded by the Mn-Cr system represents the time when chromium isotope exchange between minerals ceased, which is known as the closure time. This closure time is determined by the rate of diffusion through the minerals. In iron meteorites, the mineral troilite (FeS) serves as the primary sink for radiogenic chromium, which is generated by manganese decay. I will present new experimental data on the diffusion of chromium from a metal alloy into troilite at temperatures relevant to iron meteorites. The diffusion couples used in the experiment consist of an iron-chromium alloy with 5 wt% Cr and pure troilite. Individual cylinders of fully dense FeS and (Fe,Cr) metal were synthesized from powders in a piston cylinder at 1.5 GPa. Disk-shaped slices of these two materials were then placed together in piston cylinder assemblies, each of which was compressed to 1.5 GPa and then heated to the desired temperature. Diffusion profiles across the interface of the materials are measured using scanning electron microscopy. The diffusion coefficients of chromium both into the troilite and out of the (Fe,Cr) alloy are determined by fitting the diffusion profiles using the diffusion equation for a semi-infinite composite medium.

Research Advisor: James Van Orman, Ph.D., Department of Earth, Environmental, and Planetary Sciences

Capstone Instructor: Ralph Harvey, Ph.D., Department of Earth, Environmental, and Planetary Sciences

**Investigation of Machine Learning Models for Automatic Whole Gesture Annotation**

**Kate Carter,** The Distributed Little Ren Hen Lab, CWRU Cognitive Science

Communication is multimodal, yet most research into human communication has been on spoken or textual language due to the abundance of resources for creating and processing text-based datasets. Other aspects of multimodal communication such as facial expressions and gestures are understudied due to a lack of tools to create and analyze large datasets of audiovisual data. In the age of data science, new tools for multimodal data analysis have emerged. These have enabled advancements in multimodal communication research when properly adapted for linguistic analysis. This project investigated and qualitatively assessed machine learning models for co-speech gesture annotation. Two models, ViViT and TubeViT, have been identified as performing well on video datasets with similar hand focus and granularity as would be required for linguistic gesture analysis. TubeViT, trained on an HMI Gesture dataset, has proven effective in recognizing five classes of co-speech gestures. Going forward, this project aims to train a model to automatically recognize 8-12 classes of co-speech gestures to enable the annotation of large datasets for co-speech gestures. This will build upon labor-intensive manual tagging methods to study multimodal communication. Automatic whole gesture classification will expand the potential for large corpus analysis and is specifically designed to be integrated into the Red Hen Visual Search Engine pipeline.

Project Mentor: Mark Turner, Department of Cognitive Science

## Moving the Needle on Sudden Infant Death Syndrome: A Multidisciplinary Review of Environmental and Physiological Components

**Isabella Caruso**, Biological Anthropology

Sudden unexpected infant death syndrome (SUIDS) is currently the number one cause of death in infants between 1 month to 1 year of age in the United States. In the 1980's, SUIDS rates sat at approximately 150 deaths per 100,000 live births. Beginning in the 1990's SUIDS cases significantly decreased by over 50%. This decrease correlates with the implementation of public health initiatives that focus on infant sleep position and environment such as the "Back to Sleep" campaign. However, since 2011, SUIDS rates have reached a plateau, still resulting in about 2,500 deaths in the United States per year. This literature review focuses on current knowledge of the etiology and epidemiology contributing to SUIDS. While safe sleep education has proved to be an important piece of the SUIDS puzzle, the purpose of this review is to highlight many other environmental, biological, and pathological factors that pose a significant risk. The overall findings suggest that SUIDS is the result of multiple synergistic factors that disproportionately affect those of lower socioeconomic status. A lack of adequate resources, nutrition, and education produces an environment that amplifies biological risk factors. These findings suggest that to move SUIDS rates below the current plateau, it may be necessary to target these environmental factors when shaping public health initiatives.

Capstone Instructor: Dr. Lawrence Greksa, Department of Anthropology

## Hydraulic Fracturing & Housing Prices: Evidence from County-Level Data

**Anne Castagnero**, Economics & Political Science

Unconventional oil and gas drilling (UOGD) has occurred, and continues to occur, extensively throughout Pennsylvania and has since the initial fracking boom in 2008. There has been research into the environmental and health-related issues related to fracking, both in and outside of Pennsylvania. Papers in 2017 and 2022 found correlations between low infant birthweight and childhood cancer rates related to proximity to fracking locations (Currie et al., 2017; Clark et al., 2022). One of the main perceived economic benefits of hydraulic fracturing has been its positive impact on the housing market. This paper hypothesizes that the new, publicly available health and environment-related data may change the impact of fracking on housing prices. We pose multiple empirical models to examine this relationship. They include a DiD between Pennsylvania and New York state, along with a staggered DiD between counties within Pennsylvania. We will also include propensity score matching and a synthetic controls model. We expect to find that housing values fall as more information about fracking is made readily available or that housing values increase as fracking has become less prevalent in Pennsylvania. Once the relationship between fracking and housing value is established, this could have potential implications for PA policy to possibly increase fracking regulations.

Faculty Project Mentor: Jenny Hawkins, Department of Economics

Capstone Instructor: Jenny Hawkins, Department of Economics

**What are the Impacts of Gaming Exclusives and Subscription Services on Console Sales?**

**Isaac Gunaseelan**, Computer Science, Economics; **Christopher Castellanos**, Economics

The console gaming market was worth approximately 35 billion dollars in 2019 and is expected to continue growing. Due to this, it is increasingly important for console producers to consider video game release strategies. It is becoming common for gaming companies to restrict games so that you cannot play it on any other console but their own; as well as purchasing already existing, popular intellectual property (IP) from other developers to gain exclusivity rights to games. Producers have also been offering subscription services, which allow users to gain access to library games for a monthly fee. Console-exclusive games allow producers to attract customers who otherwise would not have considered their offerings. Furthermore, they allow console producers and developers to charge higher prices for games since there is no competing console for an exclusive game. The implications of this might influence the way companies release their games or consoles, the way consumers get their games, and even legal precedents for antitrust laws. Using time series from 2003 - 2023 with data on the number of game releases, console sales per year, and other metrics, we utilize regression and to analyze the impact of exclusive game releases on console sales over time. We use difference-in-difference to examine console sales before and after the introduction of subscription services. The model we use controls for console price, critic scores, and performance capabilities of consoles among other things. Our research adds to the existing literature by focusing on exclusive video games sales and exploring the introduction of subscription services in online game markets. We expect that exclusive video game releases and the introduction of subscription services will enable higher console sales. Our hope is to inform gaming companies on this relevant aspect of their industry and to provide insights that could shape future policy and strategies.

Project Mentor: Professor Jenny Hawkins, Department of Economics

## Family Separation Due to Deportation: Psychological, Economic, and Social Consequences on Latine Families

**Sofia Castillo,** Psychological Sciences

The United States is home to over 11 million undocumented immigrants, the majority from Latin America, many of whom live in mixed-status families (Pew Research Center, 2021; Migration Policy Institute, 2022). Immigration enforcement policies have led to widespread deportations, disproportionately affecting Latine communities and forcibly separating thousands of families. Recent increases in enforcement efforts under the current administration have renewed concerns about the psychological, economic, and social consequences of family separation, making this an urgent issue. This study is a narrative literature review synthesizing peer-reviewed qualitative and quantitative research from 2010 to 2024 to examine how immigration enforcement policies impact Latine families' mental health, financial stability, and trust in institutions. Key terms such as “Family Separation” “Deportation” “Immigrant Latino Families” were used to find sources from APA PsycInfo, Google Scholar, and PubMed. Findings indicate that family separation severely disrupts child-caregiver relationships, contributing to anxiety, depression, and PTSD in children and heightened stress and financial hardship for caregivers. Latine families affected by deportation often experience social withdrawal and avoidance of healthcare and legal systems due to institutional distrust. While some protections, like DACA, have reduced mental health risks, aggressive enforcement policies have deepened community-wide fear and uncertainty. The continued impact of family separations highlights the urgent need for trauma-informed immigration reform and expanded mental health resources for Latine immigrant families.

Faculty Mentor: Anastasia Dimitropoulos, Psychological Sciences

## Chair Assist Device

**Abigail Morse,** Mechanical Engineering; **Josue Cervantes,** Mechanical Engineering

Approximately 10.2% of adults, especially those above the age of 75 years, have reported difficulties standing up or remaining standing for longer than two hours, and even though there are several existing products that offer various levels of standing assistance, many of them are too large and expensive for the majority of people in need. These devices on the market are not suitable for all the people who develop a minor difficulty in standing due to aging, deterioration of cartilage and ligaments, and reduction in muscle mass. Our goal was to design and fabricate a cost-effective device that is a simple alternative to improve the quality of life of all these people. The working principle of the device is a wedge, and the user will crank a long threaded rod to cause linear movement of the wedge. The wedge raises up the person's seat, and the seat will angle upward on a hinge. This mechanism is capable of raising a person of up to 200 lb and height of 7' with just a few turns of a crank. At its highest setting, the seat can be lifted to an angle of about 30 degrees. The 18"x 18"x 3" design allows for easy transportation and fits on most personal chairs or sofas. While not a user-ready product, the prototype serves as a concept for a working device that meets the desired requirements.

Project Mentor: Dr. Majid Rashidi, Department of Mechanical and Aerospace Engineering

## Evaluating the Efficacy of TYK2 Inhibition in Large Granular Lymphocyte (LGL) Leukemia Using Deucravacitinib

**Hannah Chae,** Biochemistry, Zachary Brady (Translational Hematology & Oncology Research, Cleveland Clinic Lerner Research Institute), Jaroslaw Maciejewski (Translational Hematology & Oncology Research, Cleveland Clinic Lerner Research Institute)

Large Granular Lymphocyte (LGL) leukemia is a rare lymphoproliferative disorder characterized by the clonal proliferation of cytotoxic T cells or natural killer cells. Patients often present with cytopenias, autoimmune manifestations, and recurrent infections. A hallmark of LGL leukemia is the constitutive activation of the Janus kinase-signal transducer and activator of transcription (JAK-STAT) pathway, particularly involving STAT3 and STAT5. Tyrosine kinase 2 (TYK2) is a member of the JAK family, which can function as an upstream kinase to activate STAT3 and STAT5. Approximately 70% of LGL leukemia patients harbor somatic mutations in the STAT3 gene and 40% in STAT5, leading to persistent activation that promotes leukemic cell survival and proliferation. LGL patients also have elevated serum levels of TYK2 mediated cytokine pathways, such as interleukin-2 (IL-2), interleukin-15 (IL-15), and interleukin-23 (IL-23).

Deucravacitinib (Sotyktu) is an oral, selective inhibitor of TYK2, currently used to treat plaque psoriasis. Given the reliance of LGL leukemia cells on cytokine-driven JAK-STAT signaling for survival, targeting TYK2 with deucravacitinib presents a promising therapeutic approach. By inhibiting TYK2, deucravacitinib may effectively disrupt the aberrant signaling pathways that contribute to the pathogenesis of LGL leukemia, offering a novel treatment strategy for this challenging disease.

In this study, we conducted an ex vivo study using peripheral blood mononuclear cells (PBMCs) isolated from both healthy individuals and patients diagnosed with LGL leukemia. Following informed consent, blood samples were collected, and PBMCs were isolated. The isolated cells were cultured under standardized conditions and treated with varying concentrations of deucravacitinib, both in the presence and absence of IL-2. Cell viability assays were performed at designated time points to assess the differential responses between healthy and leukemic cells. We hypothesized that deucravacitinib would selectively inhibit the survival and proliferation of LGL leukemia cells, while exerting minimal effects on healthy PBMCs.

Faculty Project Mentor: Jaroslaw Maciejewski, Translational Hematology & Oncology Research, Cleveland Clinic Lerner Research Institute

Capstone Instructor: Vivien Yee, Department of Biochemistry

## Fiber Supplementation on the Morbidity and Mortality of Sepsis

**Kunal Chand**, Biology and Medicine

Sepsis is a life-threatening syndrome characterized by dysregulated host immune responses to infection. Emerging evidence suggests that dietary fiber may play a protective role in sepsis through its influence on gut barrier integrity and immune modulation—two critical components of sepsis pathophysiology. This study investigates whether prebiotic dietary fiber supplementation modulates immune responses and mitigates organ dysfunction in sepsis.

A murine cecal ligation and puncture (CLP) model of polymicrobial sepsis was used to induce sepsis following a two-week dietary regimen of either high-fiber (HF) or low-fiber (LF) intake. ELISpot assays were performed on murine splenocytes to quantify interferon-gamma (IFN-γ) and tumor necrosis factor-alpha (TNF-α). Additionally, flow cytometry was used to determine the relative distribution of $CD3^+$, $CD4^+$, and $CD8^+$ T-cell subsets in splenocytes.

Mortality between low and high fiber was not significant (n=15 per group, 7 deaths in each group, p= 0.96). High fiber was protective from hyperinflammation compared to low fiber (TNF: mean spot number of 10.9 ± 4 in high fiber conditions and 17.3 ± 2.97 in the low fiber conditions). It was also protective in adaptive readouts (IFN-γ mean spot number of 98.7 ± 50.9-high fiber, 107 ± 35.5 in the low fiber conditions). The high fiber group had a mean of 1534 ± 354 $CD4^+$ T cells, and the low fiber group had a mean of 1747 ± 282 $CD4^+$ T cells. The high fiber group had a mean of 3866 ± 656 $CD8^+$ T-cells, and the low fiber group had a mean of 3740 ± 903 $CD8^+$ T-cells.

The findings may provide critical insights into how nutritional modulation influences immune reconstitution and gut integrity, informing potential dietary strategies for mitigating sepsis-related morbidity and mortality.

Faculty Mentor: Dr. Kenneth Remy, School of Medicine

Capstone Mentor: Christopher Cullis, Department of Biology

**Selective inhibition of CBP/p300 in rhabdomyosarcoma reveals H2B acetylation as a biomarker for enhancer addiction**

**Matthew S. Chang**, Md Imdadul H. Khan, Jordyn L. Kelly, Bhavatharini Udhayakumar, Maya K. Al-Haddad, Carrietta Farma-Hai, Abbey M. Murcek, Berkley E. Gryder Department of Genetics and Genome Sciences, Case Western Reserve University School of Medicine, Cleveland, OH, USA Department of Nutrition, Case Western Reserve University School of Medicine, Cleveland, OH, USA Cancer Genomics and Epigenomics Program, Case Comprehensive Cancer Center, Cleveland, OH, USA

Enhancers drive oncogenic transcription by recruiting key co-factors, including the paralogous histone acetyltransferases CBP/p300, which facilitates chromatin remodeling and gene activation through histone acetylation. In alveolar rhabdomyosarcoma (aRMS), the oncogenic fusion transcription factor PAX3-FOXO1 (P3F) exploits these enhancer-bound co-factors, hyper-activating *cis*-regulatory elements to sustain an aberrant transcriptional program by directly recruiting CBP/p300 via P3F's activation domain. To disrupt this dependency, we developed a dual targeting CBP/p300 inhibitor termed "IHK-44" using structure-guided medicinal chemistry. Here, we observed that IHK-44 treatment reduces aRMS cell proliferation, causes widespread reduction in histone acetylation, and selectively down-regulation of P3F-target genes. Furthermore, we discovered that H2B N-terminus acetylation (H2BNTac) is a biomarker for enhancer-addicted cancers, and a strong predictor of cancer cell vulnerability to CBP/p300 inhibition. These findings reveal a novel axis to identify cancers driven by enhancer addiction with high levels of H2BNTac as well as the therapeutic potential of targeting CBP/p300 in such enhancer-addicted cancers.

Project Mentor: Fu-sen Liang, Department of Chemistry

## Prosthetic Finger System for Phalanx Amputation

**Alexander Chen**, Biomedical Engineering; **Somin Jung**, Biomedical Engineering; **Mau Koishida**, Biomedical Engineering; **Andre Lozano**, Biomedical Engineering; Colin Drummond, PhD, and Matthew Williams, PhD Department of Biomedical Engineering, Case Western Reserve University, Cleveland, OH

Phalanx amputation, more commonly referred to as a severed finger, is a common occurrence among middle-aged men with a yearly incidence rate of 13.8/100,000 people in the 45-64 age group1. The cause of these amputations traces back to blue collar work, such as farming equipment, hydraulic roller, and woodworking 2,3. Current prosthetics in the market are expensive and rely on electrical components that require regular maintenance. Given the significant decrease in the strength and functionality of a missing finger, we aim to restore the capacity to perform daily activities by designing a purely mechanical prosthetic finger system. Furthermore, this device will be designed to be an affordable discretionary expenditure for the patient by lowering production costs. Our design mainly relies on 3D printed components for customizability and affordability. Three components that model the finger knuckles will be fitted together with non-elastic and elastic strings that generate coupled forces for hinge joint movement. The use of 3D printing allows for changes in the design and fit of prosthetics to be easily adaptable to the specific needs of different users without significantly increased cost. The interaction between non-elastic and elastic components utilizes mechanical energy that is driven by the motion of the residual finger. As a result, the prosthetic simulates a healthy finger with an aim of 50 N pulling and 15 N pushing force4,5. With a structurally integral component assembly, The system will enhance the compromised grip capacity from phalanx amputation. The simplicity, affordability, and functionality of this system will increase precision and grip strength to improve activities of daily living, such as lifting heavy equipment and operating machinery. By creating a device that can generate enough force to accommodate the strength of other healthy fingers, we aim to mitigate the difficulties that patients may face in their line of work.

Faculty Project Sponsor and Mentor: Dr. Collin Drummond, Department of Biomedical Engineering, Case Western Reserve University

## CubeZone

**Ethan Kaji,** Computer Science; **Eric Yu,** Computer Science; **Annie Chen,** Computer Science; **Mia Yang,** Computer Science

Chatbot applications based on large language models (LLMs) such as OpenAI's ChatGPT, Microsoft's Copilot, and Anthropic's ClaudeAI have made a significant impact on the convenience of many daily tasks and have become a powerful resource for all individuals. Large language models and applications that incorporate them present a convenient way for both technical and nontechnical individuals to interact with the vast amount of information that models have been trained on. However, constructing LLM-based models is often complex, requiring knowledge of programming languages, cloud-based computing, and APIs to build and query LLMs. Despite the difficulty in building such applications that involve the usage of LLMs, "LLM wrappers" have been revolutionizing significant aspects of daily life thus increasing the necessity for simplifying the process of building LLM-based models. Our project, CubeZone, aims to democratize the construction of LLM applications through a modular, visual approach, providing nontechnical users a seamless experience. Ultimately, CubeZone seeks to simplify the construction of LLM applications for non-technical users by allowing the development of customized chatbots without any written code or prior computer science knowledge. It does so by showcasing a simple and intuitive frontend application where users can drag and drop their desired LLM and LLM adjacent elements, constructing a graph of connected components. After a valid graph has been constructed, CubeZone produces a chat interface based on the components the user selected. CubeZone's frontend will utilize the React to allow the user to construct their applications through a flowchart-building frontend. This will allow users to add custom nodes to their flowchart, connecting outputs together as they design applications. These nodes will then be sent to a python-based backend, running a FastAPI web server via a standard REST API. CubeZone's backend where the users and their constructed graphs will be stored in a SQLite database.

Project Mentor: Shaui Xu, Department of Computer and Data Sciences, Case School of Engineering

## Piggy Bank: Budgeting Application

**David Lee**, Computer Science; **Benjamin Wang**, Data Science & Analytics; **Boyang Chen**, Computer Science; **Sohan Muppidi**, Computer Science; **Ahmad Yaseen**, Computer Science

People often struggle with finances and find it difficult to track and manage their expenses effectively, leading to overspending and financial stress. Traditional budgeting solutions are often time-consuming, difficult to learn, and hard to maintain. With a rise in online spending, subscription services, and increased inflation, it's easy to lose track of spending habits. Piggy Bank addresses this need with an intuitive, AI driven platform that simplifies budgeting and offers visual insights, helping users take control of their finances.

Piggy Bank is a web application designed to help people track their expenses and manage their own finances. The platform allows users to input their income and expenses while categorizing their spending for better financial organization and planning. Users can log their income and expenses, assigning them to different categories for better financial oversight. Piggy Bank will visualize user's spendings using interactive charts and summaries to provide users with clear insights into their spending habits. Users will also be able to set a budget goal for themselves and be able to monitor their spending over time. To further assist users with their finances, Piggy Bank includes a basic AI assistant that offers simple budget suggestions based on spending patterns. This helps users find ways to save money and adjust their budgets as needed. The application will additionally be integrated with iOS and databases will be matching across platforms to allow for mobile access to the Piggy Bank.

Project Mentor: Shuai Xu, Department of Computer and Data Sciences

## Physician Position Monitoring System During Surgery

**Jarvis Chen**,Department of Biomedical Engineering; **Jacqui Palen**,Department of Biomedical Engineering; **Jaden Rivera**,Department of Biomedical Engineering; **Kunal Seetha**, Department of Biomedical Engineering, Case Western Reserve University, Cleveland, OH

Over 80% of surgeons experience work-related musculoskeletal injuries as a consequence of awkward or static positions sustained over long surgeries, according to Schlussel et al. Due to the growing prevalence of work-related musculoskeletal disorders (MSDs) in surgeons, we designed a way for physician positions to be monitored during surgery. This would essentially be a risk management system for residents early in their career that may be compromised to poor posture or MSDs. Thus, they may not be able to perform surgery for the adequate hours of operation. By managing this risk, we would be able to elongate their hours able to spend in surgery, therefore resulting in better patient outcomes. Some key criteria selected in our design were measurements of position, size, comfortability, and affordability. The design we selected consists of an accelerometer/goniometer combined sensor placed on a comfortable compression shirt along the direction of the spine, and an additional combined sensor placed in a headband on the back of the head. The goal is to be able to measure physician posture from the spine angle readings of the sensors, and provide insights on how residents at risk can better correct their position during surgery to reduce the risk of contracting MSDs. An example of a key metric that would be derived by the sensor is time spent by the neck in a flexed spinal position. Based on this metric we would advise the surgeon to take intermittent breaks and extend the spine to avoid working in a flexed position. Future work for this design involves further revision of the prototype to improve accuracy of the measurements and development of a software interface that provides in depth visualizations for the physician to follow key metrics that help them the most in managing their at-risk posture during surgery.

Faculty Project Mentor: Dr. Colin Drummond, Department of Electrical Engineering, Case Western Reserve University, Cleveland, OH

**Reference Free Cell Type Deconvolution from Spatial Transcriptomics using Graph Laplacian**

**Qianhe Chen**, Applied Mathematics

Spatial transcriptomics is a novel imaging technology that enables the exploration of gene expression in tissue samples while preserving spatial context. However, due to limited resolution, most platforms capture mixed signals from multiple cell types per spatial spot, necessitating computational deconvolution to infer cell type composition. Existing methods often require reference single-cell data or rely on strong distributional assumptions, limiting their generalizability and applicability, especially in clinical or novel tissue settings where reference data are unavailable. The method, named FAST (Flexible Analysis of Spatial Transcriptomics), integrates gene expression, spatial coordinates, and histology images via a graph Laplacian regularization framework**.** By constructing a biologically informed adjacency matrix that captures spatial proximity and histological similarity, FAST effectively resolves complex tissue architectures without relying on external references or marker genes. The Capstone project focuses on understanding the paper on FAST and reproducing numerical results on simulation data. In the future, we will complete real-data analysis. Overall, this work provides valuable insights into high-resolution cell-type mapping in spatial transcriptomics, and reproducing it serves as an important step in extending its applications to other biological contexts.

Faculty Mentor: Weihong Guo, Department of Mathematics, Applied Mathematics, and Statistics

## Determining the Relationship Between Butterflies' Wing Area and Coloration and Their Thermal Tolerance

**Wei Chen**, Biology

As ectotherms, butterflies rely on environmental temperatures to regulate their body heat, influencing their behavior, movement, and ecological roles. However, climate change presents a significant challenge, as rising temperatures and increasing extreme heat events threaten their survival and disrupt their habitats. Larger insects tend to experience less variation in body temperature than smaller ones, suggesting that greater size may provide a thermal buffering advantage. Additionally, previous research indicates that butterfly wing coloration plays a key role in thermoregulation, with darker pigments typically heating and retaining it effectively. In this study, we compared butterflies along a gradient from pale to dark pigmentation—including white, yellow, orange, brown, and black—to assess how wing color and size influence thermal tolerance. Using Winfolia, we measured wing area and coloration. Also, we obtained thermal tolerance across multiple species in Ohio. Our results showed that butterflies with larger wings had higher heat tolerance, likely due to their ability to absorb and retain warmth. Darker-colored butterflies, particularly those with deep brown and black pigmentation, appeared better equipped to tolerate high temperatures, while paler butterflies, including white and yellow species, showed more varied thermal responses. Brightly colored species like yellow and orange butterflies may experience unique thermoregulatory dynamics by balancing solar reflection with selective heat absorption. However, the limited diversity of species in our study and variations in pigmentation intensity may have contributed to mixed results. This knowledge could be useful for conservation efforts, especially as climate change influences butterfly habitats.

Faculty Project Mentor: Jean Burns, Department of Biology

## How External Economic Forces Shape the Performance of Prominent Chinese Manufacturing Firms

**Yifei He,** Mathematics, Economics; **Yinyuan Chen,** Economics

China's manufacturing sector occupies a central position in the global supply chain, but economic uncertainty is profoundly impacting the industry amid an increasingly complex global economy. How do rising fuel prices, RMB exchange rate fluctuations, US-China trade frictions, and shocks from the COVID-19 pandemic affect the revenue growth of Chinese manufacturing firms? Existing studies have primarily focused on macro-level impacts or individual variables, lacking a comprehensive quantitative analysis of multiple external economic factors at the firm level. This study fills this gap by using firm-level quarterly data for the first time to quantitatively analyze the impact of multiple external macroeconomic variables on Chinese manufacturing firms' revenues. The study selects eight representative firms from various industries and employs a fixed-effects panel regression model, using the rate of change in revenue ($\Delta \ln(\text{Revenue})$) as the dependent variable. Key explanatory variables include RMB-USD exchange rate fluctuations, fuel price changes, US-China tariff adjustments (dummy variable), and COVID-19 shocks (dummy variable). Meanwhile, China's and the U.S.'s GDP growth rates are controlled, and seasonal effects are eliminated through quarterly dummy variables. This study uses quarterly data from 2017-2023 to ensure coverage of market changes before and after the U.S.-China trade friction and the pandemic. This study proposes the following hypotheses: rising fuel prices increase transportation costs, especially for firms relying on maritime and air logistics; RMB depreciation may enhance export competitiveness while simultaneously increasing the cost of imported raw materials, creating a dual impact on profitability; higher U.S. tariffs on China reduce revenues for export-oriented firms, particularly in industries heavily reliant on the U.S. market; and China's and the U.S. GDP growth rates positively impact manufacturing firm revenues, reflecting the driving force of market demand. This study contributes by offering practical insights for business strategy optimization, such as using fuel futures to hedge transportation costs, employing financial instruments to manage exchange rate risks, and adjusting global supply chain layouts to adapt to tariff fluctuations. Additionally, it provides theoretical support for policymakers in shaping trade policies and industrial support measures. Amid growing global economic uncertainty, this study offers targeted decision-making guidance for Chinese manufacturing firms and policymakers.

Project Mentor: Professor Mark Schweitzer, Department of Economics

## Rapid Screening of TOPCon Solar Cells for UV Degradation

**Sijia "Jelena" Cheng**[1], J. Diego Zubieta Sempertegui[1]; Nicholas Moser-Mancewicz[3], Sophia Buffone[1], Nqobile G. Tshuma[1], Evan Jones[1], Carlos Biaou[4], Jonathan L. Bryan[4], Kristopher O. Davis[2], Mariana I. Bertoni[3], Laura S. Bruckman[1], and Ina T. Martin[1]

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This study investigates the impact of ultraviolet (UV) exposure on the durability and long-term performance of Tunnel Oxide Passivated Contact (TOPCon) photovoltaic cells. With the increasing deployment of TOPCon architectures attributed to their superior efficiency, understanding their vulnerability to UV-induced degradation (UVID) is critical for accurately predicting operational lifespan and ensuring module reliability. Employing an accelerated UV exposure methodology, unencapsulated TOPCon solar cells sourced from multiple manufacturers underwent high-intensity UV radiation designed to replicate prolonged outdoor conditions within a significantly condensed timeframe. Comparative analysis highlighted substantial variability in degradation among different cell batches, with certain samples demonstrating efficiency declines exceeding 20% after prolonged exposure. The observed performance deterioration primarily presented as reductions in open-circuit voltage (VOC) and short-circuit current (ISC). Preliminary materials characterizations, including glow discharge optical emission spectroscopy (GD-OES) and transmission electron microscopy (TEM), indicate that differences in the composition and manufacturing processes of passivation layers notably affect degradation rates. Further detailed analysis is expected to elucidate specific material attributes influencing TOPCon cell stability, thereby advancing predictive degradation modeling and guiding optimized material selection for photovoltaic technologies.

Project Mentors: Dr. Ina T. Martin, Department of Physics, Department of Materials Science and Engineering, CWRU; Dr. Laura S. Bruckman, Department of Materials Science and Engineering, CWRU

**Comparing Disparities Between Electronic Health Record Data and "Gold Standard" National Health Interview Survey Data for Inpatient and Outpatient Services**

**Ify Chidi**, Medical Anthropology

Public health surveillance increasingly analyzes EHR (electronic health record) data for health promotion and disease prevention. However, the accuracy of this data depends on how healthcare professionals document and code patient information. This can lead to potential discrepancies between inpatient and preventive care records, as inpatient coding requirements are much stricter than those for outpatient services. This study examines inconsistencies in EHR data, particularly pertaining to preventive services that may occur outside the hospital setting.

Using the 2023 National Health Interview Survey (the oldest and largest health survey in the United States) as a gold-standard comparison, this study analyzes discrepancies in reported key health measures, including live birth rates, prescription medication use, emergency room visits, wellness visits, and adherence to recommended screenings for colorectal, prostate, breast, and cervical cancer. EHR data for this study were obtained from the TriNetX Research Network, which aggregates de-identified clinical records from over 120 million patients across the United States.

Preliminary findings reveal statistically significant differences in EHR accuracy between inpatient and preventive care data, highlighting potential gaps in public health surveillance. Further research is needed to quantify these discrepancies and assess their implications for healthcare policy and clinical decision-making.

Faculty Project Mentor: Dr. Rachel Pope, CWRU School of Medicine

## Couch Meets Table

**Emma Chio**, Computer Science; **Kevin Ding**, Computer Science; **Gia Hur**, Computer Science; **Bhavya Krishna**, Computer Science

College often brings young students to unfamiliar cities, where they must navigate independent living for the first time. Finding a compatible roommate can be the deciding factor between a good or bad college experience. While CWRU has its own roommate-finding service, it lacks popularity and offers limited preference options. By only asking for a student's living style, but not what they would prefer from their roommate, this eliminates potential matches. For example, a student might go to bed early but prefer a roommate that does the opposite. In addition, being a university platform brings concerns about honesty. Lastly, students may be forced to go with a random roommate which, while sometimes successful, can be risky. These concerns will be mitigated through the use of our platform.

Moreover, CWRU's lottery system requires that a group be full before entering the housing lottery, meaning many tend to be one or two people short of their desired size. As some dorm halls require groups of a specific size, students must find additional members in order to secure their preferred building during the lottery.

Our project, *Couch Meets Table*, is an easy-to-use and personalized platform for CWRU students to find roommates. Students will build a profile and list their roommate preferences and living style. Our algorithm will filter and present potential roommates based on each student's best matches, complete with a compatibility score. Users can choose to swipe on potential roommates. This ensures that students can make informed decisions, reducing potential conflicts and overall improving the chance of a positive college experience.

**Faculty Project Mentor and Capstone Instructor:** Shuai Xu, Department of Computer and Data Sciences

**Effects of Probiotic Supplementation on Infants Born Very Preterm at a Community Hospital**

**Sameera Chiruvolu**, Biochemistry (BS), Case Western Reserve University

To evaluate the effects of a multi-strain probiotic product (Similac Triblend™ consisting of *Bifidobacterium lactis (BB-12®), Bifidobacterium infantis (BB-02™),* and *Streptococcus thermophilis (TH-4®))* on infants born very preterm in a suburban community hospital in North Texas. We hypothesized that a guideline-driven routine supplementation would be associated with a significant reduction of necrotizing enterocolitis (NEC).

Intestinal dysbiosis appears to be an important risk factor for the development of NEC in very preterm infants. Therefore, optimizing the gut microbiome with probiotics may be a favorable strategy to prevent NEC. In the United States, the use of probiotics in very preterm infants had been increasing until the recent FDA warning which prompted majority of the hospitals, including ours, to pause administration. We feel it is important to report this experience with routine probiotics administration and continue to analyze the effects of pausing probiotics in the community hospital setting.

In this cohort study, 60 very preterm infants who received probiotics (two years post implementation; October 1, 2020 to September 30, 2022; Probiotics group) were compared to a historic cohort of 34 VP infants who qualified to receive probiotics, but did not, as they were born one year prior to implementation (October 1, 2019 to September 30, 2020; No probiotics group). The outcomes of interest were NEC and death.

There were no differences in maternal or neonatal characteristics between both groups. Median age of starting probiotics was 12 hours of life and were given until 35 weeks post menstrual age. The incidence of NEC was significantly lower in the Probiotics group (0%) compared to 11.8% in the No probiotics group ($P = 0.02$). Similarly, the incidence of death significantly decreased in the Probiotics group (5%) compared to 20.6% in the No probiotics group ($P = 0.02$). No cases of probiotic sepsis were observed.

Faculty mentor: Jordan Reis MD, Pediatrics, Baylor Scott & White Medical Center – McKinney, Texas

**Determinants of Host Immunity in and Cardiovascular Disease in Rheumatoid Arthritis as measured by COVID Vaccine Induced T and B cell Response and Coronary Artery Calcium**

**Mahathi Chitti**, Nutrition BS

Investigating the T-cell response to COVID-19 vaccine is vital in understanding the long-term implications of vaccination on the prognosis of rheumatoid arthritis (RA) along with cardiovascular health. By analyzing T-cell function through the ELISPOT assay, we aim to identify potential correlations between vaccine-induced immunity and cardiovascular outcomes. The hypothesis continues to be that there will be an increased T-cell expression of proinflammatory markers such as IFNg and IL-2 in the RA samples. The inflammatory process in RA can be assessed through the ELISPOT assay. The peptide pools include CEF peptide pool (cytomegalovirus, Epstein-Barr virus, influenza virus), N/M COVID protein spanning peptide series, SARS-CoV-2 Spike Protein peptide pool (15-mer peptides with 11-amino-acid overlaps that cover amino acids 1 - 1273 on the spike protein), and Phytohemagglutinin P (PHA, mitogen). To date, we have performed 25 assays comprising 190 patient samples; however, 26 samples were excluded due to inadequate cryopreserved cell viability. Preliminary data reveal that in controls COVID spike antigen specific IFNγ responses ranged from 0–800 spot forming units (SFU)/300,000 plated PBMC, while in the experimental RA group responses ranged from 0–900 SFT/300,000 PBMC. IL-2 spike responses were lower overall than IFNg responses and ranged from 0–100 SFU in controls and 0–120 SFU in the RA group. CEF and N/M specific SFU ranged from x-y in RA and control groups. Statistical analysis and comparisons of responses by group and clinical parameters (time since COVID vaccine and/or infection, coronary artery calcium score, RA treatment medication, comorbid medical conditions, age, sex, race) are ongoing, as is determination of COVID spike antibody levels.

Project Mentor: Donald Anthony, Inflammation and Immunity

**Expanding the neurodevelopmental disease spectrum to speech and language disorders**

**Danny Cho**, Department of Biology, Case Western Reserve University

Speech and language disorders arise in childhood and typically resolve in elementary school; however, these disorders can remain throughout life with a variable developmental trajectory that consists of different phenotypes present at specific development stages. 7.7% of children between the ages of 3-17 years have a speech and language disorder, with the most ubiquitous being speech sound disorder (SSD). Childhood apraxia of speech (CAS) is the most persistent and severe subtype of SSD. Although few studies have hitherto analyzed the risk factors for CAS persistence, genetic factors are hypothesized to have implications. Among individuals with CAS, a de novo variant was identified in the gene PPP2R5D (protein phosphatase 2A, regulatory subunit B (B56), delta isoform). PP2A-B56δ holoenzymes are highly expressed in the human brain and play an important role in the neuronal signaling processes. Variants in the PPP2R5D gene have also been identified in children with autism spectrum disorder (ASD). In addition to this genetic overlap, ASD is a neurological and behavioral disorder that exhibits phenotypic overlap with CAS. Shared clinical signs among patients with PPP2R5D-related disorder include speech impairment, hypotonia, macrocephaly, and frontal bossing. Cerebral organoids are derived from human induced pluripotent stem cells (iPSC) and differentiate into structures that recapitulate the developing brain. Analysis of the organoids was conducted using markers staining for neural progenitors (SOX2) and mature neurons (MAP2, CTIP2, and SATB2). Comparison of organoids harboring de novo mutations in PPP2R5D to their isogenic controls will allow for the elucidation of neurodevelopmental similarities and differences between CAS and ASD. The outcome of this research study will reveal how speech and language disorders fit into the neurodevelopmental disease spectrum. Principal Investigator: Dr. Ashleigh Schaffer Department of Genetics and Genome Sciences Case Western Reserve University School of Medicine Faculty Sponsor: Dr. Barbara Kuemerle Department of Biology Case Western Reserve University

Project Mentor: Barbara Kuemerle, Department of Biology

**Determining Distribution of Type I Collagen Fibrils Grafted Perpendicularly to Glass Surfaces with Optical Microscopy**

**Julia Cho**,[1] Danny Saliba,[1] Danielle Latham, [2] Mai Antarasen, [2] Lydia Kisley, [2] Leena Palomo,[3] Steven J. Eppell[1]

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Soft tissue integration of dental implants may be improved by presenting the host tissue with type I collagen fibrils projecting perpendicularly from the implant surface. This is a biomimetic design strategy based on modeling the natural supracrestal fibers attaching gum tissue to teeth. Previous work showed that our lab is able to produce fibrils having this geometry. The goal of this project is to determine the surface density and distribution of these grafted fibrils. The integration of fluorescently tagged type I collagen monomers into the collagen fibrils enables the use of an optical microscope. Since imaging occurs in aqueous conditions, fibrils standing perpendicular to the surface will appear as fluorescent dots, blobs, or lines depending on their orientation. A Z-stack imaging technique will also allow us to determine the height of the fibrils from the surface. The anticipated results will help us evaluate and improve current collagen mimicry/grafting capabilities. The results will also validate previous collected mechanical testing and SEM data regarding fibril density and distribution.

Project Mentor: Prof. Steven Eppell, Department of Biomedical Engineering, Case Western Reserve University

**Photoreceptor Neurodegeneration and Retinal Neuroprotection in an Abca4-/-/Rdh8-/- Mouse Model of Stargardt Disease**

**Chloe Chung**, Department of Neuroscience, Case Western Reserve University; Marcin Golczak, Department of Pharmacology, Case Western Reserve University; Ni Made Airanthi Widjaja Adhi, Department of Pharmacology, Case Western Reserve University

Stargardt disease (STGD1) is the most common form of inherited juvenile macular degeneration, characterized by progressive photoreceptor and retinal neuron degeneration. It arises from mutations in the *ABCA4* gene, leading to impaired clearance of all-trans-retinal (at-RAL) and the accumulation of cytotoxic bis-retinoids. While STGD1 primarily affects cone-rich regions of the retina, rod degeneration is also observed, and the sequence of photoreceptor loss remains unclear. This study investigates the dynamics of photoreceptor degeneration in the *Abca4-/-/Rdh8-/-* mouse model following exposure to bright light. Optical coherence tomography (OCT) imaging, electroretinography (ERG), and immunocytochemistry are used to evaluate photoreceptor structure and function. Beyond photoreceptor loss, retinal neurodegeneration involves complex interactions between neurons and metabolic pathways. The retinal pigment epithelium (RPE) also plays critical roles in photoreceptor survival, synaptic maintenance, and metabolic support. Disruptions in these neuroprotective mechanisms contribute to neuronal dysfunction and cell death. Additionally, we examine the role of cellular retinol-binding protein 1 (RBP1) in neurodegeneration. RBP1 regulates retinoid metabolism, and its genetic deletion or pharmacological inhibition has been shown to reduce bis-retinoid accumulation and protect against retinal damage in *Abca4-/-/Rdh8-/-* mice. Understanding the interplay between photoreceptor degeneration, neuroinflammation, and metabolic dysregulation provides insight into broader neurodegenerative processes beyond the retina.

By integrating structural, functional, and biochemical analyses, this study contributes to our understanding of neuronal vulnerability in degenerative diseases and highlights potential therapeutic strategies for protecting neural circuits in the retina.

Project Mentors: Marcin Golczak, Department of Pharmacology; Ni Made Airanthi Widjaja Adhi, Department of Pharmacology

Capstone Mentor: Dr. David Friel, Department of Neurosciences

## A Review of What Causes Depression in Youth

**Julian Churchill**, Mathematics and Psychology

Mental health has proven itself to be a defining issue of the early twenty-first century. One of the most common cases is related to depression. We have seen a spike in depression rates among younger populations, which can have long term impact across multiple generations if not taken seriously. This paper explores the causes of depression in adolescents in order to raise awareness so that the general population can be more equipped to prevent it. This review analyzed ten empirical articles found using keywords such as depression, adolescents, youth, parenting, parenting style, ACEs, etc. This paper shows that depression in adolescents can be widely associated with the number of adverse childhood experiences (ACEs) that the adolescent, or their parents, went through as a child. This paper also explores how the actions of parents, specifically parenting styles, can affect their childhood negatively. Future research needs to explore how ACEs can be effectively avoided and/or treated in order to prevent the potential long lasting effects.

Faculty Mentor: Amy Przeworski, Department of Psychological Sciences

## Design and Fabrication of Football Helmet Test Rig

**Nate Cikalo,** Mechanical Engineering; **Joe Mele,** Mechanical and Aerospace Engineering; **Daniel Obloj,** Mechanical and Aerospace Engineering; **Tanner Stoops,** Mechanical and Aerospace Engineering

Concussions and traumatic brain injuries (TBIs) in contact sports, particularly football, have raised significant concerns regarding player safety. As a result, many football teams across all levels of competition have implemented a soft-shell cover called the Guardian Cap (GC) to reduce the frequency and severity of brain injuries. While the potential for the GC to reduce TBIs is high, the technology is relatively new. Only this past season (2024) did the National Football League (NFL) allow GCs for in-game use. While the NFL has reported a nearly 50% reduction in concussions among players wearing the GC in the 2024 preseason, countless scholarly articles have found no correlation between GCs and a reduction in concussions. To contribute to this ongoing discussion, this project aims to design and fabricate a low-cost football helmet test rig to evaluate the changes in acceleration of helmets with and without the GC. The test rig will utilize a free-fall drop test method, in which a football helmet is released from a predetermined height and guided along wire ropes to ensure a controlled and repeatable impact. The system is designed to minimize rotational motion and off-axis impacts, allowing for consistent testing conditions. An accelerometer mounted inside the helmet will record impact forces, enabling a direct comparison of acceleration profiles between different helmet models. Three helmet types will be tested, both with and without the Guardian Cap, to assess variations in impact mitigation. By analyzing the acceleration data, this study aims to determine whether the GC provides a measurable reduction in impact forces and improves player safety.

Faculty Mentor and Capstone Instructor: Dr. Majid Rashidi, Department of Mechanical and Aerospace Engineering

**Loss of myeloid-KLF2 alters neutrophil kinetics in response to endotoxemia in neonatal mouse pups**

**Sarah Cioffi,** Statistics; Sriram Satyavolu (The Ohio State University College of Medicine), Asha Thomas (Dept. of Medicine, Indiana University SOM), Yuexin Li (Dept. of Medicine, CWRU), Lalitha Nayak (Dept. of Medicine, Indian University SOM), Devashis Mukherjee (Dept. of Pediatrics, CWRU SOM)

Neonates experience higher mortality during sepsis than other age groups. Sepsis is associated with low levels of the anti-inflammatory transcription factor, Krüppel-like factor-2 (KLF2), which keeps myeloid cells such as neutrophils quiescent. Postnatal day 4 (P4) neonatal mice lacking myeloid-KLF2 (KO) have increased sepsis-related mortality (lipopolysaccharide, LPS) compared to Cre controls, attributable to a pro-inflammatory neutrophil phenotype. P4 KO pups have a lower storage pool of bone marrow neutrophils (BMNs) and higher circulating neutrophils than Cre pups. The mechanistic basis of how KLF2 deficiency disrupts the homeostatic equilibrium between the BM and circulating neutrophil compartments is unclear. We hypothesize that loss of KLF2 leads to an exaggerated release of immature neutrophils into the circulation. Methodology: P3 pups were injected with 5-bromodeoxyuridine (BrdU, which gets incorporated into actively dividing cells), followed by LPS after 18 h. BM was isolated at 0, 1, 2h post-LPS. BM cells underwent extracellular staining for CD45, Ly6G, CD62L, and CXCR4 and nuclear staining for BrdU, followed by flow cytometry and analysis. Results: The BrdU-negative fraction did not differ between Cre and KO pups at baseline or in response to LPS. BrdU-negative CD62LhiCXCR4lo BMNs (immature neutrophils not yet released from BM) were significantly lower in KO vs. Cre at baseline ($p=0.02$, t-test) and decreased significantly faster in response to LPS ($p<0.0001$, two-way-ANOVA). BrdU-negative CD62LloCXCR4hi BMNs (aged neutrophils returned to BM) do not exist in Cre pups, even after LPS, but increase in significant proportions in KO pups after LPS ($p<0.0001$, two-way-ANOVA). These suggest that KO pups have an exaggerated release of immature neutrophils from the BM and an accelerated return of aged neutrophils to the BM, both at baseline and in response to LPS. Future experiments will focus on studies in the circulating compartment to better understand the mechanism behind altered neutrophil kinetics in KLF2-deficient states.

Project Mentor: Devashis Mukherjee, Department of Pediatrics

## Wearable Tremor Control Device for Parkinson's Disease

**Mahi Tomar,** Department of Biomedical Engineering, CWRU; **Maxwell Clark,** Department of Biomedical Engineering, CWRU; **Hyunyi Kim,** Department of Biomedical Engineering, CWRU; **Ava Thompson,** Department of Biomedical Engineering, CWRU

Parkinson's disease (PD) affects approximately 1-3% of people over the age of 80, impacting an estimated 8.5- million people worldwide. Research has shown that one of the main symptoms, hand tremors, impacts over 75% of PD patients. Tremors can significantly interfere with basic daily activities such as writing, eating, and getting dressed. To date, there is no cure or treatment that can guarantee a total elimination of PD tremors. Surgical interventions, such as deep brain stimulation (DBS) surgery, involve substantial recovery periods, carry surgical risks, and may not achieve the desired symptom relief for all patients. Pharmacological treatments, like Levodopa, can initially reduce symptoms but cause side effects that further diminish the quality of life and may lose efficacy over time. To address these limitations, we propose a non-invasive, wearable tremor-control device designed to reduce hand tremors. The device is intended to be comfortable, user-friendly, and effective in stabilizing hand movements, enabling patients to perform daily tasks with increased ease and precision. The system consists of three primary components: an accelerometer sensor to detect the tremor, a microcontroller programmed to analyze the tremor patterns, and a vibration motor that activates to counteract the tremor. The closed-loop system between these three components continuously detects, analyses, and responds to tremors. This allows for maximal tremor reduction and allows for real time tremor stabilization. The device is activated via a momentary push button, providing users with control over when the system operates, and is designed to function throughout the day as the user chooses. Ultimately, this wearable device aims to reduce the impact of tremors, thereby enhancing patient confidence and improving their ability to engage in daily tasks independently.

Project Mentor: Dr. Matthew Williams, Department of Biomedical Engineering; Dr. Colin Drummond, Department of Biomedical Engineering

## Design of a Hydraulic System to Replace Spring-Operated Residential Garage Doors

**Nathaniel Clark**, Mechanical Engineering Major

Traditional residential garage door systems rely on torsional springs to store and release energy, aiding in door operation. These high-tension springs present safety hazards due to potential failure or improper handling. The purpose of this project is to design a hydraulic system that replaces the spring mechanism, offering a safer and more controlled method for opening and closing residential garage doors.

The project focuses on developing a detailed CAD-based design that specifies suitable hydraulic components—cylinders, pumps, valves—and their integration into a typical garage door system. The design must account for door weight, required stroke length, pressure ratings, and force application. Load analysis was conducted to determine the mechanical requirements, which informed component selection. Vendor research identified off-the-shelf parts to achieve the necessary specifications within reasonable cost.

Although fabrication is not within the scope of this project, the design ensures practical feasibility by focusing on commercially available parts and standard installation procedures. Preliminary analysis indicates that a properly sized hydraulic cylinder can replace the spring system without increasing operational effort or cost significantly.

This work demonstrates the potential of hydraulic systems in improving safety and reliability in everyday mechanical operations. The project is ongoing, with final deliverables including engineering drawings, a complete bill of materials, and vendor recommendations.

Faculty Mentor: Dr. Majid Rashidi, Mechanical and Aerospace Engineering
Capstone Instructor: Dr. Majid Rashidi, Mechanical and Aerospace Engineering

## Design and Fabrication of Active Brake Pedal for Integration with Driving Simulator

**Lewis Nguyen, Ethan Klatt, Ethan Cogdill, Roman Quesada**

The demand for realistic and immersive driving and racing simulators has increased, with enthusiasts seeking high-fidelity peripherals such as steering wheels, racing seats, and pedals. Traditional passive brake pedals lack the dynamic feedback experienced in real vehicles, reducing realism. Force feedback brake pedals address this issue by allowing users to experience adjustable pedal stiffness, travel distance, applied force, and feedback from systems like ABS and traction control. However, commercial force feedback pedals are prohibitively expensive, often costing around $1,750 for a single pedal, compared to approximately $80 for a set of traditional passive pedals. This project focuses on the mechanical design, fabrication, and integration of an affordable force feedback brake pedal while leveraging an open-source electronics and software platform for control. The design incorporates a structurally robust yet cost-effective mechanical system that seamlessly integrates with electronic components such as actuators and sensors. Testing is conducted to evaluate functionality, responsiveness, and durability. The project is ongoing, with the goal of achieving a high-performance, low-cost alternative that enhances accessibility to force feedback pedal technology for simulation enthusiasts.

Faculty Project Mentor: Professor Majid Rashidi, Department of Mechanical and Aerospace Engineering, Case School of Engineering.

# 3D Printer Filament Maker

**Cullen Combi,** Mechanical Engineering; **Lukas Dalakis,** Mechanical/Aerospace Engineering; **Matt Rodgers,** Mechanical/Aerospace Engineering; **Sawyer Dockal,** Mechanical/Aerospace Engineering

It is estimated that 300 million tons of plastic waste is generated annually, with 1,500 water bottles thrown away each second. Most plastic bottles may be easily recycled, constructed of polyethylene terephthalate (PET) or high-density polyethylene (HDPE); however, 91% of the world's plastic bottles are not recycled. Novel solutions are mandatory, including incentivizing reuse of waste plastics by cutting costs over virgin material, and feasibly reducing the environmental strain of plastic waste.

One solution is harvesting the formable properties of bottle material in order to produce 3D printer filament. 3D printing has asserted itself within rapid additive manufacturing prototyping, with a global market valuation of $20.4b and an annual growth of 23.5%. Supplementing the use of standard virgin filament is key in reducing plastic consumption.

The fundamental process is to deconstruct the used bottle into a strip, which then is formed into standard filament size and wound along a spool as a near-drop-in replacement. First, the bottle will be cleansed of residue, and non-formable parts, such as base indentations, manually removed. Next, the bottle is cut by a custom blade holder such that the resulting strip may be fed through a modified 3D printer hot end. After the initial feed is accomplished manually, a motor engages the self-winding spool and applies tension to the strip, forcing the softened material to wrap into cylindrical filament as it traverses the hot end.

Over up to two hours, the device will have wound a ready-to-use spool of recycled filament. As the process necessitates a certain pull/flow rate, a key design driver is autonomous operation such that high-quality, usable, and uniform filament is produced without continuous operator involvement. As required with any change in filament material, a custom 3D printing profile should be selected to yield the best results.

Faculty Project Mentor: Majid Rashidi, Department of Mechanical and Aerospace Engineering

Capstone Instructor: Majid Rashidi, Department of Mechanical and Aerospace Engineering

**Microbial diversity at the species- and strain- level affects microbial interactions and influences the growth of an oral pathogen**

**Brynn Connors**, Department of History and Philosophy of Science; **Grace Heine**, Department of Molecular Biology and Microbiology; and Dr. Gina Lewin, Center for Global Health and Diseases

The oral microbiome is responsible for both promoting oral health and driving oral diseases, including the highly prevalent oral disease periodontitis (gum disease). Oral disease is mediated by the virulence of oral pathogens and through their interactions with the commensal oral microbiota. For example, research shows that the commensal bacterium, *Streptococcus gordonii*, alters the fitness and virulence of an oral pathogen involved in periodontitis, *Aggregatibacter actinomycetemcomitans* (*Aa)*. *S. gordonii* modulates *Aa* through the production of hydrogen peroxide and L-lactate, which is the preferred carbon source of *Aa*. Although the interaction between *S. gordonii* and *Aa* is well defined, streptococci are highly diverse at the strain- and species-level in the oral cavity, and little is known about how other streptococci impact *Aa* fitness. We hypothesized that *Aa* fitness varies across interactions with genomically and phenotypically diverse streptococci. To test this, we conducted *in vitro* mono-culture and pairwise co-culture biofilm experiments between *Aa* and 37 diverse streptococcal species and strains followed by quantification of microbial fitness (growth). Across these 30 biofilm experiments, we found that the *Aa* fitness differed between mono-culture and co-culture, with a difference up to 8-logs in survival across co-culture with different streptococci. The variation in fitness in co-culture was significant across taxonomically-distinct clades of streptococci. Furthermore, *Aa* tended to increase streptococcal fitness relative to mono-culture, but the magnitude of this increase varied significantly across the streptococcal phylogeny. Based on these results, we conclude that strain- and species-level diversity alters commensal-pathogen interactions. Future work in the lab will further explore the molecular mechanisms driving these differences using bulk RNA-sequencing. Together, these data will elucidate the relationship between microbial diversity and pathogenicity. Understanding these microbial interactions could potentially provide insight into novel, patient-specific approaches to treat oral disease as well as influence the way we view microbial diversity and oral health.

Project Mentor: Dr. Gina Lewin, Center for Global Health and Diseases

## Self-Balancing Cube

**Colin Corday,** Mechanical Engineering**; Casey Hishinuma,** Mechanical Engineering**; Joseph Hwang,** Aerospace Engineering**; Junhao Su,** Aerospace Engineering

Our Self-Balancing Cube capstone project investigates the design and performance of gyroscopic effects, control theory, inertial effects, and reaction positioning. This project demonstrates these ideas at a university-level capstone project to endeavor to balance our cube on an edge. We will accomplish this by integrating Inertial Measurement Units for orientation sensing, reaction wheels for actuation, and a microcontroller. By leveraging PID controls, the cube will attempt to stabilize itself against any disturbances and external forces on the cube. The primary objectives of our self-balancing cube capstone project are to enhance response time and to maximize the time of stable equilibrium. Potential applications of this technology range from robotics and self-balancing mechanisms to space technology, where reaction wheel-based control is widely used.

Faculty Project Mentor: Majid Rashidi, Mechanical and Aerospace Engineering
Capstone Instructor: Sharon Milligan, Mandel School of Applied Social Science

**Exploring Electrochemical Biosensing as Rapid and Affordable Cancer Detection**

**Caeden Couch**, Chemical and Biomolecular Engineering; Sogol Asaei, Chemical and Biomolecular Engineering

Current cancer detection methods in metabolomics and liquid biopsy require large blood samples, expensive machinery, and long processing times, limiting accessibility and efficiency. This study explores biosensing via electrochemistry, specifically cyclic voltammetry, as a rapid and low cost alternative for detecting cancer-associated metabolites. Our biosensor requires minimal liquid volume and enables nearly immediate metabolite quantification by measuring the electrochemical response of hydrogen peroxide (H2O2) produced from the metabolite's reaction with a sensor-bound protein. Using cyclic voltammetry, we established a concentration curve linking metabolite levels to the induced electrochemical current. In the future, it is envisioned that the biosensors can be organized into an array, allowing for simultaneous analysis of multiple metabolites. These findings demonstrate the potential of biosensing for quick, portable, and cost-effective cancer screening, paving the way for broader clinical application.

Faculty Project Mentors: Jordan Winder, Department of Surgery, CWRU School of Medicine; Julie Renner, Department of Chemical and Biomolecular Engineering

**Automated Test for Steerable Catheter Prototype**

**Tobias Cowles,** Computer and Electrical Engineering ;**Audrey Michel,**Computer and Electrical Engineering **; Shaun Nunoo**, Computer and Electrical Engineering

Heart disease has been the leading cause of death in the United States since 1950. For decades, medical researchers have been trying to develop improved methods of diagnosing and treating life-threatening heart problems that affect millions of people worldwide. One such development is the design of the heart catheter. Heart catheters are thin, flexible hollow tubes that can navigate through major blood arteries and heart chambers to diagnose and treat blood blockages and heart conditions. Heart catheters could contain cameras and sensors for diagnosis of cardiovascular walls and blood pressure, and their hollow tube allows the passage of treatment devices, such as angioplasty and stent placements for treatment of artery blockages. Modern designs of heart catheters use the guidance of X-ray imaging. However, X-ray imaging exposes patients to harmful radiation and the general procedure is invasive. Research in Dr.Cavusoglu's lab focuses on using the power of magnetic fields and MRI imaging as an alternative way to precisely and more efficiently image and steer a heart catheter during surgery. The design adds a set of inductive coils that produce a magnetic field during operation within an MRI-controlled environment to induce force on the catheter, allowing precise movements of the catheter. Using this technology, more intricate heart procedures could be performed faster and more efficiently, leading to improved success rates and quality of medical heart procedures. Our project involves the improvement of the control firmware for the current catheter driver to allow for more reliable current testing. In addition to the catheter driver, we also designed a fully automated testing system to test the functionality of the steerable catheter system for MRI-assisted surgery. Our design aims to test four essential components of the catheter system before use in MR research: connectivity test, resistance test, inductance test, and magnetic field test. These tests will be performed to ensure that the catheter is appropriately tuned and all parameters expected for the proper function of the catheter are accurate. The expected results are based on experimental research and design choices, and our objective is to give a reliable way of demonstrating those choices. After testing, the results can be viewed using a computer via USB which displays all necessary information for confirmation of a fully functioning catheter system.

Faculty Mentor: Dr. Cenk Cavusoglu, Department of Electrical Engineering.

**Everyday Inclusion: Diversity in Children's Picture Books Beyond Tales of Discrimination**

**Roman Valine**, Psychology and Medical Anthropology, Case Western Reserve University

Picture books are a complex form of children's literary media that further the development of written and oral language, encourage critical thinking regarding the surrounding world, and facilitate caretaker-child bonding. Perhaps most significantly is the ability of picture books to also act as reflections of or lenses through which to view the life experiences of all identities of children. In 1990, author Rudine Sims Bishop proposed the theory of mirror, windows, and sliding glass doors in children's literature, which posits that books function as tools through which children can use to see themselves represented or to gain understanding of others. Diverse representation in children's literature has steadily progressed, but many picture books first focus on the oppression of marginalized identities and the effects of that oppression before they turn their attention to the celebration of identity. While these themes are important in their own right, I argue that children should have greater access to picture books where marginalized identities are implicitly normalized through background representation in plot lines unrelated to discrimination. The purpose of this project is to offer a curated list of children's picture books published within the last decade that demonstrate inclusivity in slice-of-life stories as well as present a framework for identifying other picture books that achieve the same goal. This research can then be used to inform the inclusive book choices of local Cleveland nonprofits that are focused on providing children with appropriate literature, including the Literacy Cooperative and the Cleveland Kids' Book Bank.

Project Mentor: Dr. Cara Byrne, Department of English, Case Western Reserve University

## Limitations of the minority stress model and the unique experiences of same-gender parents: An argumentative review

**Lily Crouch**, Psychology

Minority stress refers to the complex network of stress which constantly acts on sexual and gender minorities due to living in a prejudiced and discriminatory society. Little research in the area of minority stress has focused on the unique experiences of same-gender parents. In this review, I will argue that the original minority stress model fails to capture many of the experiences unique to same-gender parents. I will draw on the few studies which have been conducted in this area to explore dimensions of minority stress which go beyond experiences of overt discrimination and disenfranchisement. Last, I will present modifications to the existing model and work towards a more comprehensive conceptualization of minority stress specific to same-gender parents. Although, I qualify that, within a constantly changing social climate, no model or conceptualization will ever approach adequacy in fully articulating the experience of any individual or population.

Faculty Project Mentor: Amy Przeworski, Ph.D Case Western Reserve University, Department of Psychology

**Expanding novel analysis methods for the analysis of dense suspensions**

**Alessandro d'Amico**, Chemical Engineering; Sidong Tu, Abhinendra Singh

For 17th Midwest Regional Conference: A suspension with sufficient solid volume packing fraction exhibits strongly non-Newtonian behavior under shear. In many systems this non-Newtonian behavior is a strong increase in viscosity called shear thickening. With sufficient stress, the suspension's interparticle interactions transitions from predominantly lubricated to frictional-contact-forces dominated state. Frictional contacts between particles stabilize the contact network thus providing resistance to external deformation. This interparticle frictional contact network drives shear thickening but its characterisation remains elusive. We use a cycle characterization technique to analyze the frictional contact network in the dynamic steady state. We find that the third-order loops within the frictional contact network is the main driver of the viscosity and can help us to predict the suspension viscosity regardless of packing fraction, applied external stress, interparticle friction coefficient. This study further elucidates the crucial role of the mesoscale network in connecting the microscopic physics to the macroscopic bulk response of the material. We can characterize our network and collapse the high dimensionality of the microscopic-to-macroscopic phase diagram. As a result, network analysis can now predict system viscosity regardless of stress, interparticle coefficient of friction, and packing fraction. This further elucidates that unweighted mesoscopic network topology determines system viscosity.

Faculty Project Mentor: Abhinendra Singh, Macromolecular Science and Engineering

**Unraveling the Impact of Membrane Binding on EphA2 SAM Domain Interactions and Regulation of EphA2 Receptors**

**Joshua Dadson**, Biochemistry

The EphA2 receptor, a prominent member of the receptor tyrosine kinase (RTK) family, exhibits widespread tissue distribution, with notable expression in the nervous system, cardiovascular system, and epithelial tissues. As a transmembrane protein, EphA2 comprises distinct extracellular, transmembrane, and cytoplasmic regions. Notably, within its cytoplasmic domain lies the sterile alpha motif (SAM) domain, which plays an important role in facilitating protein-protein and protein-nucleic acid interactions through homo- or heterodimerization. Recent investigations have highlighted the significance of SAM in regulating function by suppressing dimerization and tyrosine phosphorylation in solution. This study aims to reveal the impact of membrane binding on the SAM domain's regulatory role within the EphA2 intracellular region (ICR). Understanding how this regulation occurs in a more physiologically relevant environment could provide new insights into EphA2 receptor regulation and signaling pathways in the body, thereby improving therapies that target EphA2 dysregulation observed in pathological conditions like cancer. To mimic receptor-plasma membrane binding, EphA2 ICR were conjugated onto liposomes. The kinase activity was assessed through Western Blots that were analyzed using ImageJ. The first assay determined the ability of liposome tethered wild-type EphA2 ICR to phosphorylate a catalytically inactive form of the receptor (EphA2 kinase dead) that resulted from a D739N mutation in the catalytic loop of the kinase domain. The results were compared to data from the experiment done in solution. The second assay used the same approach to determine the ability of liposome tethered EphA2 ICR without the SAM domain (EphA2 ΔSAM) to phosphorylate EphA2 kinase dead.

Faculty Project Mentor: Dr. Matthias Buck, Department of Physiology and Biophysics

Capstone Instructor: Vivian Yee, Department of Biochemistry

## The Role of MZB1 in Multiple Myeloma: Implications for Pathogenesis and Therapeutic Targeting

**Esther Dai**[1], Qingzhu Wang[2], Wanying Zhang[2], Jianjun Zhao[2]

[1]Biology Major, Case Western Reserve University, Cleveland, OH 44106, USA; [2]Department of Cancer Biology, Lerner Research Institute, Cleveland Clinic, Cleveland, OH 44195, USA.

Multiple myeloma (MM) is a hematologic malignancy characterized by the uncontrolled proliferation of plasma cells and the overproduction of immunoglobulin fragments, which places intense stress on the endoplasmic reticulum (ER). To survive this stress, MM cells rely heavily on the unfolded protein response (UPR). MZB1, an ER-resident co-chaperone protein, plays a key role in stabilizing immunoglobulin folding and maintaining plasma cell viability under high secretory conditions. While MZB1 has been associated with B-cell malignancies, its therapeutic potential in MM has yet to be fully explored. This study investigates MZB1 expression in MM cells and its viability as an immunotherapeutic target. We analyzed MM patient bone marrow samples and identified high MZB1 expression in CD138+ plasma cells using single-cell RNA sequencing, flow cytometry, and immunofluorescence. We then developed a monoclonal antibody-drug conjugate (ADC) targeting MZB1 and tested its cytotoxicity against MM cell lines in vitro. Ongoing experiments involve testing the ADC in a third-generation AEY-PVM MM mouse model to assess in vivo efficacy. This research contributes to the growing field of MM immunotherapies and proposes MZB1 as a novel therapeutic target for future clinical applications.

Faculty Project Mentor:Dr. Jianjun Zhao, Department of Cancer Biology, Cleveland Clinic
Capstone Instructor: Dr. Susan Burden-Gulley, Department of Biology

## Manually Operated Plastic Water Bottle Shredder

**Christopher Damaskos,** Mechanical Engineering **Ryan Joy,** Mechanical Engineering; **Edwin Navarrete**, Mechanical Engineering

This report covers the design, fabrication and testing of a plastic water bottle shredder. The shredder features a handle that drives two rotating shafts equipped with shredder blades. The blades are made out of cold rolled stainless steel that were cut using a waterjet. To ensure user safety, the device incorporates a protective lid that automatically closes during operation. The manual operation eliminates the need for electrical power, making it eco-friendly and cost-effective. The shredder takes _x_ seconds to completely shred a typical plastic water bottle. The estimated production cost is _x_ per unit. This device highlights the potential of simple, manually operated devices to contribute to environmental sustainability and waste reduction

Faculty Project Mentor: Majid Rashidi, Mechanical Engineering

## WorkOrbit

**Duong Nguyen** - Computer Science, **Hieu Dang** - Computer Science, **Aiden Le** - Computer Science, **Harry Vu** - Computer Science, **Albert Tran** - Computer Science, **Anh Phan** - Computer Science

WorkOrbit is an all-in-one AI-driven office assistant designed to streamline modern business operations by unifying communication, document management, and task coordination into a single cohesive platform. Leveraging a FastAPI Python backend, Next.js TypeScript frontend, Firebase Firestore for user authentication, and Google Cloud services for translation and storage, WorkOrbit addresses productivity bottlenecks caused by fragmented workflows and disjointed tools. Core features include real-time multilingual translation via Google Cloud Translation API, a document management system powered by Elasticsearch for both text and vector-based search, and an adaptive productivity chatbot enhanced by Langchain's Retrieval-Augmented Generation (RAG) and OpenAI models. Containerized with Docker for scalability and secured with robust authentication, WorkOrbit reduces cognitive load, centralizes critical functions, and enhances cross-functional collaboration—enabling organizations to boost efficiency, minimize tool overhead, and stay agile in a global, fast-paced business environment.

Project Mentor: Shuai Xu, Department of Computer and Data Science

## Long Term Adjustable Compression Sleeve for POTS Management

**Rea Marfatia, Jake Stahl, Thomas Gaither, Benjamin Danielson**: Biomedical Engineering

Home Institution: Case Western Reserve University (all) Postural Orthostatic Tachycardia Syndrome (POTS) is a condition that affects up to 3 million people in the United States. Patients experience symptoms when transitioning from standing to sitting, including dizziness, lightheadedness, and fainting. This is caused by blood pooling in the lower extremities due to low blood pressure. There is no cure, but basic compression sleeves are the primary form of symptom mitigation. Patients complain that these sleeves are uncomfortable because of unnecessary seams, non breathable materials, not enough compression, and difficulty to put on and take off. These problems lead to low compliance. To increase compliance, our sleeve will be comprised of three components: a loose-leg sleeve made of a cooling material to address the uncomfortableness, two compression bands that wrap around the upper and lower leg to increase compression level, and a dial and wire system that provides the patient with the ability to adjust the level of compression, making it easier to put on and take off. The sleeve provides adjustable, graded compression for large portions of the day that can be worn under standard legwear. It can be worn for at least 12 hours daily and compresses in the 5-50mmHg range. Our device targets individuals with POTS who have tried and tested many means of mitigation and support (i.e. compression socks, Normatec sleeve), know what pressures or conditions they need, and are unsatisfied with the current products' performance.

Faculty Project Mentor: Colin Drummond, Ph.D Case Western Reserve University Department of Biomedical Engineering

## The Price of Profit: Corporate Taxes and Their Impact on Unemployment

**Aidan Dao**, Statistics and Economics, **Julian Higgins**, Economics

Unemployment is a key economic indicator used to assess the effectiveness of public policy. Although modern economic theory suggests a relationship primarily between inflation and unemployment, policymakers continuously seek additional methods of optimizing labor market conditions while minimizing negative economic effects. A key variable that may influence unemployment is state corporate income tax rates. While some states impose no corporate income tax, others enforce various nonzero rates, allowing us to compare and evaluate their effects on unemployment. This research analyzes this effect. Specifically, it determines whether these tax rates have a quantifiable impact on unemployment at the state level. By comparing states with no corporate income tax to those with varying tax structures and rates, this research contributes to ongoing policy debates regarding taxes and economic growth. The analysis spans panel data across the 50 U.S. states from 2005-2025, comparing state-level corporate tax and unemployment rates as key variables while employing a regression analysis and difference-in-indifference approach to compare employment trends between states with and without corporate income taxes. The expected relationship is a negative coefficient on the corporate tax rate variable, suggesting that higher corporate taxes lead to higher unemployment, all else equal. To investigate this relationship reliably, the regression includes control variables of inflation rate, population growth, unemployment benefits, labor force participation rate, educational attainment, and minimum wage. Modern economic theory suggests that higher corporate tax rates reduce business investment, leading to lower job growth. There is potential for other economic factors to offset the effect of these taxes and decrease unemployment. If corporate tax rates demonstrate an ability to significantly influence unemployment, the findings could show policymakers conclusive evidence that tax reductions are favorable to stimulating job growth and the economy. Conversely, if the effect is negligible, it may show that corporate tax policy is not a primary driver of state employment trends, informing policymakers of surprising results that could drive states to consider changes to their corporate tax structure.

Project Mentor: Professor Jenny Hawkins, Department of Economics

**Design of a Wound Sensing Bandage for the Prevention of Surgical Site Infections**

**Alexander Volper**, Department of Biomedical Engineering; **Isabella Zimmer**, Department of Biomedical Engineering; **Jack Xia,** Department of Biomedical Engineering; **Rahul Darbhakul**, Department of Biomedical Engineering.

Surgical site infections (SSIs) are the most common complication during surgical recovery. The development of an SSI can severely impact not only the patient's well-being but also impose significant economic and logistical burdens on the patient and healthcare systems. In the United States, SSIs extend hospital stays by an average of 9.7 days and can add approximately $25,000 in healthcare costs per case. Alarmingly, an estimated 69% of these cases occur after the patient has been discharged, a time during which hospital staff can no longer monitor the wound closely. We propose an innovative wound infection-sensing bandage designed to detect early signs of microbial infection in wounds and increase ease of treatment within a hospital setting. When used for extended periods, traditional bandages can inadvertently create an environment conducive to bacterial growth, leading to infections that may advance to critical stages before the patient or healthcare professionals become aware. The proposed bandage will integrate sensing technology capable of detecting key biomarkers associated with infection, such as pH changes and temperature fluctuations. The bandage will provide visual alerts after processing temperature data collected via thermistors and visual color changes of a colorimetric pH indicator, enabling timely intervention and treatment. The wound-sensing bandage will also incorporate a hydrogel material to absorb wound exudate, preventing the accumulation of harmful microbes, and keeping the wound moist during the healing process. This approach will allow healthcare professionals and patients to proactively conduct dressing maintenance based on real-time feedback, preventing infections from reaching advanced stages, reducing the need for antibiotics, and promoting faster healing. The project aims to create an effective and user-friendly bandage, enhancing patient safety and outcomes in clinical and home care settings while reducing financial and operational stress on patients and the healthcare system.

Project Mentors: Professor Colin Drummond, Department of Biomedical Engineering, Professor Matthew Williams, Department of Biomedical Engineering

Faculty Sponsors: Professor Colin Drummond, Department of Biomedical Engineering, Professor Matthew Williams, Department of Biomedical Engineering, CWRU.

## The Impact of Childhood Trauma on School Performance: Correlations and Mediators

**Haddy Dardir,** Department of Psychological Sciences

Childhood trauma is prevalent in the United States, with approximately 48% of American children having at least one adverse childhood experience (ACE) (Bethell et al., 2014). ACEs are risk factors for a slew of damaging outcomes (Felitti et al., 1998, as cited by Wisnieski et al., 2023). One such outcome is worsened school performance, which can adversely affect the futures of children and adolescents if left unaddressed. The purpose of this narrative review is to investigate how trauma impacts school performance, as measured by grades, test scores, academic engagement, grade repetition, and dropout. The role of academic engagement, resilience, and psychological symptoms as mediators of the relationship between trauma and school performance is also examined. Literature was gathered from general information sources in the OhioLINK Electronic Book Center; the electronic databases Web of Science, Scopus, EBSCOhost, and APA PsychNet; and the search engine Google Scholar. Search terms such as trauma, effect, academic achievement, and school were used for gathering literature. Results indicate that trauma has a negative relationship with school performance in terms of not only academic achievement, but other dimensions of school performance—specifically academic engagement, grade repetition, and dropout—as well. In addition, although findings related to resilience and psychological symptoms as mediators of the relationship between trauma and school performance were inconsistent, academic engagement was found to be a significant mediator of the relationship between trauma and academic achievement. A primary limitation of the findings is the lack of causal evidence for some significant correlations, including the relationship between trauma and dropout. These findings show that trauma can have far-reaching effects on students, and educating everyone involved in a student's education on these effects is necessary to ensure the academic success of trauma-exposed students.

Faculty Sponsor: Dr. Anastasia Dimitropoulos, Department of Psychological Sciences

**Parvalbumin$^{+}$ interneurons and their perineuronal nets exhibit dynamic and dorsoventral position-dependent responses to alcohol exposure and withdrawal in the hippocampus**

**Soumyaa Das** (neuroscience and philosophy), Dr. Sreetama Basu (Department of Neurosciences, Lerner Research Institute, Cleveland Clinic), Dr. Hoonkyo Suh (Department of Neurosciences, Lerner Research Institute, Cleveland Clinic)

Alcoholism, one of the most debilitating addictions in the United States, has driven significant research into the cyclic nature between dependence and withdrawal. A key area of neurobiological interest is alcohol withdrawal syndromes, where abstaining from alcohol after prolonged consumption results in severe symptoms. One notable example is alcohol withdrawal-associated seizures (AWS), where individuals undergoing withdrawal experience convulsions due to the sudden loss of alcohol's inhibitory effects and dysregulation of the brain's excitation-inhibition (E/I) balance. This led to the hypothesis that alcohol exposure and withdrawal disrupt the E/I balance by forming pathological neural circuits that contribute to AWS. However, the exact mechanisms behind the formation of such aberrant circuits in the hippocampus remain unclear. In this study, we focus on the effects of alcohol withdrawal (AW) on parvalbumin-expressing inhibitory neurons (PV-INs), a critical GABAergic cell type in the hippocampus. We fed 9-week-old female C57BL/6 mice a 5% alcohol or calorie-matched diet for 4 weeks, and then analyzed PV-INs during alcohol exposure, acute (24 hours) and prolonged (4 weeks) withdrawal. We observed an interesting pattern: acute withdrawal led to an increase in PV-INs in the ventral hippocampus, while prolonged withdrawal caused a decrease in PV-INs in the dorsal hippocampus. Western blot analyses revealed that the changes in cell numbers were not always parallel with the expression levels of parvalbumin protein, suggesting a complex relationship between PV-IN activity and expression. To explore this further, we used chemogenetic activation of PV-INs to measure global and local levels of PV expression. Additionally, we examined the perineuronal net (PNN) across the dorsoventral axis. These findings highlight that the effects of alcohol withdrawal on PV-INs are dynamic and vary between acute and prolonged withdrawal, shedding light on the putative role of PV-INs in the formation of aberrant hippocampal circuits during AW.

Faculty project mentor: Hoonkyo Suh, Department of Neurosciences, Lerner Research Institute, Cleveland Clinic Foundation

Capstone instructor: Ashley Nemes-Baran, Department of Neurosciences

**Developing an at-home Intraocular Pressure (IOP) Monitoring Device for Glaucoma**

**Dhruv Shah**, Department of Biomedical Engineering; **Corinthian Ewesuedo**, Department of Biomedical Engineering; **Aditya Menon**, Department of Biomedical Engineering; **Anshul Dash**, Department of Biomedical Engineering

Glaucoma, a leading cause of irreversible blindness, affects millions worldwide. While elevated intraocular pressure (IOP) is a crucial risk factor for disease progression, current monitoring methods rely on clinic-based tonometry, leading to irregular measurements—especially among high-risk elderly and veteran patients who lack regular access to medical professionals. This project aims to develop a non-invasive, at-home (self-administered) IOP monitoring device to screen for glaucoma. The proposed device incorporates non-contact tonometry using an air puff delivery system, coupled with a Time-of-Flight (ToF) sensor to measure the corneal deformation caused by the air puff. Signal processing is handled by an Arduino-based unit and MATLAB code which cross-references the corneal deformation to known IOP values using a pre-built calibration curve rather than an infrared laser system that requires highly accurate but inefficient alignment. We are presently incorporating each of these subsystems into the overall housing to create a consolidated device. In addition to elderly and veteran patients, reducing dependency on frequent clinic visits and medical professionals also benefits patients in remote or underserved areas, facilitating regular and routine IOP monitoring. The device will allow all high-risk patients to screen for glaucoma, enabling timely interventions and empowering patients in managing their eye health.

Project Mentor: Dr. Colin Drummond, Department of Biomedical Engineering, CWRU; Dr. Matthew Williams, Department of Biomedical Engineering, CWRU; Dr. Warren Sobol, Ophthalmology-VitreoRetinal Surgery and Disease, University Hospitals Cleveland Medical Center

## Characterization of Lumbosacral Spinal Catecholaminergic Fibers in Mice Model for Amyotrophic Lateral Sclerosis

**Kausar Datta**, Department of Neurosciences

A deeper understanding of neurotransmitter release in the spinal nerves of patients with Amyotrophic Lateral Sclerosis (ALS) may provide a potential therapeutic route to manage symptoms and/or prevent further progression of the disease. The primary objective of this study was to determine the characterization of Spinal Catecholaminergic fibers in ALS mice. SOD1G93A mice (ALS model) and WT mice were procured and the lumbosacral section of the spinal cord was extracted at different time points and IHC was performed for DβH, NAT, and ChAT through IHC protocol. The sections were then imaged and an overlay for the laminae and major nuclei of the lumbosacral section of the spinal cord was placed and transformed using photoshop. The laminae and nuclei were separately imaged and saved. The analysis was done through an image analysis program on MATLAB where the area for laminae I - X, SPSy Nucleus, SDCOM Nucleus and Onuf's Nucleus, was calculated at 0.02 pixels and index of 1, and the intensity of DβH was calculated at 0.02 pixels and appropriate indexes based on the image analysis protocol. ChAT positive cells were manually counted from the photoshop image for each laminae and nucleus, including Onuf's nucleus. NAT staining was not analyzed due to poor staining/image quality. Expected results are that there will be a decrease in intensity of DβH with ALS progression in mice due to similar reductions in DβH intensity seen in spinal cord injury monkey models, but this is hard to determine due to different injuries and animal models (Bingham et al., 1975). Other expected results include a reduction in ChAT signaling with ALS progression in most voluntary motor areas and no reduction in signaling in the Onuf's nucleus (Nagao et al., 1998).

Citation: Bingham, W. G., Ruffolo, R., & Friedman, S. J. (1975). Catecholamine levels in the injured spinal cord of monkeys. Journal of neurosurgery, 42(2), 174–178. https://doi.org/10.3171/jns.1975.42.2.0174 Masahiro Nagao, Hidemi Misawa, Shuichi Kato, Shunsaku Hirai, Loss of Cholinergic Synapses on the Spinal Motor Neurons of Amyotrophic Lateral Sclerosis, Journal of Neuropathology & Experimental Neurology, Volume 57, Issue 4, April 1998, Pages 329–333, https://doi.org/10.1097/00005072-199804000-00004

Capstone Instructor and Project Mentor: Dr.Yu-Shang Lee, Neuroscience Department, Cleveland Clinic.

**Modulation of Aryl Hydrocarbon Receptor Signalling by Tryptophan Metabolites: Implications for the Cancer Immune Microenvironment**

**Dave Jiya,** Biochemistry

The amino acid L-tryptophan (Trp) is metabolized to create a variety of bioactive metabolites that are used by both microbes and mammalian cells as signalling molecules. Several enzymes including indoleamine 2,3-dioxygenase (IDO), tryptophan 2,3-dioxygenase (TDO2) are critical for tryptophan catabolism by the host through the kynurenine pathway. We are particularly interested in how different tryptophan metabolites interfere with the aryl hydrocarbon receptor (AhR) signalling within the tumor microenvironment (TIME). The activation of this receptor affects the activity and differentiation of T-cells, key immune cells that are critical to fighting tumors. We will test a variety of metabolites using a commercial AHR reporter cell line. HT29-Lucia™ AhR cells are engineered from the human HT-29 colon adenocarcinoma cell line to study AhR signalling by monitoring the activity of the Lucia luciferase reporter protein. We quantify changes by measuring average relative light units (RLU) of luciferase expression in the treated cells to measure the changes in AhR activity using a coelenterazine-based bioluminescent assay reagent for luciferase detection. We hypothesize that several tryptophan metabolites will affect AhR activity. These results will help us understand how different tryptophan metabolites affect tumor development. We will further investigate strategies for combating tumor immune escape which could involve inhibition or activation of alternative tryptophan metabolic pathways within the tumor to create more effective combination immunotherapies.

Faculty Project Mentor: Mohammed Dwider, Cardiovascular and Metabolic Sciences

**Mechanisms of Gasdermin-E Pore Formation Provide Pathological Insight into Frontotemporal Dementia and Amyotrophic Lateral Sclerosis**

**Aidan David**, Neuroscience; Dr. Tsan Xiao, Department of Pathology, CWRU School of Medicine

Gasdermins are a family of pore forming proteins that play an integral role in the inflammatory response. Upon activation of the inflammasome, the gasdermin is cleaved and cysteine residues of the N-terminal domain (NTD) are palmitoylated, allowing the protein to relocate to the membrane and form a pore from which the contents of the cell are released. However, it is unclear which specific cysteine residues are palmitoylated in all gasdermin family members. A better understanding of gasdermins' role in the inflammasome is crucial to developing a complete analysis of the inflammatory response and its role in inflammatory diseases. As such, gasdermin research has broad downstream implications for autoimmune disease therapy and management.

One specific gasdermin, gasdermin E, has been found to facilitate mitochondrial degeneration in central nervous system neurons and has been associated with frontotemporal dementia (FTD) and amyotrophic lateral sclerosis (ALS) disease progression. This project aims to elucidate the mechanism of gasdermin E NTD pore formation, specifically by isolating the specific cysteine residue that is palmitoylated in the inflammatory response of neurons. The steps necessary to achieve this aim involved mutating gasdermin E through PCR, transformation of bacteria, and transfection into human cell lines to isolate mutated proteins with specific singular cysteine residues and then determining which residues are actually palmitoylated when gasdermin E is cleaved through acyl-biotin exchange and click chemistry assays, followed by SDS-PAGE and Western blot. While the project is still underway, gasdermin E is expected to have a specific locus of palmitoylation corresponding to a cysteine residue, as prior research has elucidated the site of palmitoylation in gasdermin D, a closely related protein. The neurological implications of this research involve potential therapeutic applications for FTD and ALS once the mechanism by which gasdermin E forms a lytic pore is fully understood.

Project Mentor: Dr. Tsan Xiao, Department of Pathology, CWRU School of Medicine
Capstone Mentor: Dr. David Friel, Department of Neurosciences

## Acoustically Forced Super Sonic Flow

**Davin Cole,** Aerospace Engineering

Building on existing literature, a test rig was designed and manufactured to test the effect of acoustic waves on the formation of supersonic flow. The test rig consisted of a plenum chamber containing a pitot tube, thermocouple, and speaker with two intakes located 180 degrees from each other to ensure flow stagnation. The intake was attached to a nitrogen supply and the speaker to a function generator and power supply. The plenum chamber top was fitted with a Mach 2.5 super sonic jet. The flow formation was then imaged using Schierling imagery for various acoustic inputs.

Faculty Project Mentor: Bryan Schmidt, Mechanical and Aerospace Engineering

**Comparison of radiographic and percutaneous measurement techniques for femur and humerus lengths**

**Matthew Davis**, Biomedical Engineering; Noa B. Nuzov, Department of Biomedical Engineering, CWRU; Annie Yonas, Department of Biomedical Engineering, CWRU; Brandon Brunsman, Department of Anatomy; Tatiana Pascol, Department of Anatomy; Rebecca Prince, Department of Anatomy, CWRU; Scott Simpson, Department of Anatomy, CWRU; Andrew R. Crofton, Department of Anatomy, CWRU, Department of Pathology and Cell Biology, University of South Florida; Nicole A. Pelot[4], Department of Biomedical Engineering, Duke University; Andrew J. Shoffstall, Department of Biomedical Engineering, CWRU

Long bone length measurements have been used for decades to predict human stature. Accurate stature determinations are key for matching remains to identities and for research analyzing stature evolution. There is a strong correlation between stature and long bone lengths in the upper and lower extremities. Traditionally, prediction models gather known stature and long bone lengths from a population with a common demographic and compute a linear regression equation to extrapolate stature. The equation can be used to estimate stature when the long bone length is known. However, validation studies have found that equations are only reliable for the specific population they are created from. Factors such as race, sex, age, and time period of birth can significantly impact the accuracy of estimation equations. Therefore, it is important to apply an equation that was computed from a pool of individuals with the same demographics as the person being studied. Due to the large number of possible demographic combinations, there is a high demand for population-specific stature equations. Thus, many bone measurements need to be obtained from a variety of current, living individuals. Long bones can be measured from x-rays, computed tomography (CT) scans, or percutaneously using a tape measure or calipers. CT scanning is the most definitive means of determining length, as specific landmarks in 3D space can be located, but its accessibility and affordability are suboptimal. This study aims to investigate the validity of percutaneous and x-ray measurements compared to measurements obtained from CT scans.

Faculty Project Mentor: Andrew Shoffstall, Department of Biomedical Engineering

## Impact of Payroll on Major League Baseball Team Success

**Selah Dean**, Data Science and Analytics & Mathematics

This project examines the relationship between Major League Baseball (MLB) team payroll distribution and team success over a ten-season period (2015–2024), considering both overall performance and year-to-year consistency. In recent seasons, record-breaking free agent contracts have raised questions about whether a team can simply buy their way to more wins. During this period, there has been a gradual increase in overall team payrolls, accompanied by a widening gap between the highest and lowest-spending teams. This growing disparity raises concerns about competitive balance and whether financial constraints hinder smaller-market teams' ability to succeed. To explore the validity of the concern, this project considers all players who appeared in at least one game for a team in a given season and categorizes them into three payroll groups: pre-arbitration, arbitration-eligible, and veteran players. The analysis examines how the allocation of payroll across these groups influences team performance and consistency over time. Specifically, this project seeks to answer: Can small-market teams achieve the same level of success as large-market teams despite payroll disparities? How does the distribution of payroll across different player categories impact a team's overall performance and year-to-year variation in wins? The findings aim to contribute to the broader discussion on competitive balance in Major League Baseball and the effectiveness of different roster-building strategies in achieving success as well as sustaining success.

Project Mentor: Dr. Jonathan Ernest, Department of Economics

## Bayesian Approach to Optimize Aerosol Jet Printed Circuits

**Aidan D. Selkirk**, Mechanical Engineering; **Anthony DeCarlo**, Biomedical Engineering; **Krish Gupta**, Biomedical Engineering and Electrical Engineering; Caroline Kromalic, Materials Science and Engineering; Daniel Rakowsky, Biomedical Engineering; Peter L. Burdick, Materials Science and Engineering

Bayesian optimization is a design of experiment that focuses solely on the input and output parameters of a process. The model contains six acquisition functions which produce the next set of input parameters based on prior outputs. Each acquisition function samples a different region of the parameter space, ranging from what is predicted to be the best outcome to exploring unknown areas. This method can optimize process parameters of a novel additive manufacturing process such as Aerosol Jet Printing (AJP) which is used to fabricate flexible electronics with micron-scale resolution. Parameters including gas flows, atomizer voltage, stage speed, and platen temperature affect print conductance and conformity to design. Optimizing these process parameters using Bayesian techniques can lead to improved product quality and printing efficiency compared to other designs of experiment. Four iterations, each with five different parameter sets, were printed on polyimide thin film with silver nanoparticle ink diluted with d-limonene and then thermally cured. Each AJP circuit was imaged using a Keyence digital optical microscope under the same imaging conditions. Each image was analyzed using a custom MATLAB script, turning the visual observations into numerical data. This data was standardized, weighted based on perceived importance, and combined into one value, the Visual Conformity Grade (VCG). The VCG is used to compare the precision and accuracy of the printer to the intended G-Code. In parallel, the resistance of each print was measured using a four-point probe and the respective conductance was calculated to determine electrical performance. Conductance and print conformity calculations from each iteration were used to determine the next printing parameters. VCG and conductance data were plotted to identify specimens exhibiting maximum values indicating a better performing print. These results will provide insights of the parameter space and effectiveness of a Bayesian approach.

Project mentor: Janet L. Gbur, Materials Science and Engineering

**Longitudinal Changes in Sleep Quality During PTSD Treatment: Impact of Demographics and Symptom Severity**

**Halle Deericks**, Psychology Major, Case Western Reserve University

Sleep disturbances, such as insomnia and nightmares, are prevalent in individuals with Post-Traumatic Stress Disorder (PTSD). The research linking sleep disturbances in PTSD to treatment outcomes is limited, despite sleep disturbance being a commonly reported residual symptom following treatment. This study explores the impact of PTSD treatment on sleep and how factors like age and biological sex affect changes in sleep quality with treatment. We hypothesized that sleep quality would improve over time, this improvement would correlate with age and sex, and PTSD symptoms at post-treatment would be predictive of post-treatment sleep quality. Participants (n=110) were randomized to receive 10 weeks of prolonged exposure (PE) alone or PE plus sertraline. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), PTSD symptom severity with the PTSD Symptom Scale – Interview (PSS-I), and demographic factors (age, sex) were collected. Repeated measure analysis of variance (ANOVA) was used to assess PSQI scores over time, correlation coefficients were calculated between PSQI changes scores and age and sex, and a logistic regression was carried out to predict post-treatment PSQI scores from post-treatment PSS-I scores. Results indicated that while PSQI scores changed significantly over time $F(3, 243) = 43.73$, $p < .001$, there were only differences between pretreatment scores and scores at other time-points. Age and sex were not significantly associated with PSQI change (all p's > .05). PSS-I scores significantly predicted posttreatment PSQI scores ($\beta = .218$, $t = 6.59$, $p < .001$); however, this model only explained about 29% of the variance in PSQI scores. These findings suggest that while sleep disturbances improve during PTSD treatment, they're not influenced by factors such as sex or age. The model explains only some variance, suggesting sleep disturbances may also be influenced by lifestyle and coping mechanisms, which could change as the PSS-I score decreases.

Project Mentor: Sarah B. Rutter, Department of Psychological Sciences

Faculty Mentor: Dr. Norah Feeny, Department of Psychological Sciences

## Personalized Movie Recommendation System using Category Specific User-to-User Collaborative Filtering

**Christian Diaz Medina** (Computer Science); **Alex DelGarbino** (Computer Science); **Jasmine Ongole** (Data Science); **Matthew Plotnick** (Data Science)

The entertainment industry faces a paradox of choice, with audiences inundated by countless films yet underserved by traditional recommendation systems that rely on generalized ratings or vague metadata. Our project addresses this gap by developing a personalized movie recommendation platform that leverages category-specific user ratings. By collecting detailed evaluations in areas such as acting, cinematography, editing, effects, sound, and writing, our system captures the nuanced preferences of individual viewers that standard approaches often overlook.

Using a robust framework that combines category-specific ratings with user-to-user collaborative filtering, the platform dynamically adapts to the evolving tastes of its users. The methodology incorporates adaptive weighting, whereby categories receiving consistent engagement are prioritized to enhance recommendation precision. The backend, powered by Supabase, supports flexible and scalable data storage, while a React-based frontend provides an intuitive user interface. An integrated analytics dashboard further enriches the user experience by visualizing key metrics such as watch history, genre preferences, and overall engagement.

Preliminary tests suggest that this detailed, data-driven approach yields more tailored and accurate movie recommendations compared to traditional methods. While the project is ongoing, initial feedback indicates promise in enhancing user satisfaction and discovery. Our work contributes to the broader research context by offering a novel solution that bridges the gap between simplistic ratings and the complex, multifaceted nature of movie preferences.

Faculty Project Mentor:Shuai Xu, Computer and Data Sciences, CWRU
Capstone Instructor:Shuai Xu, Computer and Data Sciences, CWRU

## CAPGLO: A Capture and Detection Device

**Patrick DeLuca**, Physics

The CAPGLO project has been an ongoing collaboration between the Molecular Biology and Physics Department to deliver a cost-effective cellular capture and detection device. The CAPGLO device uses magnetic force to isolate target cells in a solution and fluorescent microscopy to image the target cells once isolated. As part of an interdisciplinary project, the goal is to be able to implement the device for a variety of applications. One application we anticipate is working with the CWRU School of Medicine to use the device to isolate T-cells as part of an immunotherapy apparatus. Over the past year the main focus has been to evolve the project so that the device takes the form of a compact device ready to be used in a lab bench environment. We have successfully overhauled the software used by the device as well as the internal infrastructure of the device, allowing the device to be easily accessible via a wireless connection and easy to move. Furthermore, the device will be able to be produced and distributed at a much lower cost than similar technologies, allowing for the technology to be accessed by a wider audience. Once the device has been fully completed, it will be able to be distributed and utilized in a variety of lab settings.

Project Mentors: Professor Robert Brown, Department of Physics and Dr. Deissler

## Radar On The Race

**Emma Shumaker,** Electrical Engineering; **Isabella Devai Camacho de Oliveira,** Computer Science ,**Yang Shang,** Systems Engineering

The Big Wheels Relay is a fundraising event organized by the Cleveland Hearing and Speech Center in which participants race on tricycles. To help the Cleveland Hearing and Speech Center fundraiser relay raise more money, we are trying to increase attendees' engagement and enjoyment levels. The team wishes to measure the tricycle speeds and share them with the crowd in real-time. The proposed solution is a cost-effective RADAR velocity measurement device that differs from commercially available RADAR guns by offering Bluetooth connectivity and lower production costs. The device differs from similar products, such as a RADAR gun, as it can share results wirelessly and will be cheaper than current options. The device will implement an HB100 RADAR chip to measure the velocity and an ESP32 to process signals and send data via Bluetooth. The HB100 measures velocity through the Doppler Shift effect, where a RADAR signal (with 10.625 GHz) is transmitted and reflected off of the object whose velocity it is measuring with a frequency shift as a result of the object movement; the chip then receives that shifted signal, then it mixes the transmitted and received signals resulting in a wave with the frequency being proportional to the velocity. That wave will be amplified and filtered to improve the signal quality and ensure that the ESP32 can read it. Then, this signal is sent to the audience using Bluetooth. To improve accuracy, the design includes an increased amplifier gain, enhanced frequency-detection software, and a custom PCB for improved signal integrity.

Faculty Project mentor- Professor Evren Gurkan Cavusoglu, Electrical, Computer, and Systems Engineering department

Capstone advisor - Professor Gregory Lee, Electrical, Computer, and Systems Engineering department

**Investigating Rothia's Polymicrobial Interactions Across Oral Sites and Health States Using Co-Occurrence Network Analysis**

**Ritika Devarakonda**, Biology; Allison Suddaby

The oral microbiome is the second most diverse microbial community in the human body, with over 200 species of bacteria inhabiting an individual's mouth at any given time. Commensal microbes in the oral cavity influence both oral and systemic host health through diverse microbe-microbe interactions with other commensal and pathogenic taxa. Thus, understanding the polymicrobial interactions of commensal oral bacteria is important for understanding how to promote health. Rothia is a genus of bacteria that is abundant in the oral cavity during both health and disease, but its symbiotic relationships within the oral microbiome remain poorly understood. This study aims to illuminate microbe-microbe interactions between Rothia and other oral bacteria by constructing a microbial co-occurrence network. We chose to use a co-occurrence network, as it allows for the identification of patterns in microbial presence and abundance, highlighting potential synergistic or antagonistic relationships between bacteria. We compiled 595 publicly available 16S rRNA gene sequence datasets from three oral sites—tongue dorsum, supragingival plaque, and subgingival plaque—under various health states, including oral health, dental caries, periodontitis, and cancers. Our analysis reveals that overall, Rothia's abundance is positively correlated with commensal genera such as Streptococcus, Actinomyces, and Prevotella. Further, Rothia exhibits distinct patterns of association across different oral environments, suggesting that its ecological role may be context-dependent, and preliminary analyses also suggest shifts in co-occurrence patterns between health and disease states. Ultimately, identifying these co-occurrence relationships could direct in vitro characterization of Rothia's microbe-microbe interactions, paving the way for future research and co-culture experiments. In sum, understanding the complex relationships between Rothia and other oral microbes provides insights into the microbial ecology of the oral cavity and highlights the importance of microbial interactions in health and disease.

Faculty Project Mentor: Dr. Gina Lewin, Center for Global Health and Diseases, Case Western Reserve University

## RoomieMatch

**Ian Kwak**, **Jenny Zhang**, **Kashika Dhanjal**, **Kathleen Du**, **Misaki Matsuura**,**Isabella Francesconi**, **Sophie Wirt-** Department of Computer and Data Science

RoomieMatch is a web-based application developed to address the challenges of finding compatible roommates at Case Western Reserve University (CWRU). The purpose of this project is to create a platform that improves the roommate-matching process by using data-driven compatibility scores based on students' lifestyle preferences. The traditional methods, such as using social media or basic surveys, are often inefficient and overwhelming. This often results in mismatched roommates leading to unnecessary conflicts and a reduced quality of living for both people. This project seeks to provide a more accurate, interactive, and secure solution for students by leveraging technology.

The project utilizes a detailed questionnaire to collect user data on living preferences such as cleanliness, noise tolerance, sleep schedules, and social preferences. Additionally, users can select tags that reflect their hobbies and interests. The gathered data is processed by an algorithm that generates compatibility scores using a point system, offering personalized roommate recommendations. The platform also allows users to upload profile photos and write brief biographies to help potential roommates get to know them better.

The expected outcome is a more efficient, reliable, and enjoyable roommate-search experience, reducing the likelihood of conflicts in shared living situations. The application will be developed using Python for the backend, SQLite for database management, DB Browser for SQLite, Tailwind CSS, and TypeScript for the front end. Machine learning techniques, such as clustering algorithms, will be employed to refine the roommate suggestions over time.

Faculty Project Mentor: Shuai Xu, Department of Computer and Data Science, CWRU

Capstone Instructor: Shuai Xu,  Department of Computer and Data Science, CWRU

**Subcranial Static Magnetic Stimulation Effect on Neuron Propagation in a Hippocampal Mouse Model In Vitro**

**Gabriel Dias,** Neuroscience

Transcranial static magnetic stimulation (tSMS) is an emerging non-invasive neuromodulation technique that has demonstrated promise in reducing neuronal excitability, particularly in models of Dravet syndrome—a severe form of epilepsy linked to mutations in the *SCN1A* gene encoding the α-subunit of the Na1.1 voltage-gated sodium channel. Although the underlying mechanisms of tSMS remain largely unclear, it is hypothesized that magnetic fields may influence neuronal activity by modulating ion channel dynamics through membrane deformation or by exerting Lorentz forces on moving ions. This study investigates the effects of subcranial static magnetic stimulation on signal propagation within the hippocampus, focusing on the CA3-to-CA1 pathway in an *in vitro* rodent brain model. Following surgical extraction, horizontal hippocampal slices are maintained in oxygenated artificial cerebrospinal fluid supplemented with 4-aminopyridine to enhance synaptic transmission. Field electrodes are placed in the CA3 and CA1 regions to record evoked electrical responses. After baseline propagation is established, neodymium magnets are intermittently positioned adjacent to the tissue to apply a static magnetic field. We aim to quantify changes in propagation amplitude and frequency under magnetic stimulation, with the hypothesis that tSMS will attenuate both parameters, reflecting reduced neuronal excitability. Preliminary results indicate that the introduction of tSMS leads to a decrease in propagation amplitude accompanied by an increase in signal frequency, changes that may contribute to an overall reduction in network excitability. The findings of this research may contribute to a better understanding of how static magnetic fields alter hippocampal circuitry and support the development of novel therapeutic strategies for neurological disorders characterized by hyperexcitability.

Faculty Mentor: Dominique M. Durand, PhD, Department of Biomedical Engineering

## Receiving GPS-Timed Acoustic and Radiofrequency Costas Array Sounding Signals

**Andres Dickson Alarcon**, Electrical Engineering**; Yaodan Zhang**, Electrical Engineering**; Solomon El-Ghannam**, Electrical Engineering

Understanding the static and dynamic properties of the ionosphere, a layer of ionized charges that affects the propagation of radiofrequency waves, is of great fundamental and technological importance. We developed an ionospheric sounding system, consisting of a synchronized transmitter and receiver, that transmits Costas arrays. The Costas array is a code that could be used to unambiguously extract the time delay and Doppler shift information of the signal, providing a direct probe to the state of the ionosphere. Our receiver system utilizes synchronization and signal processing techniques to derive the time of flight and Doppler shift measurement from a transmitted Costas Array signal in audio and RF mediums.

Project Mentors: David Kazdan, and John Gibbons
Sponsors: Case Amateur Radio Club W8EDU; Amateur Radio Digital Communications Foundation.

**The Gut-Brain Axis: Contribution of Bacterial Metabolites and Intestinal Cytokines to Neurodegeneration**

**Jade Dohner**, Neuroscience and Nutritional Biochemistry, CWRU; Dr. Anna Kondratova, Department of Molecular Biology and Microbiology; Amy Chae, Cognitive Science and Accounting; Samuel Demski, Biochemistry; Cynthia Dong, Biology

The gut-brain axis is a highly complex network connecting the gastrointestinal and central and enteric nervous systems. We hypothesize that through this network intestinal cytokines and bacterial metabolites regulate brain function and contribute to inflammation and neurocognitive decline. Indeed, chronic neuroinflammation and microbiome dysbiosis are hallmarks of conditions such as Alzheimer's and Parkinson's disease; however, the mechanisms are unclear. This study focuses on individual intestinal cytokines and bacterial metabolites, known to be elevated in the cerebrospinal fluid (CSF) during neurodegeneration, to determine their effects on neuronal growth, differentiation, structure, survival, function, and morphology. The Lund's Human Mesencephalic Cell Line (LUHMES), a human mesencephalic embryonic neuronal precursor cell that can be differentiated into dopaminergic-like neurons, was used. This served to mimic a Parkinsonian model, as dopaminergic neuron death in the Substantia nigra pars compacta (SNpc) is the hallmark of the disease. The cells were expanded and passaged, then induced to differentiate. Experimental treatments included concentration gradients and time curves for cytokine IL-17A and bacterial metabolites phenylacetyl-L-glutamine and indoxyl sulfate, in addition to hydrogen peroxide (H2O2) gradients. After the experimental period, one of three analyses was conducted: Western Blotting, immunocytochemistry, or viability assays. For Western Blotting, the cell lysate is analyzed to determine expression of accepted neuronal protein markers: tyrosine hydroxylase, dopamine transporter, and synaptophysin. We hypothesized that expression of these three proteins would be modulated with treatment. For immunocytochemistry, cells were fixed to glass slides to determine expression of the neuronal protein markers. Viability assays included Alamar Blue and MultiTox Reagent to ascertain cell death. Thus far, results with IL-17A have shown no considerable differences between treatment and control groups. Future experiments will increase the length of treatment time and incorporate other analysis techniques such as ELISA and immunofluorescent staining. Studies with the bacterial metabolites are ongoing.

Project Mentor: Dr. Alan D. Levine, PhD., Department of Molecular Biology and Microbiology, SOM, CWRU

## Muon Telescope Apparatus for Energy Calibration

**Collin Dowhan**, Physics and Astronomy

When high-energy protons from across the universe interact with particles in Earth's upper atmosphere, they create several unstable additional particles. One such is the pion which subsequently decays into muons and muon neutrinos. The muons created after the decay have very large energies and can be detected through several experimental methods. Two common methods are through the detection of Cherenkov and Scintillation light. While both are effective on their own, the combination of the two methods leads to insights into energy resolution. This paper will discuss the development of a "muon telescope" apparatus integrated with an existing Cerenkov effect water detector used for cosmic ray detection. Muons that pass vertically through the top and the bottom of a Cerenkov detector will deposit roughly the same amount of energy into the tank, resulting in a distinct photomultiplier tube signal. To filter other muon events (top-side, side-bottom, or side-side), two counting devices, consisting of a scintillation panel, a discriminator, and an inverter, we placed above and below the water tank. The signals from the two are placed in coincidence which filters out all other events besides the vertical muons. By fitting a Gaussian distribution over a histogram of the Chrenkov light pulses, the mean and standard deviation is extracted resulting in a value for the energy resolution of the tank.

Faculty Mentor: Dr. Corbin Covault, Department of Physics

Capstone Instructor: Dr. Idit Zehavi, Department of Physics

## Galactic Foreground Subtraction and r Constraints

**Anil Driehuys,** Physics

The cosmic microwave background (CMB) is a very faint signal stemming from the early universe, which provides critical insights towards constraining cosmological models. This signal is overshadowed by much larger signals called foregrounds which make it difficult to pick out small anisotropies loaded with information. This project aims to develop techniques to mitigate these foregrounds, in order to constrain the cosmological parameters. The primary parameter of interest here is the tensor to scalar ratio r which has previously been limited to under 0.044 with a 95% confidence level. This value tells us about the relative power of gravitational waves and density perturbations in the early universe. We utilize the PySM library based on Planck satellite data to understand the frequency dependence of the dust signal, and accurately isolate the CMB. These techniques can be applied to many experiments to better isolate a desired signal. We focus on the B mode polarization of the CMB which characterizes the value of r.

Faculty Project Mentor: John Ruhl, Department of Physics

Capstone Project Mentor: Idit Zehavi, Department of Physics

## Novel Use of Morcellator for Gastrointestinal Clot Removal for Endoscopic Procedure

**Kriti Shukla,** Biomedical Engineering; **Amanda Duban,** Electrical Engineering; **Angel Ramirez,** Computer Science; **Abigail Roeckmann,** Systems Engineering

Gastrointestinal clots are a condition that can significantly impact endoscopic procedures by obstructing the path and vision of the physician which prolongs the procedure. It can delay surgical treatments, further causing risk or harm to the patient, so removing gastrointestinal clots during endoscopic procedures is imperative. Current solutions used to remove these clots include a suctioning device combined with forceps, snares, and distal caps. However, these methods are ineffective for larger clots and have an increased risk of device clogging. We propose the novel use of a morcellator attachment to an endoscope. The morcellator attachment would liquefy the clot and simultaneously remove it, thus clearing the visual field. The morcellator is made of a stainless steel rotating inner cannula with blades and a stationary outer cannula. The outer cannula would have a cut opening through which the clot would enter to interact with the inner cannula's blades and prevent direct contact between the blade and the patient's gastrointestinal tract. The suction between the inner and outer cannula would ensure the removal of the clot as it is cut up. The device will require the depression of both a hand trigger and a foot pedal to activate morcellator rotation to reduce safety risks from accidental triggering. The user will receive visual feedback via liquid crystalline display regarding the rotation speed of the morcellator to ensure that the device is functioning at ideal operating speeds, inform the user if the morcellator is slowing due to device clogging, and lead to an automatic increase in device speed to compensate. To assess the effectiveness of this device, we will simulate blood clots with gelatin, and measure the morcellator's ability to liquify these clots in an esophageal-shaped environment.

Faculty Project Mentors: Dr. Colin Drummond, Department of Biomedical Engineering, Case School of Engineering, School of Medicine, CWRU, Dr. Matthew Williams, Department of Biomedical Engineering, Case School of Engineering,CWRU

Capstone Project Mentor: Colin Drummond, Department of Biomedical Engineering

## Smart Occupancy Monitoring System

**Gage Duesler,** Electrical Engineering; **Jimmy Nguyen,** Electrical Engineering; **Luke Gensler,** Electrical Engineering

The goal of the Occupancy Monitoring System is to address the challenges that event organizers and security face in tracking and maintaining crowd sizes – in order to adhere to occupancy limits and maintain a safe environment. We look to accomplish this goal by creating a smart occupancy monitoring system that uses computer vision and artificial intelligence to get a real time headcount of people walking past a predetermined zone. Current solutions, such as turnstiles and infrared counting devices, are often expensive and not practical for small venues such as popular local Thursday night bars. By using an affordable, webcam based system, our project offers a low cost solution to these traditional methods. Our algorithm detects and tracks individuals entering and exiting through a doorway, more specifically every entry/exit door. With the camera mounted above the door frame, it will assign each person a unique ID, then track their Y-coordinate as they move through the frame. This way, once a certain percentage of each person (bounding box) passes a horizontal threshold line, it will count the person based on the direction they move. It is able to accurately distinguish the differences between entries and exits, maintaining a real-time headcount that is displayed through a user-friendly interface. When the occupancy limit is reached, our system will send out an alert to notify the user, allowing them to take action in maintaining a safe environment. Our biggest challenges include optimizing the performance of our system, making sure we maintain real time processing with minimal latency, while still achieving affordability. By offering real time occupancy monitoring, our system helps users in maintaining crowd control in an efficient, affordable, and accessible way.

Faculty Mentor: Dr. Hassan Najafi, Department of ECSE

Capstone Instructor: Dr. Gregory Lee, Department of ECSE

**Avian Magnetoreception: Dynamic Radical Pair Systems Under Magnetic Field Inversion**

**Rae Dugger,** Physics; Pip Benjamin, University of Oxford, Department of Chemistry; Peter Hore, University of Oxford, Department of Chemistry; Lydia Kisley, University of Oxford, Department of Chemistry

Migratory birds perceive sensory information from the Earth's magnetic field through a radical pair mechanism. Behavioral studies have shown that the avian compass is sensitive to the inclination, rather than the polarity, of external magnetic fields, resulting in symmetry under magnetic field inversion. However, dynamic radical pair models sometimes exhibit field inversion asymmetry (FIA), contradicting these behavioral observations. This project seeks to investigate and characterize this discrepancy by simulating more realistic and dynamic radical pair systems, incorporating three distinct types of noise: monochromatic, Ornstein-Uhlenbeck, and broadband.

Faculty Project Advisors: Lydia Kisley, Peter Hore

Capstone Instructor: Idit Zehavi

## QuantifyMRI: Applying novel neural network architectures to magnetic resonance fingerprinting

**Samuel Dyer,** Physics

Kolmogorov-Arnold Networks (KANs) are a novel neural network architecture which leverages the Kolmogorov-Arnold Representation theorem to create learnable activation functions, modeled as splines. These learnable activation splines replace the weights of traditional multi-layer perceptrons (MLPs). This provides KANs the unique ability in physical applications to be interpretable, something not possible for MLPs. When applied to magnetic resonance fingerprinting (MRF), connections between the T1 and T2 values, and signals obtained through magnetic resonance imaging can be drawn, unlike anything previously. KANs provide the structure to turn the signals of magnetic resonance imaging into both mathematical and visual representations of their T1 and T2 values, enhancing the applications of MRF.

Faculty Mentor: Michael Martens, Department of Physics

Capstone Menton: Idit Zehavi, Department of Physics

## Classification and Characteristics of False Positive Activations in the Cardiac Catheterization Lab

**Alexander Egoavil, Biology**; Aditya Mantha; Jacqueline Tamis-Holland

ST-segment elevation myocardial infarction (STEMI) requires rapid reperfusion to restore coronary blood flow and is best treated with emergency angiography and percutaneous coronary intervention (PCI). Some patients referred for emergency coronary angiography for suspected STEMI are ultimately canceled or diagnosed with an unrelated condition after undergoing coronary angiography. While these situations have been collectively referred to as a "False Positive Activation" (FPA), there are distinct differences between canceled cases and those ultimately diagnosed with an unrelated condition after undergoing coronary angiography. We aimed to classify the FPA at Cleveland Clinic to determine the proportion of canceled cases vs. those referred for coronary angiography but diagnosed with an unrelated condition and to examine the patient demographic and clinical characteristics. Our hypothesis was that there are distinct differences in the characteristics of these two groups of patients. The findings from these 100 patients will guide a broader investigation of 3000 patients by ensuring a more targeted approach to exploring FPA. We reviewed our screening log of suspected STEMIs from January 1, 2018, to December 1, 2024, to identify FPA and randomly selected 100 patients for review. We performed a detailed review of the electronic medical record of these 100 cases. We categorized FPA into three categories: 1) Cancelled cases of patients found to have an unrelated diagnosis 2) Cancelled cases of patients with true STEMI but not appropriate for invasive angiography 3) Cases referred for coronary angiography but ultimately found to have an unrelated diagnosis. We compared baseline clinical characteristics for patients in each group. Among a group of patients labeled as FPA, cancellations were marked before emergency angiography or referred for angiography but ultimately diagnosed with a different condition. Identifying predictors of FPA will reduce unnecessary healthcare resources and improve patient care in healthcare systems.

Faculty Mentor: Stephen Haynesworth, Department of Biology

## The Effect of Strict Voter ID Laws on Voter Turnout

**Gabriel Miller,** Economics; **Michael Elias**, Economics

The Introduction of Voter ID Laws has been controversial as proponents often claim that the introduction of the laws offers little downside while decreasing voter fraud. Our question is whether the introduction of said laws have affected the overall voter turnout both on an overall state level and broken down into gender, race and ethnic groups. Looking at president voter turnout from 2000 to 2020, collected from the US Census Bureau, as well as fixed effects such as unemployment and education level from IPUMS, we intend to use diff in diff analysis with controls and synthetic control to study and isolate the effect of voter ID laws. The voter ID laws themselves will be classified as strict or non-strict, where strict means that there is no alternative to a voter ID and face vs non-face ID laws where a face voter ID is one in which the "face" is required. Previous research suggests that voter ID laws tend to act as a "poll tax" which affects lower income individuals and disproportionately affects minorities such as blacks and hispanics. Thus the current hypothesis is that minorities will experience a negative correlation of voter turnout with the introduction of voter ID law. With the inclusion of sex and minorities such as asians, it is hard to exactly predict what the effect will be if any, but nonetheless, it provides another interesting angle to this study. The implications of negative correlations are vast because if it is true that voter ID laws are correlated with negative voter turnout, specifically among minorities, then it may be argued that these laws are an attempt to deliberately disenfranchise voters as earlier poll taxes did during the Jim Crow times. Additionally, the absence of any findings may suggest that benefits they provide towards securing elections outweigh concerns of non-significant disenfranchisement. Either way, because these findings are on a state level (the level at which these laws are usually passed), then these findings are extremely relevant to the laws at hand.

Project Mentor: Jenny Hawkins, Department of Economics

Capstone Mentor: Jenny Hawkins, Department of Economics

## Artificial Intelligence Agents for Playing Hearts

**Emil Ekambaram**, Computer Science; **Rohith Eshwarwak**, Computer Science; **Isaac Hubbard**, Computer Science; **Ashraf Ibraheem**, Computer Science; **Ben Kurzion**, Computer Science; **Rachel Tjarksen**, Computer Science; **Gabriel Wolf**, Computer Science

Artificial Intelligence (AI) has excelled in games with perfect information, such as Chess, but many card games such as Hearts pose a unique challenge due to hidden information and uncertainty. This project explores two approaches to playing the game of Hearts: reinforcement learning via a Deep Q Network (DQN) and search-based decision-making using Information Set Monte Carlo Tree Search (ISMCTS). Here, our implementation features a modular game framework with a front-end interface, allowing users to compete against both agents. The Deep Q Network (DQN) evaluates the goodness of a move given a game state. It is trained based on experiences, or games, that the model has seen. In an iterative fashion, the model plays many games, learns and improves from those experiences, and repeats. On the other hand, ISMCTS is a more classical approach that explores determinizations of the game tree using statistical methods to choose the best action in each state. An object-oriented approach allows both agents to use a common framework for implementation. We compare the two agents with respect to various metrics evaluating self-play and performance baselines. Future improvements could involve refining learning strategies, optimizing computational efficiency, and exploring hybrid models that combine search and learning techniques.

Capstone Instructor: Prof. Shuai Xu, Department of Computer and Data Sciences

## Love It or Leave It? What Drives Retention in Finance

**Maha EL M'hasbi**, Economics; Siphesihle Nxumalo

In today's rapidly evolving economy, the financial sector faces persistent employee turnover, leading to significant operational and economic challenges. Rising recruitment costs, the disruptive impact of market fluctuations, and the lasting effects of the COVID-19 pandemic underscore the need for innovative retention strategies. Our research is motivated by the crucial importance of understanding employee retention from a workforce perspective, a viewpoint largely overlooked in previous studies. This study aims to bridge this gap by examining personal and organizational factors that drive job tenure. The main objective of this study is to determine the key factors influencing the finance sector employees to remain in their roles. We analyze a comprehensive set of variables, including income, educational attainment, job tenure, work-life balance indicators, and proxies for job stress and career mobility. Using individual-level data from the IPUMS Current Population Survey covering 2015 to 2024, we provide a robust framework to assess sectoral changes before, during, and after the COVID-19 crisis. This study employs econometric modeling and regression analysis to evaluate the relationship between compensation, job stress, career mobility, and retention outcomes. Retention is assessed through job tenure, employment status, and continued job placement over time. The analysis controls for additional factors such as age, education, race, and firm size to isolate the effects of financial and workplace conditions on retention. We anticipate that higher compensation, improved work-life balance, and greater career mobility will positively correlate with employee retention. However, these relationships may vary across different finance roles. While higher wages and benefits are expected to lead to longer job tenure, this effect may be weaker in high-stress finance jobs. Employees with better work-life balance, indicated by lower weekly hours or flexible work options are likely to exhibit higher retention rates. By analyzing these relationships, this study aims to provide empirical insights that can inform workforce policies and retention strategies in the financial sector.

Faculty Project Mentor: Mark Schweitzer, Department of Economics

**The Impact of Religious Affiliation on Attitudes Towards Capital Punishment and Medical Aid in Dying: A Literature Review**

**Jacob Elsass**, Physics

With the recent annual increase in death penalty executions, the moral dilemma of capital punishment has yet again entered public and private discourse. At the same time, an increased awareness of healthcare practices from neighboring countries has brought the idea of medical aid in dying to the forefront of some healthcare and treatment discussions. This review will investigate (1) patterns of religious belief, (2) patterns of public opinion concerning capital punishment, and (3) patterns of public opinion concerning medical aid in dying. Through this analysis, we can gain an understanding of the historical context surrounding these factors and make educated predictions on how public opinion of these topics may sway in the future.

Faculty Project Mentor: Sharon Milligan, Mandel School of Applied Social Sciences

Capstone Instructor: Sharon Milligan, Mandel School of Applied Social Sciences

**REVA: Mapping Differential Vagus Nerve Morphology and Myelination Across Anatomical Levels to Optimize Electrode Placement for VNS**

**Karim Elsharkawy**, Neuroscience

Vagus nerve stimulation (VNS) is an established neuromodulation therapy for epilepsy and other neurological disorders; however, limitations in our anatomical understanding of the vagus nerve (VN) hinder optimal electrode placement, affecting therapeutic efficacy and side-effect profiles. This study characterizes VN morphology and myelination across cervical levels to inform electrode positioning for improved stimulation outcomes. Our findings reveal differential myelination patterns along the VN, with increased myelination observed in the cervical region, particularly around C6-C7. This suggests that targeting these areas with low-frequency VNS could maximize signal conduction while minimizing unintended activation of nearby structures. Histological analysis using H&E staining provides structural insights into fiber organization, while immunohistochemistry (IHC) enhances the identification of specific neuronal populations within the VN. Future directions include further characterization of VN fiber subtypes and functional organization to refine stimulation paradigms and electrode design. By establishing a comprehensive anatomical framework, this research aims to enhance the precision and efficacy of VNS in the treatment of epilepsy and other neurological conditions.

Project Mentor: Andrew Shoffstall, Department of Biomedical Engineering
Capstone Mentor: Andrew Shoffstall, Department of Biomedical Engineering

**Integrated Battery Charging and Monitoring System for High Powered Rockets**

**Sanket Makkar,** Computer Engineering**; Tristan Emmanual,** Computer Engineering**; My Le** - Computer Science, Computer Engineering**; Jonathan Hsu,** Electrical Engineering

High-powered amateur rockets rely on multiple onboard batteries to power critical avionics systems, but current methods of charging and monitoring these batteries require time-consuming disassembly and might compromise the integrity of the components. This forces rocket users to risk damaging the rocket in disassembly, and makes battery analysis and charging excessively difficult and time consuming. To address this, we propose an Integrated Battery Charging and Monitoring System that enables simultaneous charging of all batteries within the avionics bay via a single external connection, while also supporting real-time diagnostics and communication. Our system incorporates a USB-C power distribution architecture, modular battery management, onboard diagnostics using microcontroller-driven sensors, and wireless data transmission to both external laptops and onboard flight computers. In addition, a graphical user interface is available to allow users to monitor battery metrics. Our product streamlines pre-launch preparation and enhances the reliability and safety of rocket launches, which results in smarter and more maintainable avionics systems.

Project Mentor: Richard Bachmann, Department of Mechanical and Aerospace Engineering

Capstone Instructor: Gregory Lee, Department of Electrical, Computer, and Systems Engineering

**Treatments for Adolescents with Comorbid Major Depression and Substance Use Disorder: A Review**

**Marko Enriquez,** Psychology

Major depressive disorder (MDD) and substance use disorder (SUD) are common co-occurring psychiatric diagnoses among adolescents. Together, they increase the risk of adverse outcomes such as relapse and suicide. However, the current understanding of how the presence of one disorder affects the treatment of the other is limited. This review aims to search the existing literature to identify effective treatment methods for this particular dual diagnosis. A literature search of online databases was conducted using keywords such as “adolescent depression,” “dual diagnosis,” “major depressive disorder,” “pharmacotherapy,” and “substance use disorder.” Eleven empirical studies examining the treatment outcomes of adolescents with comorbid MDD and SUD were selected and reviewed. All treatments except one utilized cognitive-behavioral therapy (CBT) techniques, and many involved pharmacotherapy. One study tested the efficacy of a specific medication without the presence of CBT. Within studies, no significant differences in MDD and SUD symptom reduction were found between treatment groups. However, individual differences among adolescents, such as involvement in the criminal justice system and severity of substance use, may be more powerful predictors of treatment outcome than the nature of the treatment itself. Further research should be aimed at identifying more of these moderators and their impact on the effectiveness of adolescent-targeted treatments for comorbid MDD and SUD.

Capstone Instructor: Dr. Amy Przeworski, Department of Psychological Sciences

## The Comorbidity of Polycystic Ovarian Syndrome and Depression in Young Adults

**Anna Esmael,** Psychology and Sociology

Polycystic Ovarian Syndrome is the most common cause for irregular menstruation and leading cause of infertility which affects 6-13% of reproductive-aged women worldwide. Depression affects approximately 5% of adults worldwide and is far more common in women than in men by double the rate and even more so in women with PCOS. Given the comorbidity, it can be extremely difficult to advocate for oneself as a patient suffering from two disorders that have overlapping traits and symptoms. This systematic review dissects the comorbidity of depression that occurs in young adult women with PCOS. The parameters for this systematic review were to review 10 articles from the PsychInfo database that all contained the keywords "young adult," "PCOS," and "depression." The systematic review yielded the results that there is a high comorbidity between polycystic ovarian syndrome and depression at 2.5 times the rate of the average individual with 70% of individuals with PCOS suffering from only PCOS. The factors that give rise to depression are many which include hirsutism, weight gain, among other factors. Current research establishes that depression and PCOS may be comorbid, however there is not a set protocol for diagnosis nor establishing how to proactively help individuals that suffer from both illnesses. Further research should be conducted to determine a protocol for more accurate diagnosis of PCOS among patients who are also diagnosed with depression or vice versa.

Project Mentor: Amy Przeworski, Department of Psychological Sciences

Capstone Mentor: Amy Przeworski, Department of Psychological Sciences

## What is the Impact of Constitutional Carry on Gun Homicides?

**Qingyang Fan**, Economics; **Zhihao Lu**, Economics

We evaluate the impact of different states waiving requirements in concealed firearm carrying on the state-level gun homicide rate. As many states waived the requirements for concealed weapon carry in the past 15 years, it is much easier for residents in those states to hold firearms. According to prior studies, more firearms tend to lead to a higher number of gun-related deaths in 27 developed countries. More specifically in this scenario, all of the states with constitutional carry law changes have a significant increase in gun-related homicides over the years we selected. Therefore, it is crucial at this moment to assess the effects of those law changes empirically. To conduct this study, we use data from 2013 to 2022 and select the states that changed constitutional carry laws between 2016 to 2021 to compare data for the two years before and after the law change, along with our controls such as state gun ownership per household, real median household income, state annual unemployment rate, and the state police budget to test whether our x-variable, a dummy of whether state waived requirements for concealed carry, have significant effect on our y variable, gun homicide rate per 100,000. Using a difference-in-difference model, we look at the impact of constitutional carry law (X) on the gun homicide rate (Y), controlling for factors such as gun ownership rate, police budget, income level, and unemployment. While we estimate a positive correlation between the Y and X variables, which the legislation change can increase gun ownership rate and gun homicide rates, our null hypothesis is established as the legislation does not impact the gun ownership rate and is not associated with an increase in gun homicide. A rejection of the null hypothesis will associate the legislation with an increased level of gun violence. In the concluding section, we can thoroughly conclude if the legislation of constitutional carry is exacerbating violent gun crimes or not. The results of our study can be of useful reference for states to evaluate the possible impact of passing constitutional carry laws, or for the states with constitutional carry laws, to reevaluate the benefit or cost.

Project Mentor: Professor Mark Schweitzer, Department of Economics

## Small Molecules ACA-28 and C-021 Modulate MEK/ERK Activity

**Amanda Farrar,** Biochemistry; Marc A. Scemama de Gialluly, Department of Pathology, Case Western Reserve University School of Medicine; Drew J. Adams, Department of Genetics and Genome Sciences and Chemical Biology Program, Case Western Reserve University School of Medicine, Department of Pharmacology, Case Western Reserve University School of Medicine

The MEK/ERK signaling pathway is relevant in about 40% of human cancers, and proteins such as Ras/Raf higher up in the pathway have been painstakingly studied for therapeutic intervention, but are often not targetable by traditional chemotherapeutics. This project intends to build a foundation for exploring how small molecules ACA-28 and C-021 modulate MEK/ERK activity. Using DepMap dependencies, we will use melanoma cell lines to conduct target identification experiments, including biotin pulldowns, CETSAs, in-gel fluorescence, immunofluorescence, and western blotting. By determining the target of these small molecules, we can further investigate their mechanisms of action and potentially improve the molecules' functionality within cells. While the project is ongoing, preliminary data shows that ACA-28 and C-021 are biologically active in the melanoma cell line COLO-800 via cellular viability assays. Additionally, foundational experiments point to DUSP4 as a potential target, which is a phosphatase that interacts with ERK proteins to dephosphorylate them. By studying proteins that modulate, but may not directly be involved in, the MEK/ERK pathway, the same therapeutic benefits of modulation may still be achieved.

Faculty Member: Drew Adams, Ph.D., Department of Genetics and Genome Sciences and Chemical Biology Program and Department of Pharmacology, Case Western Reserve University School of Medicine

## The Evolving Blueprint of Case Western Reserve University

**Isabel Fedewa,** English and Biology

The landscape of Case Western Reserve University has changed dramatically, starting from the farmland of Liberty Holden and Martha Ford, split between two colleges, to the Interdisciplinary Science and Engineering Building currently under construction. I am building an interactive online map of the University Circle campus using GIS technology. This project uses ArcGIS StoryMaps to build a website around the base maps that connects the maps to images, stories, and context from CWRU's history. The project covers the physical history of the campus from Western Reserve College's move to University Circle in 1882 to the present day. My project is building on previous projects, including "Case School: The Evolving History", an interactive Scalar website of Case Institute of Technology's history, and "The Changing Campus", a photograph digitization project of campus buildings on the CWRU Archives website. My final project will cover the entire University Circle Campus, with special focus on Western Reserve College, which was not covered in the Scalar project. The project layers historical maps of the campus over modern maps using geospatial data. The website connects pictures of former buildings to their former locations, alongside historical information. The project includes pictures and stories of important events associated with specific locations, as well as anecdotes and pictures from former campus students and employees. This project happens to be well timed to contribute to the celebration of the 200th Anniversary of Western Reserve College's founding. CWRU is undeniably a future-oriented university, but that is all the more reason to remember our past.

Faculty Project Mentor & Capstone Mentor: Dr. Aviva Rothman PhD, History

**Using Drosophila and iPSCs to Understand Disease-state Neural Dynamics of Epilepsy and Alzheimer's Disease**

**Faith Ferry**, Department of Neuroscience, CWRU; Victor Sanchez Franco, Dr. Vipin Kumar, Dr. Masashi Tabuchi, Department of Neurosciences, Case Western Reserve University School of Medicine

Epilepsy is a brain disorder characterized by abnormal brain activity leading to recurrent seizures or periods of reduced awareness, while Alzheimer's disease (AD) affects cognition and memory. This project sought to characterize neuronal firing alterations associated with epilepsy and AD and to explore the impact of a novel ion channel involved in potassium-buffering on epilepsy-associated sleep changes. We used hiPSC cultures derived from healthy, AD, and epileptic patients, and cultured them on MED64 electrophysiological recording plates. Each week, electrophysiological recordings were analyzed to examine firing rate, variance in firing patterns, and transition probability (between stable brain 'states'). Previous research using *Drosophila* (fruit flies) showed the effect of omega-fatty acids on seizure activity in bang-sensitive mutants (epilepsy model). We wanted to see how this result could manifest in cell lines, and cultured cells with three different fatty acids. The hiPSC results showed general differences between the control and epilepsy-derived cells, including changes to firing rate, spike variance, and Markov analysis transition changes. However, we found no attenuation of these changes with fatty acid supplementation. As another way to investigate abnormal electrical activity underlying seizures and sleep disturbances, we investigated a pH-sensitive chloride channel (Alka) that is expressed in neurons and astrocytes, where it is thought to mediate chloride movements and potassium buffering that influence membrane excitability, potentially mediating seizures. We used *Drosophila* expressing wild-type and mutated Alka channels and analyzed their sleep patterns to compare them to sleep changes commonly observed in epilepsy phenotypes. The changes observed could prompt investigation of human homologs of this channel and allow for exploration of AEDs that might resolve changes induced in epilepsy by targeting this channel. Furthermore, we found shared dynamic instabilities in human iPS-derived neural cultures from patients with Alzheimer's disease and epilepsy, demonstrating how microscale neuronal instabilities can induce macroscopic disease phenotypes.

Faculty Project Mentor: Dr. Masashi Tabuchi, Department of Neurosciences, CWRU School of Medicine

## Driveshaft Based 4WD System for Baja SAE

**Liam Flanagan,** Mechanical Engineering

The Driveshaft-Based 4WD System for Baja SAE aims to enhance the reliability, efficiency, and packaging of the four-wheel-drive (4WD) system in off-road vehicles used in Baja SAE competitions. The previous chain drive system exhibited issues such as chain stretch, disconnections, and frequent maintenance, which compromised vehicle endurance and performance. The proposed driveshaft-based system offers a more robust, lightweight, and low-maintenance alternative, reducing overall weight from 16.2 lbs to 7.1 lbs while improving packaging and handling characteristics. This project explores the feasibility, design, and validation of this drivetrain modification.

In the broader research context, drivetrain efficiency and durability are critical in automotive engineering, where mechanical losses can significantly impact performance. Previous studies and practical applications have shown that driveshaft-based systems provide superior power transmission with fewer maintenance requirements compared to chain-driven alternatives. This project contributes to existing research by adapting a driveshaft solution to a Baja SAE vehicle while maintaining competitive performance targets.

The methodology consists of several key phases: (1) reviewing past designs to establish performance benchmarks, (2) designing and modeling system components in CAD, (3) performing Finite Element Analysis (FEA) to assess stress distribution, (4) fabricating and integrating the driveshaft system, and (5) conducting experimental testing. Bench tests will evaluate drivetrain durability and efficiency, while on-vehicle tests will assess torque distribution, RPM consistency, and overall reliability.

As the project is ongoing, results will focus on the expected improvements in weight reduction, system robustness, and handling benefits compared to the chain drive. Data from wheel torque sensors and Hall Effect RPM sensors will validate power transmission efficiency.

The findings from this research will help inform future drivetrain designs for off-road applications.

Faculty Project Mentor: Richard Bachmann, Mechanical and Aerospace Engineering, CWRU
Capstone Instructor: Majid Rashidi, Mechanical and Aerospace Engineering, CWRU

## Spinal Cord Injury: Pathophysiology and Emerging Treatments

**Braden Frank**, Biology

Spinal Cord Injuries (SCI) are a life-altering injury that occurs during a traumatic event. The site of the injury leads to a long-term pathological process with a complicated microenvironment, making these injuries extraordinarily hard to treat.This paper aims to establish the pathophysiological mechanisms present, and highlight a few emerging treatment methodologies that have shown great promise in animal studies. SCI is a multifaceted neurological injury, and consists of a primary injury and secondary injury phase. It is during this phase that a cascade of cellular and biochemical processes creates a pathological process that prevents recovery. Research has shown that immune cell infiltration is likely a large contributor to this. Therefore, neuroprotective mechanisms must be established to begin neuroregenerative treatment. In addition to the immune infiltration, SCI causes molecules inhibitory to growth such as Nogo-A and CSPGs to flood the injury site. The glial cells will also tend to form fibrous scars, further limiting the already limited regenerative capability of neurons. To address both neuroprotective and neuroregenerative needs, a number of new combinational therapies are being developed. New treatments for these combinational therapies are wide ranging, but each has their own strengths and weaknesses. Stem cell therapies promote powerful neuroregeneration, plasticity, and axonal growth, but are difficult to administer, have malignant side effects, and carry ethical concerns for example. The combination of various therapies best addresses the multifactorial nature of SCI, and studies have shown increased efficacy as compared to solo therapies. This review was conducted via database queries, focusing on papers within the past 8 years. Databases such as PubMed and Google Scholar were utilized for this search, using papers available to CWRU students.

Faculty Project Mentor: Abdel Halloway, Dept. of Biology

Capstone Instructor: Abdel Halloway, Dept. of Biology

**Assessing SPPL2B as a Promising New Risk Factor in Parkinson's Disease**

**Frankel Ellisa**, Neuroscience

Parkinson's Disease (PD) is a neurodegenerative disorder which causes tremors, difficulty of movement, and rigidity alongside many other non-motor symptoms. It is primarily hallmarked by the accumulation of toxic alpha synuclein (aSyn) aggregates and the death of dopaminergic neurons in the substantia nigra. Current treatments are unable to prevent long-term neurodegeneration, so more research is needed to improve long term outcomes. The multifactorial genetic nature of PD requires the identification of new risk factors and therapeutic targets. My project identified signal peptide peptidase like 2B (SPPL2B), a lysosomal aspartyl protease involved in regulated intramembrane proteolysis, as a promising potential risk factor in PD. We aim to determine the role of this factor in PD pathology. This project has primarily focused on cell culture of SH-SY5Y neuroblastoma cells. We find SPPL2B levels consistently upregulated in aSyn overexpressing dopaminergic cell models and in the dopaminergic neurons of A53T-aSyn expressing mice. In SPPL2B knockout (KO) SH-SY5Y cells generated via CRISPR-Cas9 gene editing, we find a consistent decrease in lysosomal protein levels, lysosomal activity, and total functional lysosomes. We link this lysosomal dysfunction to the dysfunction of mitochondria through reduced mitochondrial lysosomal contact spots in SPPL2B KO cells, pointing to a decrease in mitophagy. We also find an increase in mitochondrial oxidative stress and changes in proteins involved with mitochondrial dynamics, indicating mitochondria are not working at full capacity. In addition, we find an exacerbation of aSyn pathology upon SPPL2B KO. These results together show a potential role for SPPL2B in the pathology of PD through lysosomal and mitochondrial dysfunction and provide new possible avenues for therapeutic treatment. In the future, we plan to identify the mechanism by which SPPL2B is impacting lysosomal and mitochondrial dysfunction along with testing an overexpression line.

Faculty Project mentor: Xin Qi, Physiology & Biophysics, MED - School of Medicine

## Assessing College Success Skills in Incoming College Students from Underrepresented Backgrounds: A Qualitative Study

**Sharon Fung,** Psychological Sciences; Dr. Rita Obeid, PhD, Department of Psychological Sciences, Case Western Reserve University; Manal Alkabani, Department of Psychological Sciences, Case Western Reserve University; Dave Ki, Department of Psychological Sciences, Case Western Reserve University; Arthur Evenchik, Office of the Dean of the College of Arts and Sciences, Case Western Reserve University; Dr. Stephen E. Haynesworth, Department of Biology, Case Western Reserve University

There have been many implications that suggest the beneficial aspects of collaborative study groups, resulting in higher student academic performance and engagement (Wei et al., 2024). This notable finding is reflected in summer bridge programs– short and intensive programs that focus on strengthening academic skills to ease student transition from high school to college. For instance, summer bridge programs have often emphasized student skills pertaining to group work and active learning, while promoting accelerated learning and consistent GPA retention among underrepresented, first-generation, low-income students (Cooper et al., 2017, Johnson et al., 2024). Furthermore, this project examines how the Nord Family Emerging Scholars Summer Bridge Program (ESP) at Case Western Reserve University equipped underrepresented students to grow in collaborative study skills, while measuring such influence on student perception of collaborative study and group learning. Qualitative interviews were administered to two cohorts of students (2023 and 2024, n=18). Each student participated in two interview conditions: pre-test, and post-test relative to the program duration. Then, all qualitative interviews were transcribed, checked, and coded for themes (including reliability). Preliminary data has shown both a noteworthy increase in self-reported effective collaborative study skill attainment, and greater positive attitudes toward collaborative study. Students additionally reported reduced academic pressure, greater enjoyment, enhanced peer support and increased motivation as a result of collaborative study groups. These findings highlight the potential for summer bridge programs, specifically the Nord Family ESP, to improve not only academic performance but also social and emotional well-being by fostering collaborative learning skills.

Faculty Project Mentor: Dr. Rita Obeid, PhD, Department of Psychological Sciences, Case Western Reserve University

Faculty Sponsors: Dr. Stephen E. Haynesworth, Department of Biology, Case Western Reserve University; Arthur Evenchik, Office of the Dean of the College of Arts and Sciences, Case Western Reserve University

## Tippings Points in the Atlantic Meridional Overturning Current

**Nathan Fuss,** Mathematics and Physics

The Atlantic Meridional Overturning Current (AMOC) is a massive heat and salinity distribution system in the Atlantic Ocean. It takes cool water along the ocean floor from near Greenland and Iceland down the coast of the Americas and warm water along the surface in the opposite direction. The whole system moves heat at a rate of one petawatt ($10^{15}$ Watt) which is around 50 times more energy than the entirety of human civilization. It is theorized that there exists a tipping point in the flow of AMOC. This is seen as a rapid decline in strength due to a transition from a stable equilibrium to an unstable equilibrium. Thus far scientists have been unable to pin down exactly when this tipping point will be reached. The most recent estimates are confident that this will not be reached by 2100, but estimates of when range from hundreds to thousands of years. One of the reasons this is hard to estimate is that the systems governing weather are inherently chaotic. To handle this, typically, variables will be split into two terms, a dynamic term and a stochastic noise term to represent weather. Tipping points in AMOC have been studied in simple models that neglect the role of the "noise" due to weather, and in large scale simulations which presumably incorporate this in the detailed simulations of the dynamics, but where it may be difficult to understand the details. This project worked to extend the simple Stommel Box model to include a stochastic term to represent the weather noise. This has been done by coding the model in python. I will then be exploring various methods of generating random noise to examine the effects they have on the flow as salinity decreases due to glacier melts.

Faculty Mentor: Cyrus Taylor, Department of Physics

Capstone Instructor: Idit Zehavi, Department of Physics

**Organizational Factors in Physician Burnout After COVID-19: Lessons for the Future**

**Sreeja Gadepalli**, Department of Quantitative Health Sciences at Cleveland Clinic

Ensuring trust in early trial data allows for accurate transitions to subsequent steps of the discovery process. Additionally, resources used in the research process can be directed to innovations with stronger evidence. Transparency about these sample size considerations is also crucial for study replication. By producing generalizable data and ensuring transparency about sample size selection, we can streamline the process of scientific innovation and provide more options for patients in need. To this end, this study evaluates the rigor of sample size justifications in recent clinical neurology research in order to augment translational success.

This study examines the prevalence of complete sample size justifications in publications in the top five clinical neurology journals. Secondary goals include comparing study designs and clinical populations to explore whether some may be more likely to include inadequate sample size considerations. Recent studies (n = 125) in Lancet Neurology, Alzheimer's and Dementia, JAMA Neurology, Acta Neuropathology, and Brain were evaluated. Inclusion of components of an ideal sample size justification will be determined: effect size to be detected (standardized or unstandardized), alpha, power, and from where values were derived. Prevalence and completeness will be compared among study designs, clinical populations, and with regards to journal reporting requirements.

Principal Investigator: Dr. Olivia Hogue, Department of Quantitative Health Sciences

## Soft Rolling Robot: BB9

**Gangai Aidan,** Mechanical Engineering; **Gilliam Cameron,** Mechanical Engineering

Soft robots offer significant advantages in adaptability and resilience, making them well-suited for applications in search-and-rescue, medical devices, and exploration. For this project, we started with the general design of the Metacrawler, a soft, tubular robot developed by Dr. Yusuf Dikici which can move in 5 worm-like locomotion modes. These locomotion modes make it perfect for applications like space or maze exploration, vertical traversing, and pipeline inspection. We made modifications to the design in order to add a 6th locomotion mode: rolling. Rolling would be orders of magnitude faster than the other modes, greatly expanding the robot's applications. We employed iterative prototyping and experimental testing. Variations in thickness influence flexibility and structural integrity, while node geometry modifications affect surface contact with the ground. Additionally, we tested different actuation sequences to find ones that initiate and maintain rolling. This research aims to refine the interplay between mechanical design and actuation strategies, contributing to the broader development of soft robotic locomotion. Future work includes refining actuation algorithms and integrating sensor feedback for enhanced autonomy and control.

Faculty Project Mentor: Yusuf Dikici, Mechanical and Aerospace Engineering, ENG - Case School of Engineering

## Enzymatically Crosslinked *in situ* Hyaluronic Acid – Lipid Nanoparticle Composite Hydrogel Platform for Controlled Hemostatic Drug Release

**Maanyav Gangaraj**, Department of Biomedical Engineering

This study evaluates the diffusive release characteristics of an enzymatically crosslinked *in situ* forming Hyaluronic Acid – Lipid Nanoparticle (HA-LNP) composite hydrogel platform for controlled hemostatic drug release. Hemostasis is the body's natural process by which a necessary clot is formed at an injury site to stop bleeding, while maintaining physiological blood flow in systemic circulation. Factor XIII (a transglutaminase enzyme) is an important endogenous trigger for the *in situ* formation of hydrogels, as it acts upon fibrin (a transglutaminase substrate) to form a robust clot. Thus, Hyaluronic Acid (HA), a biocompatible ECM component, has been conjugated to the FXIII responsive $\gamma$-chain (a transglutaminase peptide: TGP) of fibrin's precursor to form HA-TGP. These gels are further combined with plasmin-cleavable LNPs decorated with the same peptide at controlled ratios to form HA-LNP composite hydrogels. In order to characterize their release profiles, formed hydrogels will be immersed in a warmed buffer, from which samples will be taken at specific time points and analyzed via fluorescence intensity. The aim of this study is to characterise the release characteristics of HA-LNP composite hydrogels, and their potentials for use in delivering pro-hemostatic payloads.

Project Mentor: Elizabeth Wakelin, Department of Biomedical Engineering, Case Western Reserve University

Faculty Mentor/Principal Investigator: Dr. Anirban Sen Gupta Ph.D., Department of Biomedical Engineering, Case Western Reserve University

## The Surprise of Fatima: Cognitive Biases, Perception, and Emotion in the 1917 Marian Apparition

**Monica Garcia**, Economics

This case study examines the Miracle of the Sun in 1917 in Fatima, Portugal where thousands reported witnessing a predicted divine solar phenomenon. The study examines the varied interpretations of the event using a cognitive science framework to demonstrate the effects of surprise on belief formation. Drawing from eyewitness testimonies, historical records, similar Marian apparitions, and cognitive science theories, the analysis will investigate how perception bias, cognitive dissonance, and other cognitive mechanisms are tied to the experiences witnessed in the Miracle of the Sun. Findings suggest that perception biases influenced belief formation amongst witnesses leading to varying belief formations of those who interpreted the event as a religious experience. These insights contribute to cognitive science research on elements of surprise in supernatural experiences and their role in faith formation.

Capstone Instructor: Vera Tobin, Department of Cognitive Science

## Asprosin-Ptprd Signaling in Mice Forebrain

**Sebastian Garcia**, Neuroscience; Hiba Obied, Bijou Basu, McKenzie Yun, Elizabeth Sabath Silva, Atul Chopra

The forebrain is traditionally associated with a variety of higher cognitive functions, sensory processing, and emotional regulation. The expression of CaMKIIα within the forebrain makes it a suitable structure to utilize the CaMKIIα-Cre/loxP recombination system and improve understanding of phenotypes that arise from this region. Receptor-type D protein tyrosine phosphatase (PTPRD) is a key mediator of appetite, thirst, and potentially other behaviors in the brain through its interactions with the protein hormone asprosin. Elucidating the role of asprosin-Ptprd signaling within the forebrain could provide insight into a new mechanism that controls memory and feeding behaviors. To create a site specific knockout of Ptprd, the Cre/loxP recombination system was exploited by utilizing a promoter derived from CaMKIIα gene that resulted in deletions of *Ptprd* in regions of the forebrain that express CaMKIIα. We hypothesize that the resulting CaMKIIα-Cre, Ptprd (flx/flx) male mice will exhibit notable metabolic changes that manifest as a reduction in food consumption, water intake, and body weight when compared to wild-type controls. Additionally, we hypothesize changes in spatial learning and memory alongside recognition memory and object discrimination. Alterations in these phenotypes would signal a new found role of asprosin-Ptprd signaling in the forebrain.

Faculty Project Mentor: Atul Chopra, Genetics and Genome Sciences, Harrington Discovery Institute

Capstone Instructor: David Friel, Department of Neurosciences

## HER2 and GD2 as Immunotargets for Osteosarcoma in Both Established and Patient-Derived Cell Lines

**Abhav Garde**, Biology; Dr. Zachary Burke, Department of Translational Hematology and Oncology Research, Lerner Research Institute, Cleveland Clinic

Osteosarcoma, a rare and aggressive bone cancer, is characterized by the production of osteoid, or immature bone by malignant cells, and primarily affects children and adolescents. Despite advances in neoadjuvant chemotherapy, there has been no significant improvement in effective treatment and prognosis for osteosarcoma due to its metastatic nature. Recently, immunotherapy targeting tumor-specific antigens has presented a promising strategy to improve therapeutic outcomes of many types of cancers. Disialogangliosides (GD2) and human epidermal growth factor receptor-2 (HER2) are candidate target antigens because of their expression across numerous osteosarcoma cell lines - bispecific antibodies are a good candidate for targeting these antigens to minimize unwanted targeting.

We tested GD2 and HER2 expressions on osteosarcoma cells of various origins in vitro by immunofluorescence (IF) staining and found various levels of expression. We utilized western blotting (HER2) to confirm our IF results and characterize the expression of HER2 throughout osteosarcoma cell lines. Fluorescence-activated cell sorting (FACS) was performed to confirm the IF results. Upon confirmation, cell killing events of osteosarcoma cell lines will be quantified by time-lapse live cell imaging with an IncuCyte.

GD2 and HER2 were expressed at various levels in a majority of osteosarcoma cell lines. HER2 expression varies among osteosarcoma cell lines and patient-derived cells. GD2 expression was detected in many osteosarcoma cells with some expressing very high signals despite variances in GD2 expression among osteosarcoma cell lines. Initial results confirm varied expression of HER2 and GD2 among osteosarcoma cell lines, potentially demonstrating them as therapeutic targets. After confirming and quantifying HER2 and GD2 with western blot and FACS, we intend to perform an osteosarcoma killing assay by coculture with T cells in the presence or absence of bispecific antibodies targeting either HER2 or GD2 and engaging T cells.

Project Mentor: Dr. Zachary Burke, Department of Orthopedic Surgery, Cleveland Clinic; Department of Translational Hematology and Oncology Research, Lerner Research Institute, Cleveland Clinic

Capstone Mentor: Dr. Elliot Gardner, Department of Biology

**Assessing Diuretic Resistance Across the Spectrum of Acute Heart Failure: Validation of a Machine Learning-Based Risk Score (BAN-ADHF Score)**

**Jeffrey George**: Department of Biology (CWRU); Dr. W. H. Wilson Tang, Department of Cardiovascular Medicine (Cleveland Clinic Heart Vascular and Thoracic Institute)

Acute heart failure (AHF) is a prevalent condition that manifests as an acute onset or worsening of heart failure symptoms, resulting in high hospitalization, morbidity, and mortality. Treatment of AHF primarily focuses on decongestion via loop diuretics but is frequently challenged by diuretic resistance (DR), a diminished individualized response despite adequate diuretic dosing. DR often results in persistent congestion, higher readmission rates, and worse patient outcomes. The BAN-ADHF score, a machine learning-based risk stratification tool incorporating laboratory values and clinical characteristics, aims to predict diuretic response and patient prognosis. However, external validation of its real-world clinical utility is limited.

A retrospective external validation of the BAN-ADHF score was conducted in consecutive AHF patients hospitalized between November 2024 and April 2025 at a tertiary academic medical center. Clinical variables collected on admission were used to calculate BAN-ADHF scores, and diuretic efficiency was assessed through changes in urine output and weight per standardized diuretic dose. The primary outcome was defined as diuretic efficiency, assessed through urine output and weight change per 40 mg furosemide dose equivalent, with a threshold of >3L urine output within the first 24 hours post-admission. Urine output was additionally monitored for 72 hours to evaluate sustained diuretic response. Patients were stratified into quartiles based on their BAN-ADHF scores, and diuretic response patterns were subsequently analyzed. Furthermore, diuretic dosing practices were retrospectively evaluated to determine their alignment with new individualized risk profiles and decongestion targets.

Findings suggest that higher BAN-ADHF scores correlate with greater diuretic resistance, as evidenced by reduced urine output and weight loss despite higher diuretic doses. These results underscore the BAN-ADHF score's potential to enhance risk stratification and optimize diuretic strategies for AHF patients. Further validation is necessary, but integrating BAN-ADHF into clinical workflows may enhance individualized treatment strategies and improve decongestion outcomes in AHF patients.

Project Mentor: Dr. Wilson Tang, Department of Cardiovascular and Metabolic Sciences, Cleveland Clinic Heart Vascular and Thoracic Institute

Faculty Sponsor: Professor Nancy DiIulio, Department of Biology, CWRU

**RPTP and RPTP localization in cultured murine hippocampal neurons & astrocytes based on permeabilized vs. non-permeabilized conditions**

**Joel George**[1,2], Physiology and Biophysics,

Running Title: Differential RPTP and RPTP localization in murine hippocampal cultures

Receptor protein tyrosine phosphatase and , (RPTP or RPTP), are the sole members of the R5 protein tyrosine phosphatase (PTP) subfamily within the broader PTP proteome, expressed throughout the central nervous system. The presence of an extracellular catalytically inactive carbonic anhydrase-like domain (CALD), which is hypothesized to bind $CO_2$ and $HCO_3^-$ to detect changes in extracellular $[CO_2]_o$ and $[HCO_3^-]_o$, categorizes them into a distinct PTP subfamily. In addition to the CALD, RPTP and RPTP feature an extracellular fibronectin III domain, a single transmembrane-spanning -helices and two intracellular (D1 & D2) phosphatase domains. These components enable RPTP and RPTP to translate extracellular $[CO_2]_o$ and $[HCO_3^-]_o$ into an appropriate intracellular response to maintain internal pH ($pH_i$). Alongside $pH_i$-regulation, RPTP and RPTP bind contactin to stabilize cell-cell interactions and influence cancer progression. Previous studies analyzed the distribution of RPTPγ/RPTPζ using immunocytochemistry (ICC). Many procedures, however, permeabilized cells before applying the primary antibody. Our research aims to elucidate the role of RPTPγ/RPTPζ in sensing extracellular Δ[CO2]o and $\Delta[HCO_3^-]_o$ and modulating $pH_i$. We sought to establish parameters that specifically focus on the relative expression of these proteins on the surface of cultured hippocampal neurons and astrocytes. In contrast to the standard permeabilized ICC protocol, non-permeabilized staining patterns for RPTP and RPTP exhibited distinct "halos" at neuron peripheries, aligning with expectations for membrane-localized staining. The new protocol revealed that, on average, 93.7 ± 3.5% and 86.8 ± 11.8% of neurons exhibit peripheral RPTP and RPTP staining respectively. In contrast, 6.3 ± 3.5% and 13.2 11.8% of neurons lack RPTP and RPTP expression respectively. Astrocytes express neither RPTP nor RPTP. Given RPTP/RPTP's hypothesized role in sensing $[CO_2]_o$ and $[HCO_3^-]_o$, future research should explore how hypocapnia modulates the relative surface expression of RPTP and RPTP.

Capstone faculty : Fraser J. Moss, Department of Physiology and Biophysics, Case Western Reserve University, School of Medicine, Cleveland

## Sibling Constellation Impact On Psychosocial Outcomes of Children With ASD: A Systematic Review

**Elizabeth Georges**, Psychological Sciences

Autism Spectrum Disorder (ASD) is a developmental disorder that impacts social interaction, specifically with peers. One in every thirty six children are diagnosed with ASD, with more prevalence in boys than girls. Some signs and symptoms include lack of eye contact, no response to name by 9 months of age, flat affect, lack of joint attention and limited imagination during play. The aforementioned symptoms impact social skills, adaptive behavior, and theory of mind– all together which address psychosocial developmental outcomes. Siblings are a unique potential intervention for psychosocial deficits in children with ASD as they may be able to practice social skills, turn taking, and witness modeled adaptive behavior. Families of children growing up with ASD play an important role in their psychosocial development by providing a supportive environment for communication and serving as behavioral role models. However, most literature on the relationship between ASD children and their family members examines how the ASD diagnosis in one sibling impacts the development of their typically developing (TD) siblings. The research regarding how the age, number and birth order of typically developing siblings (sibling constellation) may impact psychosocial development of children with ASD is limited. This systematic review aims to determine how TD sibling presence, as well as sibling constellation, impacts psychosocial development for children with ASD.

Findings expand on previous conclusions regarding sibling constellation impact on psychosocial development and demonstrate a need for further exploration of how existing family systems dynamics impact children with ASD.

Project Mentor: Doroteja Rubez, PhD Candidate, Department of Psychological Sciences, CWRU
Faculty Sponsor: Dr. Julie Exline, Department of Psychological Sciences, CWRU

## Manufacturing of Anti-Reflection Structures for Microwave Optics

**Jonah Gezelter,** Department of Materials Science and Engineering; Johanna Nagy, Department of Physics, CWRU

Telescopes for probing the Cosmic Microwave Background Radiation (CMB) require specialized detectors that are isolated from the environment to avoid noise from thermal and acoustic sources. The cryostat, where the detectors are held, must have a window that is transparent to microwave radiation. This window, in turn, must reflect as little light as possible, to prevent both the loss of incoming signal and the reflection causing errors in the image that the detectors eventually see. To prevent this, optimized structures for minimized reflection in the 150 GHz band have been developed. These high aspect ratio structures are challenging to manufacture in the material of choice, UHMWPE, using conventional machining methods. To prevent this, molds can be made using conventional machining methods out of stronger and more heat resistant materials, and the molds can be used to transfer the anti-reflection structure to the UHMWPE.

The work of this project has been developing the methodology for producing the full-scale cryostat window. The work done so far has not been able to develop a methodology that will fully transfer the anti-reflection features, but progress has been made on the characterization procedure for determining the effect of a mold process.

Faculty Advisor: Johanna Nagy, Department of Physics, CWRU

## Design Process for Proof-of-Concept Thermochromic Mug

**Jonah Gezelter,** Materials Science and Engineering; **Ravi Lin,** Materials Science and Engineering; **Justin Zimmerman,** Materials Science and Engineering

Thermochromism is an optical property of some functional materials in which a temperature change produces a visible phase and color change. This property is useful for determining the temperature of objects, including novelty mugs whose printed designs appear only when filled with hot beverages. This novelty effect can be leveraged to create a more useful product: one with two such changes to indicate to the user when the liquid contained within is both safe and comfortable to drink. This project encompasses the design process for developing a thermochromic coating more practically applicable to ceramic mugs and other drinkware. The goal is to create a coating that would undergo multiple color changes at specific and distinct temperatures corresponding to temperatures in the range of drinkability. Ideally, this should include a minimum comfortable temperature as well as one to indicate an unsafely high temperature for drinking.

Faculty Advisor: John J.Lewandowski, Department of Materials Science and Engineering, CWRU

**Correlates of Brain Atrophy and Survival Outcomes in Elderly and Non-Elderly IDH1-Wildtype Glioblastoma (WHO Grade IV) Patients**

**Robin Ghotra,** B.S. Neuroscience; Sree Gongala, George Wang, Franco Alonso, Grace Redmon, Parisa Arjmand, Yilun Sun, Haley K. Perlow, Tiffany Hodges, Chaitra Badve

Glioblastoma is a highly aggressive and often fatal brain tumor diagnosed in patients with a median age of 65 years old. Recent literature suggests no significant age-based differences in survival outcomes in glioblastoma patients. However, a gap in literature remains in understanding whether age specifically influences the biological characteristics of glioblastomas, including baseline brain health. Through an IRB-approved retrospective, single-center study involving 223 patients diagnosed with an IDH1-wildtype, WHO grade IV glioma treated at University Hospitals Cleveland Medical Center from 2012-2024, this paper examines age-specific differences in tumor parameters such as sex, Karnofsky Performance Score, MGMT promoter methylation, extent of resection, tumor locations, volumes, and several other features. Overall and progression-free survival was analyzed using univariate and multivariate Cox proportional hazard models, with survival differences assessed through Kaplan-Meier curves and log-rank tests. Additionally, brain atrophy in patients was analyzed using both subjective and quantitative tools, including a neuroradiologist review to assess global cortical atrophy (GCA) across 13 key brain regions using a standardized scale. Voxel-based morphometry was employed to computationally measure differences in gyrification, cortical thickness, grey (GM) and white matter (WM) volumes, and sulcal depth through voxel-wise comparisons of serial MRI images. Non-elderly patients had higher GM volumes compared to elderly patients (Median: 161.12 mL in non-elderly vs 140.47 mL in elderly, $p<0.001$). There were no significant differences in WM volumes, thickness, and depth. However, significant differences were seen in the gyrification index (27.92 mm in non-elderly vs 27.59 mm in elderly, $p<0.001$). Multivariate cox analysis demonstrated that a higher gyrification index, larger thickness, and smaller sulcal depth significantly reduced the risk of mortality in glioblastoma patients without accounting for age. This study indicates that baseline brain health influences survival in glioblastoma patients, regardless of age, with markers of better cortical health linked to improving patient survival outcomes.

Principal Investigator: Dr. Chaitra Badve, Department of Radiology, University Hospitals & CWRU School of Medicine

Capstone Instructor: Dr. Jon Niemi, Department of Neurosciences, CWRU School of Medicine

## Getting Real About Sex Education

**Rachel Ginn,** Psychology and Environmental Studies

In the United States, considerable controversy has surrounded how to best teach sex education since its beginnings in the early 20th century. Discussions have centered on what content is covered broadly, as well as how, when, and where these programs are implemented. No federal laws or mandates dictate sex education, so state and local decisions on sex education differ greatly from program to program (Planned Parenthood). Development of a nationwide sex education program could provide a stable, consistent resource for schools and would likely improve outcomes for students. The purpose of this comparative literature review was to explore important considerations for development and implementation of a comprehensive sex education program. Major areas to be considered in the development of sex education programs include why sex education is important, the barriers to sex education implementation, the history of sex education, and the different formats of sex education currently available. This review provides information on a newer comprehensive program, the 'Get Real: Comprehensive Sex Education that Works' curriculum, and evaluates its ability to fulfill the qualifications needed for a federally mandated program. The main findings revealed that modern sex education has grown more comprehensive in response to research recommendations, yet the general US population cannot agree on what form of sex education to promote and different governmental administrations handle federal funding towards sex education differently. The 'Get Real" program shows promise as a national program, as it incorporates parents and family and covers important territory like consent and LGBTQIA+, but further information is needed from the current Wellesley study and additional researchers regarding its applicability to the general US population.

Project Mentor: Dr. Jennifer Grossman, Wellesley Center for Women, Wellesley College

Capstone Instructor: Dr. Elizabeth Short, Department of Psychological Sciences

## The Signaling Role of the Viral Protein Motif Tip37 in CAR-NK Cell Therapy for Cancer Treatment

**Krithin Reddy Godala**, Biology and Psychology; Dr. Wooram Jung, Department of Cancer Biology, Cleveland Clinic Lerner Research Institute.

Immunotherapy, which works by improving the body's immune system to fight cancer, was previously thought to be a final effort to treat cancer only after exhausting the usefulness of chemotherapy and radiation. However, the development of CAR T cells, or Chimeric Antigen Receptor T cells, has pushed immunotherapy to the forefront of cutting edge research into cancer biology. CAR T are specially engineered T cells with the goal of fighting cancerous tumor cells. New research in this field has led to hopes that immunotherapy will soon become the first defense against cancer and not just the final effort.

Like T-cells, NK or Natural Killer cells are another lymphocyte. NK cells function similarly to T cells and can also be compatible with CAR. NK cells belong to the innate immune system, while T-cells are part of the adaptive immune system. We hypothesize that this difference may provide alternate possibilities in the therapeutic function of CAR when expressed in an NK cell rather than a T-cell.

The first generation of CAR T cells used protein segment CD3-ζ which has tyrosine amino acids that must be phosphorylated to activate the single chain variable fragment that targets cancer cells. LCK, or lymphocyte-specific protein tyrosine kinase, is what causes this phosphorylation. Our lab discovered Tip-37 when investigating Herpesvirus Saimiri (HVS) and it was seen that Tip37 was very efficient at binding LCK to increase phosphorylation. The objective of the project is to introduce Tip37 into the CAR and investigate its effect on the cytotoxicity function (killing capacity) of the CAR NK cell. We hypothesize that if this could be used as an additional protein motif in a CAR it would improve the efficiency of activation and effector function against tumor cells.

Project Mentor: Dr. Wooram Jung, Department of Cancer Biology, Cleveland Clinic Lerner Research Institute.

Capstone Instructor: Dr. Robert Ward, Department of Biology, Case Western Reserve University

## FROG Pond Controller

**Wiktor Golczak**, Electrical Engineering

In temperate climates small ornamental fish and amphibian ponds require artificial intervention to maintain a healthy environment during winter. Without intervention, a sheet of ice will form over the surface, inhibiting gas exchange. This causes the pond water to become depleted of oxygen and saturated with methane, killing most beneficial organisms and resulting in a foul smell. These conditions destroy the fragile balance of plant, bacterial, and invertebrate life needed to maintain good water quality in the summer season. Pond heating consumes significant electrical energy which makes it expensive and taxing on the environment. Thus, an efficient pond heater uses only the energy needed to keep the surface above 0°C.

Unfortunately, this amount of energy is different for every individual pond depending on size, shape, climate, and sun and wind exposure. To solve this problem and achieve maximum pond heating efficiency, an active temperature control system is needed.

Currently, it is possible to control pond heaters through commercially available smart powerstrips or general purpose PLCs. However, these devices have limitations that make them unsuitable for most users. Thus, the need for an active pond temperature control system is still unmet. Our research seeks to address this problem by developing the titular device, the FROG pond controller. This device will connect between the outlet and heater, using thermometers to measure temperature feedback and control power to the heater. Wifi connectivity will allow remote configuration of the device from indoors. By integrating active temperature feedback, the FROG will reduce the cost and environmental impact of pond heating.

Faculty mentor: Christian Zorman, Electrical, Computer and Systems Engineering, ENG - Case School of Engineering

## Expanding a Stance Model to Analyze Passive Stability

**Joshua Goldberg:** Mechanical Engineering

Although there has been a significant amount of research into how animal stance affects perturbation, there is not a generic model out there that can be used to predict how several animals, each with different stances, will react. Some animals, like humans and horses, have a threshold for how much they can be perturbed while walking until they fall over, but some insects do not. The goal of this project is to expand an existing model so it can better predict how different animals with different stances will react to perturbation. An important component of stance in particular is dynamic stability. Standing stance of a human can be modeled as a four bar linkage, with hip joint width generally being proportional to height. Expanding this model was accomplished by first taking an existing Simscape expansion of the model that was done in the lab, which was scaled based on animal size. These animals were the horse, human, cat, rat, mouse, fruit fly, and cockroach. Then, the model was edited to add knees between two leg segments instead of just having a singular leg segment and knee joints were implemented, each with their own respective stiffnesses and damping. To take the model from two-dimensional to three-dimensional, extra sets of legs were added to the model in order to add accurate depth. After this, the model was switched from Simscape to Mujoco using Python, and oscillations and natural frequencies were modeled and collected. Although the project is still in progress, it is expected that animals that are smaller are statically stable and have a higher natural frequency than walking frequency, while larger ones aren't statically stable and have a lower natural frequency than walking frequency. The model is currently being made more accurate for the fruit fly, and perturbations are being scaled.

Project Mentor: Dr. Roger Quinn, Department of Mechanical and Aerospace Engineering

## Mapping PIEZO2 Channel Expression in Rat Brain Cortex

**Mikhail Goldenberg,** B.S Neuroscience, Case Western Reserve University

PIEZO2 is a mechanosensitive ion channel known for its role in peripheral sensory functions, but recent studies suggest it may also be involved in interoceptive processes within the central nervous system. Interoception refers to the brain's ability to sense and interpret signals from within the body, such as changes in blood pressure, respiratory stretch signals, and GI motility. More specifically, cardiac interoception involves the brain's detection of internal signals generated by the heartbeat and blood flow, which can influence emotional state and homeostatic regulation. PIEZO2 channels are emerging as key mediators of internal sensory feedback, with growing evidence suggesting their expression in specific brain regions allows mechanical signals, such as vascular pulsations, to directly influence neuronal activity. The aim of this study is to map the distribution of PIEZO2 channels in the rat brain cortex, with a focus on identifying their expression in cortical neurons.

Using transcardiac perfusion fixation (4% PFA), cryostat serial sectioning, and immunohistochemistry, we analyzed cortex sections through fluorescence microscopy by qualitative measures. Preliminary findings showed PIEZO2 positive channel expression in neurons within the visual and entorhinal cortices. By examining the location and density of these channels within cortical regions, we can begin to understand how organ function may influence cognition, perception, and other higher brain functions through direct interoceptive coupling between the heartbeat and neuronal excitability.

Project Mentor: Mathias Dutschmann, PhD, Department of Pulmonology, Critical Care, and Sleep Medicine

## Beam Mapper for CMB-S4

**Margaret Goldstein**, Engineering-Physics

CMB-S4 is a new ground-based cosmic microwave background experiment that will use more than 500,000 cryogenically cooled superconducting detectors. These detectors are fabricated in arrays on silicon wafers and integrated with feedhorns and readout electronics to form a module. Before these detector modules can be deployed, they need to be tested to ensure they meet the operating requirements of CMB-S4. One important test for these detector modules is mapping their beams over the range of frequencies of their intended use. A beam mapper consisting of a thermal source mounted on multi-axis translation stages can be used to test these detector modules. The purpose of this project is to design, develop, and test a beam mapper to create an efficient method for testing CMB-S4's detector modules.

Project Mentor: Johanna Nagy, Department of Physics, CWRU

Capstone Instructor: Idit Zehavi, Department of Physics, CWRU

## Post-Stroke Wearable Upper Arm Support

**Ana Cecília Gomes,** Biomedical Engineering; **Ben Kwiatkowski,** Biomedical and Electrical Engineering; **Andrew Smith**, Biomedical and Electrical Engineering; **Victoria Rose Warady**, Biomedical Engineering

Over 790,000 people suffer a stroke each year, with approximately 26% of them experiencing upper arm hemiparesis. Improper rehabilitation of the upper extremities can lead to learned nonuse and reinforce abnormal synergistic movements, which may further impede an individual's ability to complete activities of daily living (ADLs). Abnormal synergies occur when attempted voluntary contraction of specific muscles or muscle groups results in the involvement of extraneous muscles. Abnormal shoulder-elbow flexion, in which the elbow, wrist, and fingers flex upon voluntary abduction of the shoulder, is frequently observed. However, this atypical synergy does not occur when an external effort is applied. Current solutions to mitigate this problem include active, motorized exoskeletons or arm supports. Existing active shoulder supports are bulky and intended for vocational strength enhancement rather than movement support, and other solutions provide little to no ambulatory capabilities. To address these limitations, we have designed a wearable device that can provide short-term, active movement support at the shoulder for individuals with upper-limb hemiparesis, particularly those demonstrating the potential for partial to full restoration of movement. This novel device, which should be employed during post-stroke rehabilitation, is intended to actively facilitate flexion and extension at the shoulder and inhibit abnormal synergies, thereby increasing reach and ADL capabilities. A motor positioned on the back will provide active movement assistance about the shoulder, as triggered by user muscle contractions captured and processed by an EMG sensor and a microcontroller, respectively. The sensor will output a rectified and integrated raw EMG signal, which will then be compared against the maximum voluntary contraction for signal processing and actuation of the motor. The lifting component will be supported by a brace that extends down the arm and includes the ability to adjust the allowed elbow flexion and extension.

Project Mentor: Dr. Matthew Williams, Department of Biomedical Engineering, Case Western Reserve University.

**Predicting the Unseen: AI, Depression, and Suicide Risk Detection in Older Adults**

**Trinity Goodloe,** Psychology and Communication Sciences and Disorders

Suicide in older adults, largely driven by underdiagnosed and untreated depression, is a growing public health crisis. Late-life depression is often misattributed for normal aging, leaving many at risk undetected and contributing to late-life suicide. Conventional screening tools fail to identify high-risk individuals, particularly those who do not verbalize distress due to stigma, cognitive decline, or misattributed symptoms, leaving a dangerous gap in prevention efforts. Artificial intelligence (AI) offers a groundbreaking solution by integrating multimodal data sources to uncover hidden patterns of suicidality, improving early detection and post-intervention strategies. This critical review of 22 studies examines AI-driven models leveraging speech acoustics, facial micro-expressions, neurobiological markers, and behavioral patterns to detect subtle cues often missed by traditional assessments. Studies were identified through a rigorous search using keywords. Findings reveal that AI-powered multimodal approaches outperform only standard clinical tools, achieving prediction accuracies between 83.91% and 96.6%. Despite these advancements, challenges remain, including data standardization, age related concerns, and clinical integration. As suicide rates among older adults rise, AI-driven mental health screening is no longer an option, it is a necessity. Future research must refine AI models for broader clinical application and optimize their use in real-world settings. This review underscores the urgent need to integrate AI into suicide prevention frameworks, advocating for age specific, data-driven approaches that can revolutionize early intervention and save lives.

Keywords: depression, depressive disorder, elderly, suicide prediction, suicide prevention, machine learning, older adults, depression detection, speech analysis, facial expression recognition, neurobiological markers, multimodal assessment, early intervention

Capstone Instructor: Amy Przeworski, Department of Psychological Sciences

**BlazePath: Smart Evacuation Routing and Hazard Tracking for Wildfires**

**Meghana Gopu,** Computer and Data Sciences; **Abhinav Khanna,** Computer and Data Sciences; **Michael Kong,** Computer and Data Sciences; **Ved Shivade,** Computer and Data Sciences; **Jayshree Srinivasan**, Computer and Data Sciences

Thousands of wildfires burn in the United States annually, posing significant risk to life and property. This year's most severe wildfire, the Palisades Fire in Los Angeles, CA, covered a staggering 23,707 acres at its peak in January, taking 29 lives and displacing 150,000 others. Evacuation orders and road closures often change hourly, making it challenging to stay updated and navigate the latest conditions.

To address this need, we present BlazePath — a web-based GIS (Geographic Information System) application designed to assist residents in wildfire-prone areas of the U.S. by providing optimized, hazard-aware evacuation routing. BlazePath integrates real-time data from weather forecasts, Air Quality Index (AQI), traffic APIs, and crowd-sourced, user-submitted updates on active fires, road closures, shelters, and resource locations. This data is aggregated to determine the safest and most efficient evacuation routes by balancing speed with hazard avoidance. BlazePath is built with a ReactJS and Leaflet.js frontend, supported by a Python/Flask backend.

From a data science perspective, BlazePath features a predictive heatmap that identifies fire-prone regions using a machine learning model trained on merged historical wildfires (from NASA Firms 2022-2025 satellite dataset) and weather data (from OpenMeteo API).

BlazePath empowers communities to better prepare for wildfires by forecasting risk zones and guiding users away from danger — enabling faster, safer evacuations and more informed decision-making.

Project Mentors: Professor Shuai Xu, Department of Computer and Data Sciences

Faculty Sponsors: Professor Shuai Xu, Department of Computer and Data Sciences

## Determining the Emotional and Temperamental Risk Factors for Stuttering in Preschool-Aged Children

**Katherine Gordon**, Case Western Reserve University, Communication Sciences and Disorders

Developmental stuttering is a speech fluency disorder that occurs in preschool-aged children, with 70-80% of those affected recovering without any formal treatment. Why some children continue to stutter—also known as persistent stuttering—and others recover remains a question for many researchers. While some risk factors of persistent stuttering such as gender and family history have received a lot of attention in the past, emotional and temperamental risk factors have generated much interest in recent years. This systematic review aims to uncover the emotional and temperamental risk factors present in preschool-aged children who stutter that may lead to persistent stuttering in school age or adolescence. To conduct this review, studies were selected from PubMed and EBSCO with the search criteria of a preschool-aged population and the examination of at least one emotional/temperamental risk factor for persistent or more severe stuttering. Of the 26 studies imported for screening, five duplicates were removed, six studies were deemed irrelevant at the abstract screening level, and another seven were excluded for not meeting the inclusion criteria at the full-text level. This left eight studies for analysis. These studies will undergo data extraction to determine which temperamental and emotional characteristics—most commonly negative affect, effortful control, and emotional reactivity—may increase the risk of persistent stuttering for preschool-aged children.

Faculty Project mentor: Angela Ciccia, Communication Science

**Cellular and Molecular Mechanisms of 15-PGDH Inhibition in Idiopathic Pulmonary Fibrosis Treatment**

**Filip Goshevski**, Biomedical Engineering; Mariana Fragoso , Lyannah A. Contreras, Rahul Chaudhary , Sanford Markowitz , and Amar B. Desai

IPF is a chronic lung disease of unknown etiology, characterized by interstitial remodeling, progressive lung scarring, and pulmonary dysfunction. Annually 50,000 Americans are diagnosed with IPF, while as many as 40,000 die from the disease. The pathogenesis of the disease is complex and involves environmental, age-related and genetic factors. Recent evidence suggests IPF develops after recurrent injury of the alveolar epithelium, followed by mild inflammatory response and dysregulated repair process. This results in the accumulation of myofibroblasts, resulting in exaggerated ECM deposition and decline of lung function. While treatment options have increased in recent years following the approval of the anti-fibrotic agents Pirfenidone and Nintedanib, both agents are only able to slow the rate of inevitable disease progression, with neither drug able to actually stop or reverse disease, demonstrating the need for the development of new promising drug candidates. Our team has identified a novel approach to treat IPF by upregulating Prostaglandin E2 (PGE2) and inducing lung repair. We achieved this by developing a small molecule that inhibits 15-Prostaglandin Dehydrogenase (15-PGDH), an enzyme that mediates the degradation of PGE2. In particular, our group was the first to demonstrate that 15-PGDH inhibition is an effective therapeutic strategy in murine IPF as evidenced by a reduction in pulmonary inflammation, collagen deposition, and lung injury scores, coupled with enhanced respiratory function and survival. We aim to establish two different preclinical models of IPF (the bleomycin-induced model and the inducible SFTPC-I73T model that recapitulate the IPF phenotype of human familial IPF) and demonstrate the efficacy of (+)’291 in reversing the disease in both models. The ultimate goal of our study is to determine the cellular and molecular mechanisms through which ’291 induces lung repair by identifying the cellular subtypes and signaling pathways that are key mediators of ’291 therapeutic effect using scRNAseq.

Faculty Mentor: Amar Desai, Case Comprehensive Cancer Center Case School of Medicine

## The Implications of Free Community College on Homelessness Rates

**Adam Gousie**, Economics, Mathematics; **Nell Harris**, Economics

We examine the effect of free community colleges (CC) on homelessness rates by analyzing the changes in homelessness rates before and after the implementation of free CC tuition in various Continuums of Care (CoC) across the U.S. Continuum of Care are geographic areas coined by the Department of Housing and Urban Development (HUD) to more easily provide housing services for the homeless population. While there is already meaningful research addressing homelessness in the U.S., we seek to explore a potential factor that is often overlooked when looking at homelessness: education. Specifically, we investigate whether free higher education directly impacts homelessness because this would allow for new approaches to housing legislation. We compare homelessness rates at the CoC level between states that have free CCs and those without. The homelessness data was recorded annually by HUD and spans from 2007 to 2024 at the CoC level. Our control data comes from Census data via the Bureau of Labor Statistics across the same time period. Using a difference-in-differences model, we explore the relationship between homelessness and free CC tuition. Our model compares homelessness levels in CoCs with free CC before and after the free CC programs were introduced, using lag effects to account for any delay in the onset of effects. We hypothesize that free CC tuition is associated with a decrease in homelessness because an increased number of financially disadvantaged students will have the opportunity to earn a degree, which will improve labor market outcomes for these students. If our results support our hypothesis, then policymakers could begin to integrate their education and homelessness policies to have more substantial positive effects on the homeless population across the U.S.

Project Mentor: Professor Jenny Hawkins, Department of Economics

## Metabolic Alterations in Amyotrophic Lateral Sclerosis

**Ashley Grant,** Neuroscience; Dr. Xin Qi, Department of Physiology and Biophysics

Amyotrophic Lateral Sclerosis (ALS) is a disorder characterized by a progressive loss of muscle control due to degeneration in upper and lower motor neurons. Previous research studies have reported on metabolic alterations contributing to common symptoms observed among individuals with ALS, such as muscle weakness, respiratory dysfunction, and ultimately paralysis. A prominent proteinopathy in ALS involves the accumulation and mislocalization of TDP-43, a protein involved in RNA processing and regulation of gene expression, in the cytoplasm. Due to the aggregation of TDP-43 in the cytoplasm, its normal function of RNA metabolism is impaired which results in mitochondrial dysfunction. We have utilized a human cell line provided by Human Embryonic Kidney 293 (HEK293) cells to further examine how our protein of interest, hexokinase 1 (HK1), impacts mitochondrial function and cellular metabolism in ALS pathology. Our lab has previously shown that HK1, a protein that regulates ATP production, is dysregulated in TDP-43 models. Since our previous reports show that an increase in pathogenic TDP-43 decreases HK1, we seek to determine if an increase in HK1 will alter TDP-43 and promote pathogenic proteinopathy. In order to determine the effects of HK1 overexpression on TDP-43, we overexpressed HK1 in an *in vitro* model and utilized immunoblot techniques to determine that there was no change in the total amount of TDP-43. Our findings emphasized that an increase in HK1 does not promote the deleterious effects of TDP-43. Through this data collection, we aim to determine if the overexpression of HK1 results in the alteration of TDP-43 provide further insight into disease mechanisms and prominent biomarkers for ALS.

Project Mentor: Dr. Xin Qi, Department of Physiology and Biophysics

## Political Polarization and Its Impact on Mental Health of the United States

**Nathan Green**, Department of Psychological Sciences

On January 6th 2021, the United States experienced the first insurrection against its government because of the rising tension in the political climate. Political polarization doesn't just result in political eruptions such as this, but it can also affect an individual's mental health. After the 2020 election, 14% of voters' mental health became worse, while 15% of voters' mental health became better. This changing of mental health as a response to an election or person in office was a trend across the literature. The evidence indicates 70% of voters share an implicit bias toward their party, and an even higher explicit bias. This leads to in-group out-group formations amongst individuals along partisan lines. As such, if an individual is perceived to be in the political out-group they can experience the negative mental health outcomes of out-group bias. Studies conducted on adolescents showed that liberals experience more depressive symptoms, anxiety symptoms, and loneliness than conservatives from the years 2004-2018. The latter year being the most politically polarized midterm in the past two decades. Studies have also shown that there is a physical health impact to polarization and not just a mental health impact. Those who perceive politics as becoming more polarized experience an average of 2.59 days of poorer health per month. The evidence acquired from the literature presents that political polarization is not just a simple stressor, but a catalyst for poor mental and physical health outcomes for part of the population.

Faculty Sponsor: Dr. Anastasia Dimitropoulos, Department of Psychological Sciences

**Characterization of Ansa Cervicalis and Vagus Nerve Branch Patterns in the Carotid Triangle of Human Cadavers**

**Morgan Griffith;** Neuroscience; Dr. Andrew Crofton; Department of Anatomy, School of Medicine

Vagus nerve stimulation (VNS) within the carotid triangle of the cervical region is an FDA-approved treatment for conditions such as migraines, depression, and epileptic seizures. The VNS electrodes are placed in the carotid triangle region, which is defined by the intersection of the sternocleidomastoid, omohyoid, and posterior belly of the digastric muscles. That region houses several important structures aside from the vagus nerve that may contribute to potential adverse effects from the procedure, such as hoarseness or trouble swallowing. Notably, the ansa cervicalis nerve, responsible for innervating the infrahyoid muscles that assist with swallowing and phonation, is also typically located within this region. Although these adverse effects have been assumed to be the result of variation in the vagus and surrounding nerves, the normal anatomical variation within this region remains relatively unexplored. We hypothesize that significant variation exists in the nerve structures within the carotid triangle between individuals. To test this hypothesis, we investigated the branch patterns of the vagus nerve and ansa cervicalis in human cadavers. Measurements of the ansa cervicalis diameter and branch count were taken from 6 cadavers (5 bilaterally, 1 unilaterally), along with the trajectory and number of the vagus nerve branches in the cervical region. Our analysis revealed individual variation in both the number of branches and the diameters of these nerves. In conclusion, there is evidence to suggest that there is anatomical variation between individuals within the carotid triangle, which should be considered before procedures in this region to ensure potential side effects are avoided.

Project Mentor: Dr. Andrew Crofton, Department of Anatomy, School of Medicine

Capstone Instructor: Dr. David Friel, Department of Neuroscience

## Improved Modeling and Controls for Biohybrid Robots

**Ryan Grummer**, Mechanical and Aerospace Engineering, CWRU

One of the greatest deficiencies of modern robots is the actuators used. Electric motors are best at fast, low force, continuous rotation (the exact opposite of what a robot's limb does) while pneumatics and hydraulics require bulky external pressure sources. The field of biohybrid robotics seeks to address this issue using the most widely deployed actuator on planet Earth, living muscle tissue. Unfortunately, there is a lack of design tools with integrated muscle models based on experimental data. This limits the ability to use simulators for robot and controller development. This project seeks to remediate this issue by developing a custom muscle forcing function for the simulation package PyElastica and implementing that function on a pre-existing lattice worm robot simulation. The muscle forcing function is based on previously collected experimental data fit to a Hill-type muscle model for the I3 muscle of the Aplysia californica (a species of sea slug). This muscle can be readily harvested and has potential for use in biohybrid robotics for marine applications. The I3 is one of the largest muscles in the sea slug's feeding apparatus and can produce high forces while being small enough that nutrient diffusion can be used to sustain the muscle. To demonstrate the implementation of this model it was integrated into a lattice worm robot simulation and the controls for the worm were developed to account for this more accurate form of muscle model.

Project Mentors: Dr. Roger Quinn, Mechanical and Aerospace Engineering, CWRU and Dr. Victoria Webster-Wood, Mechanical Engineering, Carnegie Mellon University

Capstone Instructor: Dr. Majid Rashidi, Mechanical and Aerospace Engineering, CWRU

# PREDICTING EVOLUTION OF TREATMENT RESISTANT MUTATIONS WITHIN CANCER CELL POPULATIONS USING ECOLOGICAL POPULATION DISTRIBUTION MODELS

**Julia Gumina,** Physics

Resistance to treatment is a major concern for many illnesses such as those caused by bacterial infections and cancer. This resistance comes about through evolution of living cells which means new treatments can only be created in response to newformed resistance. Thus, leaving medical research constantly playing catchup to the ever-evolving diseases. Being able to predict how the cell populations will evolve to form resistance would be a huge step in avoiding it and may give treatment research a competitive advantage in the future. This project will expand on previous research that found cancer cells could be modelled using population distribution models formed from the study of population genetics. The aim is to form a model that takes into account the physical distribution of mutated cells within a tumor and how the layout of a tumor would impact the relative fitness of mutations that occur.

Project Instructor: Dr. Michael Hinczewski, Department of Physics Case Western Reserve University, Senior Project Committee

## Demonstration of Resonance in a 1 DOF System

**Gupta Aashka,** Mechanical Engineering

Vibration remains an important and overlooked aspect of failure analysis. Failure by resonance is a technical and practical consideration in many engineering structures, and understanding the physical effects of resonance is crucial. In this project, I mathematically identify the natural frequency of a 1DOF system. The natural frequencies are then displayed by a test rig that vibrates the system at that natural frequency. I first calculate system parameters based on the dimensions, contents, and composition of my system. Using these constraints and differential analysis, matrix math is conducted to identify the eigenvalues of the system. These relate to the natural frequencies that are found. Upon obtaining natural frequencies, the test rig is fabricated. The test rig consists of a support on which to mount the system and a means of excitation. The materials are chosen to themselves resist the natural frequency of the system while demonstrating resonance on it. In order to identify the magnitude of the effect of the frequency, a linear potentiometer identifies the displacement in the system. The results are tabulated.

Faculty Instructor: Majid Rashidi, Mechanical and Aerospace Engineering, ENG - Case School of Engineering

## Opening the Door to a Better Shelf

**Caroline Kromalic**, Materials Science; **Anuvi Gupta**, Mechanical Engineering; John J. Lewandowski, Department of Materials Science and Engineering, CWRU

While refrigerator shelves are an important and useful item used daily, they often present a plethora of problems. Plastic refrigerator shelves tend to break under heavy loads, while spills may be difficult to clean. In general, the shelves may not be accessible to the short or the elderly. Our design opens the door to a better future for refrigerator shelves by making improvements in all these areas. For the shelves within the refrigerator itself, we will be replacing the plastic shelves with a metal rack, which is less likely to break. To prevent spills from causing a mess in the refrigerator, our design includes a clear plastic crumb tray under each wire shelf that is easy to remove if something spills. This way, food or liquids spill onto the tray instead of the rest of the refrigerator. In addition, to make the shelves more accessible in the refrigerator, each shelf has wheels to enable easier access to items by simply pulling the shelf out. A small barrier is added to the front of the shelf to prevent items from falling off the shelf during movement, while a hinge will be designed for easier access to items at the front of the shelf. The shelves on the door will also be designed with a hinge on the front wall, while the entire shelf is made of metal to improve their fatigue resistance and strength. These design modifications from typical refrigerators are intended to make refrigerators cleaner and more accessible.

Project Mentor: Professor John J. Lewandowski, Department of Materials Science and Engineering, CWRU

## Induction of A1 Reactive Astrocytes in 3-D Cortical Organoids

**Avnish A. Gupta**, Biology

Cerebral organoids provide a versatile system for studying cellular interactions and organization but lack consistent methods to induce A1 reactive astrocytes, a neurotoxic subtype linked to neurodegenerative diseases. Here, we generated A1 reactive astrocytes in human cerebral organoids derived from human derived induced pluripotent stem cells (iPSCs) using Tumor Necrosis Factor, Interleukin-1α, and Complement Component 1q administered at specific maturation stages. We assessed astrocyte reactivity by quantifying and visualizing the expression of A1 reactivity markers C3 and GBP2 and evaluated downstream effects on oligodendrocyte and neuronal populations.

Although no statistically significant differences in C3 and GBP2 expression were observed across treatment groups, trends of increased expression in prolonged cytokine exposure groups warrant further investigation. Additionally, oligodendrocyte marker expression (Sox10 and PDGFR-α) remained unchanged, suggesting limited impact on oligodendrocyte populations. These findings underscore the challenges of modeling A1 reactive astrocytes in cortical organoids and emphasize the need for optimized experimental conditions.

Project Mentor: Paul J. Tesar, Ph.D., Department of Genetics and Genome Sciences, Case Western Reserve University School of Medicine

**Liver Fibrosis as an Independent Prognostic Factor Affecting Liver Disease-Free Survival and Overall Survival in Patients with Colorectal Cancer Liver Metastases**

**Nikhil Gupta,** Biology

Colorectal cancer (CRC) is a leading cause of cancer-related deaths, with liver metastases (CRLM) occurring in 25-50% of patients. Prognosis for CRLM remains poor as there are limited treatment options and high recurrence rates. While liver fibrosis is typically correlated to tumor progression, evidence suggests that it may improve survival outcomes. This study aimed to investigate the protective role of liver fibrosis in CRLM on liver disease-free survival (DFS) and overall survival (OS).

Data was obtained from TCIA for 197 CRLM patients who underwent liver resection. Inclusion criteria were confirmed CRLM, available pathology data, and preoperative multi-detector CT scans. Kaplan-Meier survival curves and Cox proportional hazards models assessed survival outcomes and prognostic factors. A p-value $< 0.05$ was considered statistically significant.

Among patients in the dataset, median liver DFS was 53 months, and median OS was 76 months. Univariate Cox analysis identified numerous prognostic factors that modestly predicted survival outcomes. Multivariate Cox analysis of these variables confirmed that fibrosis $\geq 40\%$ (HR = 0.34; HR = 0.37), presence of an extrahepatic disease (HR = 2.2; HR = 2.4), and chemotherapy (HR = 2.4; HR = 1.7) significantly predicted both liver DFS and OS outcomes. Spearman correlation heatmap analysis revealed predictable correlations between variables such as NASH and steatosis and unexpected correlations between variables such as fibrosis and residual tumor percentage.

This study demonstrates that liver fibrosis $\geq 40\%$ has a potential protective role as it associated with improved liver DFS and OS in patients with CRLM. Modifications induced by fibrosis in the tumor microenvironment, such as increased tissue stiffness and ECM remodeling, may inhibit tumor progression. Despite limitations, including dependence on image-based assessments and a retrospective design, fibrosis is a possible biomarker for CRLM prognosis. Future prospective studies are needed to investigate mechanism and validate results.

Project Mentor: Andrew Dhawan, Cleveland Clinic Lerner Research Institute

Capstone Instructor: Dr. Barbara Kuemerle, Department of Biology

## Spinal Cord Stimulation for Chronic Pain Relief in Veterans: A Single-Site Questionnaire Study

**Rachana Gurudu,** Chemical Biology; Akash Raju, School of Medicine, Case Western Reserve University; Dr. Sherry Ball, VA Northeast Ohio Healthcare System, Pain Management Service; Dr. Elias Veizi, VA Northeast Ohio Healthcare System; Department of Anesthesiology and Perioperative Medicine, Case Western Reserve University

Chronic pain is a leading cause of physical and mental debilitation, especially for veteran populations that experience chronic pain at a rate of 65.6%. The Veterans Healthcare Administration offers numerous medical and biopsychosocial interventions to treat chronic pain, including medication, physical therapy, behavioral therapy, patient education, and surgery, but many patients with chronic neuropathic pain do not experience adequate pain relief from these first line interventions. For these patients, and patients who want to avoid the negative side effects of pharmacotherapy, spinal cord stimulator (SCS) implants can serve as a surgical method to reduce pain by delivering electrical stimulation that disrupts ascending pain signals. SCS has been shown in prior literature to significantly improve pain relief when compared to conventional medical management in veteran populations, but limited research exists on long-term outcomes with spinal cord implants and some studies suggest that pain relief wanes after six months. For this cohort of veterans, we analyzed de-identified comprehensive questionnaire data looking not only at chronic pain changes, but also changes in behavioral health and health-related quality of life through a variety of questionnaires to gain more accurate outcomes data for SCS in veterans. paired t-tests and Hochberg tests were used to statistically analyze differences in pain responses. We aimed to track long-term outcomes for veteran patients undergoing SCS implantation at the Louis Stokes Cleveland VAMC through a retrospective analysis of de-identified questionnaire data collected over a 24-month periods. Findings display that while patients experienced reductions in pain from SCS implantation from baseline testing to initial post-operative timepoints, by 24 months improvements either plateaued or declined, indicating the need for more stringent pre-operative protocol to optimize SCS effects for better fitted patient populations.

Faculty Project Mentor: Dr. Elias Veizi, Department of Anesthesiology and Perioperative Medicine, Case Western Reserve University

**Beyond the Body: Comparing Traditional Embodied Sport Training with Enactive and 4E Cognition**

**Griffin Gushman,** Cognitive Science

Traditional approaches to sport training emphasize embodied cognition, where skill acquisition is understood through the interaction between motor learning and cognitive processes within the constraints of an athlete's body. These methods often rely on internalized motor programs, repetitive drills, and explicit instruction to refine technique and develop expertise However, recent perspectives from enactive and 4E (embodied, embedded, extended, enactive) cognition suggest that skill acquisition is not merely a function of internalized motor programs but is shaped by dynamic interactions between the body, environment, and social context. This study compares these two paradigms by examining key concepts such as attunement, body schema and body image, dynamic systems, and affordances, with a particular focus on social affordances in team sports. Drawing on discussion of enactive cognition and empirical findings on motor skill development, this research explores how these frameworks inform sport training methodologies. By analyzing differences in feedback mechanisms, perception-action coupling, and the role of environmental constraints, this study aims to provide a nuanced understanding of how athletic skill is cultivated. The findings have implications for coaching strategies, particularly in optimizing training environments that facilitate learning through real-time interaction rather than static repetition. This comparative analysis ultimately challenges reductionist perspectives on motor learning and highlights the broader cognitive dimensions of athletic performance.

Faculty Instructor: Todd Oakley, Cognitive Science, CAS - College of Arts & Sciences

## Optimizing Fab Production for Glycine Receptor Analysis

**Alexander Hager,** Chemistry

Glycine receptors (GlyRs) are a class of membrane ion channel receptors that inhibit neural excitation. They are mainly found in brain stem and spinal cord neurons. Their significant impact on motor coordination and sensory processing makes GlyRs a promising therapeutic target for pain, anxiety, drug addiction, and other neurological diseases. For this reason, there is substantial interest in understanding GlyR behavior at the single-molecule level, both in purified systems and in native cellular conditions. GlyRs belong to a large family of receptors called pentameric ligand-gated ion channels (pLGICs)that assemble as a pentamer of homologous subunits. There are multiple GlyR subtypes, each varying on the types of subunits that compose the pentamer. One subtype called homomeric GlyRα1 is composed of five identical α1 subunits. To help distinguish between GlyR subtypes, it is essential to characterize tools that can recognize specific subunits. One such tool is a Fragment Antigen Binding (Fab) region of an antibody that has been established as a biomarker in protein characterization. Structurally, the Fab consists of one heavy and one light chain, bound by a disulfide bond, with the chains each consisting of a constant and variable domain. With a relatively smaller molecular weight of 55 kDa, Fab adequately serves as a fiducial marker for larger proteins with homologous subunits, such as GlyRα1. A GlyRα1-Fab complex has previously been developed for this purpose, however, its effects on channel structure and function have not been fully characterized. Here, we present our protocol for purifying this Fab along with size-exclusion chromatography data of purified GlyRα1-Fab complex. We plan to further experiment with this complex using cryo-electron microscopy.

Faculty Project Mentor & Capstone Instructor: Dr. Sudha Chakrapani, Department of Pharmacology, Case Western Reserve University School of Medicine

## WearWell

**Aniyah Shirehjini,** Computer Science; **Luke Pastore**, Computer Science; **Lexi Twitty**
**Computer Science**; **Sam Halahurich,** Computer Science

In today's world, many people's lives could be optimized by removing the decision of what to wear in the morning. The goal of our app WearWell is to aid this process through machine learning, image processing, and cloud-based storage to provide outfit suggestions on the needs of the day to let the user focus on more critical tasks. Users will upload their wardrobe and our algorithm will organize clothing and suggest various outfits based on occasion, weather, or style.

Currently, some apps allow users to follow a similar protocol, however, our inclusion of auto-tagging removes the hassle of identifying each aspect of a users wardrobe. This ultimately saves time and promotes engagement. Photos will be uploaded to Firebase at a lower resolution, and the link will be added to MongoDB with an access token. Furthermore, we will use MongoDB to store all the tags, user data, and wardrobes. We will use Mobilenet V2 and the deep fashion 2 dataset to recognize the characteristics of our clothing(color, texture, etc.) and pass this on to our CSP algorithm to generate outfits.

Our final goal is to allow users to keep track of their wardrobes in a fun and interactive way. They will be able to create different outfits and determine what pieces they should keep in their wardrobe. We also will provide users with analytics based on their outfit patterns, as well as the value they receive from their wardrobe with a cost-per-wear tracker. Ultimately, we hope to provide users with an app that will not only assist them in managing and keeping track of their wardrobe but one that will improve their daily process of organizing an outfit.

Faculty Project Mentor: Shuai Xu, Computer Science

## Areas of Pythagorean Triangles, and Congruent Numbers

**Jiachen (Jason) Han**, Applied Mathematics

This capstone project investigates the properties and significance of Pythagorean triangles, with a particular focus on the notion of congruent numbers—positive integers that can serve as the area of a right triangle with rational side lengths. Beginning with a historical overview, the study examines the evolution of right-angle triangle knowledge from Babylonian mathematics, as evidenced by Plimpton 322, through Greek geometry, highlighting the transition from practical problem-solving to rigorous theoretical proofs.

Building on these foundations, the project delves into the theoretical framework of Pythagorean and rational triangles. It explores how integer-based Pythagorean triples emerge from coprime pairs, then extends these ideas to rational triples whose areas define congruent numbers. By leveraging elliptic curves, the work reveals a powerful method to generate infinitely many rational right triangles sharing the same area. Formal proofs establish why certain integers, such as 1 and 2, cannot be congruent.

The project culminates in concrete examples, counterexamples, and potential real-world applications, spanning geometry, physics, and cryptography. Overall, this capstone both reorganizes and expands upon classical knowledge in number theory, offering fresh insights into the deep interplay between Pythagorean geometry and modern mathematical tools such as elliptic curves.

Project (Capstone) Mentor: Dr. David Singer, Department of Mathematics, Applied Mathematics, and Statistics

## Short-form Video Addiction and ADHD Symptoms in Adolescents and Emerging Adults: A Systemic Review

**Tanvir Hasan**, Psychology

The rise of short-form video content on platforms such as TikTok, Instagram, Facebook, and YouTube has transformed digital consumption patterns, fostering an environment of rapid, high-reward engagement cycles. While these platforms are designed to maximize user attention and interaction, growing concerns suggest that excessive engagement with short-form video content may contribute to an increase in ADHD-like symptoms among adolescents and young adults. This review synthesizes empirical evidence from neuroscientific, psychological, social, business, and marketing studies to examine the potential link between short-form video addiction and ADHD-related cognitive deficits in youth. Studies on reward system dysfunction suggest that individuals with ADHD traits exhibit reduced activation in brain regions responsible for reward anticipation, such as the nucleus accumbens and prefrontal cortex (Stark et al., 2011). Thorell et al. (2024) provide longitudinal evidence indicating that higher digital media consumption in early adolescence predicts increased ADHD symptoms over time. Xie et al. (2023) further demonstrate that excessive short-form video use correlates with increased impulsivity and distractibility, leading to difficulties in sustaining attention on non-digital tasks. Additionally, Holroyd (2024) explores the socio-cultural impact of short-form video platforms, particularly their role in normalizing and amplifying ADHD discourse through self-diagnosis trends and digital peer influence. By integrating findings from diverse disciplines, this review highlights the need for further research into the cognitive and psychological implications of short-form video addiction. The paper also discusses potential interventions, including digital literacy education, self-regulation strategies, and content moderation, to mitigate the adverse effects of excessive short-form video consumption on attention and impulse control.

Faculty Project Mentor: Professor Anastasia Dimitropoulos, Department of Psychological Science

## Do Neutrophils Phagocytose Myelin?

**Faye Hashim ,** Chemical Biology; Dr. Brian Balog, Department of Neurosciences; Dr. Richard Zigmond, Department of Neurosciences

Wallerian degeneration involves the breakdown and fragmentation of the myelin sheath surrounding damaged axons, resulting in myelin debris that is ultimately cleared by non-neuronal cells; this is required for regeneration. While Schwann cells and macrophages were once considered the primary cells responsible for phagocytosis during this process, neutrophils also participate in debris clearance following nerve injury. Neutrophils are essential components of the innate immune system, primarily in clearing bacteria and neutralizing invasive microbes through mechanisms such as phagocytosis. While prior studies have focused on neutrophil interactions with bacteria, their role in engaging nervous system components, such as myelin in the absence of other immune cells, remains poorly understood. The rapid spatial-temporal activity of neutrophils alongside myelin makes it challenging to obtain clear imaging.
This study aims to determine whether neutrophils can directly phagocytose myelin in an in vitro assay. Using a neutrophil-myelin phagocytosis assay, we observed myelin-neutrophil association and now seek to distinguish whether it is mere adhesion or driven by phagocytosis. These findings provide a foundation for further investigation into the mechanisms of neutrophil-myelin interactions, particularly under live imaging conditions and in the presence of phagocytosis inhibitors to assess their impact on this process.

Faculty Project Mentor: Dr. Brian Balog, Department of Neurosciences
Capstone Mentor: Dr. Fu-sen Liang, Department of Chemistry

## Motorized Platform for Moving Scenic Elements

**Emily Hawkins,** Mechanical Engineering; **Nolan Sayer**, Mechanical Engineering

Modern theatres use understage tracking systems, where set pieces are attached to small metal carriages that sit in understage tracks, which are moved by large winches stored backstage. This approach allows heavy set pieces to be moved quickly, quietly, accurately, and without visible run crew. The Theatre Department at Case Western Reserve University approached our team about wanting to achieve a similar effect without installing understage tracking, since they are unable to cut into their stage. Our team researched stage automation systems, talked with theatre safety specialists, set designers, and the technical team at the theatre department in order to create a list of requirements. With these requirements we designed an RC controlled modular path following system consisting of two stepper motors, two 12 volt batteries, a drive computer, electromagnetic sensor, and emergency stop/hold system. The whole system is modular, allowing it to be installed on different platforms or set pieces depending on the needs of the show. The drive computer receives signals from an RC controller, allowing the platform to be manually driven, but it can also be switched to path following mode, where the computer follows a strip of copper tape under black gaff tape. This system means that the platform can follow precise paths, and stop at exact points on stage, and the tape it is following blends into the stage and can also be painted over. Finally there will be an e-stop on the motorized platform in order to allow emergency shutoff on the unit, and there will be an emergency hold switch on the controller, to allow an offstage operator to stop the machine remotely.

Faculty Project Mentor: Jill Davis, Department of Theater

Capstone Instructor: Majid Rashidi, Department of Mechanical and Aerospace Engineering

**FrameBlender: Building a Ground Truth Dataset for Frame Blending with LLMs**

**Luke Henriquez**, Cognitive Science; Zhongheng Cheng, Department of Computer Engineering, Columbia University; Deepak Soni, Computer Science and Engineering, Gyan Ganga Institute of Technology Sciences

Large language models (LLMs) have revolutionized linguistic research, serving as powerful tools for analyzing patterns and structures. However, a significant gap exists in the absence of a dedicated dataset containing scored blends, hindering the fine-tuning and evaluation of LLMs in this domain. This project aims to address this by creating a ground truth dataset to investigate and model frame blending, a cognitive process rooted in frame semantics. Frame semantics enriches language understanding by interpreting words through their conceptual structures, while frame blending explores the integration of multiple frames. This research seeks to leverage the increasing capabilities of LLMs to deepen our understanding of linguistics through frame blending.

The methodology involves utilizing FrameNet, a lexical database documenting semantic frames, their elements, and evoking lexical units. Data collection will be facilitated by the FrameBlender tool, a terminal-based GUI application designed to generate frame blending examples using LLMs. FrameBlender incorporates retrieval-augmented generation (RAG) with the FrameNet database to enhance accuracy and minimize false outputs. The expected outcome of this ongoing project is a valuable ground truth dataset that will serve as a crucial resource for training and evaluating LLMs in generating, understanding, and modeling the complex cognitive process of frame blending. This dataset will significantly contribute to advancing the computational modeling of conceptual integration in language.

Project Mentor: Mark Turner, Department of Cognitive Science
Capstone Instructor: Mark Turner, Department of Cognitive Science

**Design and fabrication of a showerhead retrofit to show water temperature during use**

**Hans Holst**, Mechanical Engineering; **Michael Lombardi**, Mechanical Engineering; **Stephen Henry**, Mechanical Engineering

Burns caused by showering in water that is too hot cause thousands of injuries each year and can cause deaths. We hope to create a device that would limit the frequency of these events happening. We are creating a shower head retrofit to show the temperature of the water in the shower, allowing users to know the temperature of the water before it touches their skin.

Faculty Project Mentor: Majid Rashidi, Department of Mechanical and Aerospace Engineering
Capstone Instructor: Majid Rashidi, Department of Mechanical and Aerospace Engineering

## Spinal Stimulation Input Reader and Analyzer

**Kyle Heston**, Electrical Engineering; **Pieter Verbeek**, Electrical Engineering; **Ethan Willner**, Electrical Engineering

Spinal Cord Stimulation (SCS) is a widely used neuromodulation technique for managing chronic pain by delivering controlled electrical pulses to the spinal cord. This project focuses on the development of a high-voltage electrical stimulator designed to optimize pain relief through precise and adaptive stimulation. The system comprises two key components: (1) a custom-designed printed circuit board (PCB) that serves as a triggering circuit to regulate pulse generation and delivery to an electrode implanted in the patient's spine, and (2) a MATLAB-based software platform that records, analyzes, and filters signals from electrodes placed at various spinal locations. The PCB circuit ensures accurate timing and voltage control, allowing for adjustable stimulation parameters tailored to individual patient needs. The MATLAB program processes incoming electrode data, utilizing advanced filtering techniques to isolate relevant neural responses while minimizing noise and artifacts. Through real-time signal analysis, the system enables dynamic adjustments to stimulation patterns, potentially improving the efficacy of pain relief. Additionally, data visualization tools aid in assessing the physiological effects of stimulation and optimizing electrode placement strategies. This research aims to enhance the precision and adaptability of SCS therapy, offering a data-driven approach to pain management. By integrating hardware and software components, the project provides a platform for refining stimulation protocols, ultimately contributing to improved patient outcomes in chronic pain treatment. Future work will focus on clinical validation, algorithm refinement, and potential applications in broader neuromodulation therapies.

Project Mentor: Stephan Nieuwoudt; Neuronoff, Inc.
Capstone Advisor: Gregory Lee; Department of Electrical, Computer and Systems Engineering

**Determining the Mechanisms of UNC93B1 in the Cellular Tropism of Neurotropic Viruses**

**Andrea Hochwald**, Biology; Eun Hee Ha, Department of Infection Biology, Dr. Xianfang WU, Department of Infection Biology, Cleveland Clinic Lerner Research Institute

Neurotropic viruses, such as West Nile virus (WNV) and Venezuelan equine encephalitis virus (VEEV), pose significant threats to human health, particularly due to the lack of effective treatments and preventive measures against them. Within the central nervous system, these viruses display a preference for specific neural cell types, replicating more efficiently in mature neurons than in other cells, such as neural progenitor cells (NPCs). To explore the mechanisms underlying this cellular tropism, we selected genes with antiviral properties from a list of differentially expressed genes in NPCs and neurons. Among these genes, we identified UNC93B1 and SIRPA as being more highly expressed in NPCs than in neurons. RT-PCR results of the two genes showed that UNC93B1 exhibits a greater significant difference in relative expression levels than SIRPA. We hypothesized that changes in UNC93B1 expression would affect NPC susceptibility to neurotropic viruses. To test this hypothesis, we knocked down UNC93B1 in NPCs to determine the possible in vitro mechanisms of the gene. Then, we analyzed UNC93B1's influence on key cellular functionalities associated with neuron, stem cell, or viral development. Additionally, we examined transcription factors responsible for UNC93B1 regulation to manipulate its expression levels in future studies. Following this, we plan to infect various neuronal cells other than NPCs, such as mature neurons, astrocytes, and oligodendrocytes with relevant neurotropic viruses to compare their susceptibility to NPCs. Our goal is to deepen our understanding of host-cell interactions with neurotropic viruses and to guide the development of targeted antiviral therapies, ultimately paving the way for interventions specifically tailored to neural cells.

Project Mentor: Dr. Xianfang Wu, Department of Infection Biology, Cleveland Clinic Lerner Research Institute

Capstone Instructor: Dr. Ronald Oldfield, Department of Biology

**What is the effect of foreign military aid on battlefield success in the Russia-Ukraine War?**

**Brianna Penkala**, Economics; **Kai Hoeger**, Economics

Since the buildup to and subsequent invasion of Ukraine by Russia from January 24, 2022 to December 31, 2024, the highest contributing governments of foreign aid to Ukraine have collectively committed $182.37 billion in military aid. The U.S. has contributed the greatest proportion of military aid of any one country ($70.56 billion) in the two year span. While the EU has contributed a similar amount of aid to Ukraine as the U.S., President Trump's recent discontinuance of military aid could result in a drastic shift in how Ukraine is supported.

This research seeks to address whether the provision of foreign military aid has had a causal effect on Ukraine's battlefield success, measured by changes in the frequency of violent events. We consider success in a layered manner, measuring (1) the change in frequency of Ukrainian-instigated violent events and (2) the change in frequency of Russian-instigated violent events. Focusing on the timespan from 2022 to 2024, we utilize panel data on foreign aid packages from the Kiel Institute for the World Economy in combination with a tool from the Armed Conflict Location and Event Data initiative to conduct an empirical analysis on the effect of foreign military aid on Ukrainian battlefield success. We use trends in user searches related to the war as an instrumental variable. Our research contributes empirical evidence to a field currently composed of qualitative research.

Our initial research leads us to two hypotheses: H1. Foreign military aid is associated with an increase in Ukrainian-instigated events; H2. Foreign military aid is associated with an increase in the frequency of violent events. With recent changes in U.S. policy related to military aid, our hypothesis implies there are likely going to be large implications on the outcome of the war and the fate of Ukraine.

Faculty Project Mentor: Professor Jenny Hawkins, Department of Economics

## Autonomous Exploration and 3D Mapping System in Enclosed Environments

**Tiancheng Pu**, Electrical Engineering; **Zifei Hong,** Electrical Engineering; **Xiaorong Wang,** Electrical Engineering

This project aims to develop a robot platform to explore and create accurate 3D maps of enclosed environments autonomously. By integrating wheel speed sensing, RPLidar scanning, and real-time data transmission, the system addresses the challenge of mapping indoor spaces with minimal human involvement. Methodologically, the approach merges hardware and software innovations: an Arduino-based robot car captures odometry and lidar data, transmitting it via Bluetooth to a computer for further data processing. Point cloud denoising reduces sensor noise, and both coarse and fine alignments are performed through iterative closest point algorithms or feature-based registration. A world coordinate system further refines positional accuracy, minimizing overlap errors between scans. Although testing has revealed certain constraints—such as limited feature availability in corridor settings—the refined workflows for data stitching, noise filtering, and coordinate calibration for the 3D reconstructions. Preliminary results indicate that the system can reliably generate accurate maps suitable for basic navigation.

Faculty Project Mentor: Peng (Edward) Wang, Associate Professor, Mechanical and Aerospace Engineering

**Investigation of ACAN Expression Levels in Situ using RNAscope in the CNS of MPS VII Mouse Models**

**Kylie Hosey,** Neuroscience and Psychology; Yiwen Zhang, Department of Neurosciences, Dr. Dhananjay Yellajoshyula, Department of Neurosciences

The extracellular matrix (ECM) is an important component of the brain that provides structural support and aids in neural plasticity. Its main components include fibrous proteins and glycosaminoglycans (GAGs). Mucopolysaccharidosis (MPS) is a disorder that results in disruption of GAG degradation, resulting in GAG buildup in surrounding tissues. MPS VII, also known as sly syndrome, is an autosomal recessive disorder that is the result of a loss of function mutation in the gene that encodes for the lysosomal enzyme β-glucuronidase (GusB).

Preliminary research in our lab using mouse models MPS VII have identified that total loss of GUSB activity results in the loss of the formation of the major ECM structures known as perineuronal nets (PNNs) around parvalbumin (PV) interneurons.

Aggrecan, which is encoded by the gene *Acan*, is an abundantly expressed proteoglycan that is a major component of PNNs that aids in its organization and structure. Previous studies have shown loss of ACAN ablates PNN formation, demonstrating its importance in organizing the PNN structure. The goal of this study is to understand how Acan RNA expression levels vary in the mouse model carrying mutant allele of *Gusb* (*Gus*$^{mps}$) that has no GUSB activity with critical loss in PNN structure. To test my hypothesis, I have used RNAScope to stain for *in situ* RNA expression of ACAN in PV+ neurons in P14 mice, both mutant (homozygous *Gusb*$^{mps/mps}$ or GUS-MPS) and control wildtype littermate. The results of my studies show that there is no significant difference in Acan expression between these tissues. These results suggest that loss in ACAN expression is not responsible for the loss of PNN in the GUS-MPS brain. An alternate explanation is that the loss of PNN is the result of inflammatory response via microglia, as previously observed in other models. In the MPS VII model, microglia could become overactive and secrete components that degrade PNNs around PV interneurons. Overall, these results identify microglial activation and not *Acan* expression as the contributing factors to decreased PNN formation in MPS VII.

Project Mentor: Dr. Dhananjay Yellajoshyula, Department of Neurosciences

Capstone Mentor: Dr. David Friel, Department of Neurosciences

**Predicting Used Car Prices: A Regression-Based Data Analysis Approach**

**Shifan Hou**, Statistics

In this project, I will explore and analyze the used car market in India using a comprehensive data set containing various vehicle attributes, including price, mileage, engine size, power, transmission type, ownership, and fuel type. First, perform data cleansing and preprocessing steps to reduce the impact of error and extreme values. The cleaning methods I use include working with missing values, filtering unrealistic or extreme values using domain knowledge and IQR methods, and converting categorical variables into factors. Exploratory data analysis (EDA) is then used to visualize key relationships between variables and reveal underlying patterns between different vehicle types. Scatter charts, box charts and related heat maps provide insight into how different factors affect car pricing. Finally, multiple linear regression models of numerical variables and non-numerical variables are established and logarithmic transformation stability variance is used to improve the model fit. Multiple linear regression models can be built for residual plots and QQ plots, which can be used to evaluate hypotheses. The goal of the project is to understand the pricing dynamics and functional importance of the used car market in India, which may help inform buyer behavior and seller strategies.

Faculty Project Mentor: Jenny Brynjarsdottir, Department of Mathematics, Applied Mathematics, and Statistics

Capstone Instructor: Jenny Brynjarsdottir, Department of Mathematics, Applied Mathematics, and Statistics

## Crosstalk Between Skull Bone and Brain

**Trunee Hsu**, Neuroscience; Lei Xiong, Department of Neurosciences, School of Medicine, Case Western Reserve University; Wen-Cheng Xiong, Department of Neurosciences, School of Medicine, Case Western Reserve University

ATP6AP2 (ATPase H+ transporting accessory protein 2), also called PRR (pro-renin receptor), is a highly conserved and expressed protein in the renin-angiotensin system, a subunit of V-ATPase, and a regulator of *Wnt/β-catenin* signaling. Conditional knockouts of this gene result in diverse effects such as dysregulation of blood pressure and disruption of lysosome function. Previous findings revealed the interaction between bone regulation and *Wnt*/*LRP6*/*β-catenin* signaling. *ATP6AP2* promotes *LRP6* trafficking to the cell surface, promoting *Wnt/β-catenin* signaling. The subsequent activation of downstream genes induces bone formation and inhibits bone resorption. Consequently, the conditional knockout of *ATP6AP2* in osteoblast-lineage cells revealed decreased trabecular bone density. However, this knockout revealed an increase in cortical bone mass.

The skull is a flat bone enclosing the brain, and develops via intramembranous ossification. Its composition and remodeling are fundamentally different from those of long bones, which develop through endochondral ossification. The objective of this study is to investigate the phenotypic characteristics of the skull bone of the *ATP6AP2* conditional knockout in the OB-lineage cells of a mouse model. 3-month-old mutant mice demonstrated increased thickness of the skull bone and disorganized skull bone marrow. The skull bone was collected at multiple time points to discover the onset of phenotype presentation. We used additional markers to determine the change in bone and bone marrow cells. These results were collected and analyzed through methodological techniques such as, frozen sectioning, immunofluorescence staining, confocal imaging, and micro-CT reconstructive analysis.

Besides the classical roles of skull bone in support and protection, skull bone is reported to provide myeloid cells to the brain border. Skull bone marrow allows bidirectional communication between the skull bone marrow and the cerebrospinal fluid. As a result, development of skull bone and skull bone marrow is critical to the immune system and development of the brain.

Faculty Project Mentor: Wen-Cheng Xiong, PhD, Department of Neurosciences

Capstone Instructor: Ashley Nemes, PhD, Department of Neurosciences

## High Efficiency & Low Cost Charging Station for UAVs

**Jinyu Hu,** Electrical Engineering & Computer Engineering; **Ashraf Ibraheem,** Computer Engineering & Computer Science; **Juho Jeon,** Electrical Engineering

This project addresses the challenge of developing an efficient and safe charging station tailored for unmanned aerial vehicles (UAVs). The research explores optimal battery management, charging efficiency, and system durability under variable outdoor conditions, thereby meeting a critical need in UAV technology. Grounded in established standards such as IEEE 1725, IEC 60364, and IEC 60529, our study examines current battery types, charging circuits, and electronic components to mitigate risks like overcharging and thermal stress.

Our methodology combines in-depth research, hardware design, and embedded software development to create a modular system. Key tasks include the selection of robust components, design of a power distribution network, development of battery monitoring firmware, and iterative prototyping with rigorous environmental and performance testing. Preliminary testing indicates improvements in charging speed and energy efficiency, while the ongoing integration of safety features promises enhanced battery longevity and reliability. The final phase integrates all components into a fully functional system, optimized for real-world deployment as a practical and durable UAV charging solution. The final prototype is expected to serve as a scalable model for future UAV infrastructure applications.

Faculty Project Mentor(s): Dr. Christos Papachristou, Department of Electrical, Computer, and Systems Engineering, Case School of Engineering, Case Western Reserve University.

Capstone Instructor: Dr. Greg Lee, Department of Electrical, Computer, and Systems Engineering, Case School of Engineering, Case Western Reserve University.

**Automated Identification of Topological Defects Using Deep Learning Approaches**

**Yucheng Huang**, Applied Mathematics

Topological defects are critical structures found in diverse physical systems and are instrumental in the study of phase transitions and material behavior. However, their identification remains a challenge due to the complexity of patterns and limitations of traditional. In this project, we propose a deep learning-based method to automate the classification of topological defect types using both experimental and artificially generated image data. We train a ResNet-18 convolutional neural network (CNN) to distinguish defect types by learning hierarchical features from visual patterns. Preliminary results indicate that our model effectively identifies distinct types of topological defects with high accuracy, demonstrating the advantages of a data-driven approach over conventional techniques. As an ongoing extension, we aim to apply machine learning models to localize defect positions, further improving the practical utility of our system. This work lays the groundwork for analysis of topological phenomena in physical and materials science contexts.

Project Mentor: Longhua Zhao, Department of Mathematics, Applied Mathematics and Statistics

**Enhancing Frame Retrieval Latency and Accessibility: A Vector Database Approach with Multi-Model Inputs for Video Applications**

**Vi Huynh**, Computer Science; **Helen Nguyen** Computer Science; **Kiet Nguyen** (Data Science, CWRU), **Harley Phung**, Computer Science; Shuai Xu, Department of Computer and Data Science

The present research work is concerned with solving the issue of efficiently retrieving targeted video frames in large collections, a key demand in security surveillance and content management applications. The study explores a framework proposed for expert video frame retrieval that brings together multi-modal input processing along with vector database technology. This system integrates FAISS and CLIP models to create an end-to-end retrieval system for metadata processing, keyframe extraction, and interactive interface using Streamlit Community API. For frame-level retrieval, our system allows interaction with the interface directly and text-based querying. The efficacy of our approach, which integrates cutting-edge vector database search techniques and binary encoding for video keyframe metadata, is experimentally confirmed on a variety of video datasets. Within the application scenarios of semantic search, the system exhibited high frame-matching precision while delivering considerable gains in retrieval latency. The outcomes validate the assertion that advanced structures of vector databases considerably enhance the efficiency of video frame retrieval and therefore add to corresponding research questions and significant contributions to the area of video processing and retrieval systems. Future research will cover extensions of multi-query capabilities and considerations with regards to cloud deployment strategies.

Faculty Project Mentor: Shuai Xu, Department of Computer and Data Science, CWRU

Capstone Instructor: Shuai Xu, Department of Computer and Data Science, CWRU

## Social and Economic Impacts on Legalized Gambling

Seungwon Hwang, Business Information Technology

The idea of gambling is simple. You take the risk, with a possibility of winning a prize. In a world of gambling and taking risks, there are two types of people. Risk takers and those who are risk averse. This quantitative review of literature will look into the legal gambling market in the US, from micro to macro level. From a macro level, This paper will discuss the public policies regarding gambling in legal states that allow it. From public policy perspectives, it will identify if states benefit from having legal gambling industries with taxable gains. This review will also find out if states benefit with the employment rate by legalizing gambling and allowing casinos to move into their states. From industry perspective, some of the measurements will be mentioned, such as Gross Gaming Revenue, Elasticity of Demand for gambling, and Cost-Benefit Analysis. From microlevel, level of risk taking of individual gamblers will be identified, the social impact on families of gamblers within legal states, and correlation between illicit drug usage to net loss amount from default.

Faculty Project Mentor: Sharon Milligan, Mandel School of Applied Social Sciences

Capstone Instructor: Sharon Milligan, Mandel School of Applied Social Sciences

**PGD2/DP1 signaling regulates the integrity of the Blood-Brain Barrier**

**Vidya Indrakumar**, Department of Neuroscience; Anusha Bangalore, Department of Neuroscience, Case Western Reserve University; Cora Donoghue, Department of Biochemistry, Case Western Reserve University**;** Yeojung Koh, Department of Pathology, Case Western Reserve University; Zea Bud, Frances Payne Bolton School of Nursing, Case Western Reserve University; Emiko Miller, Department of Neuroscience, Case Western Reserve University; Andrew A. Pieper, Department of Psychiatry, Case Western Reserve University

The blood-brain barrier (BBB) serves as a highly selective interface between circulating blood and the brain. This essential barrier is primarily composed of a monolayer of endothelial cells interconnected by tight junction proteins, which effectively restrict the entry of peripheral substances into the brain. Astrocytes and pericytes contribute significantly to the maintenance and regulation of BBB integrity. However, in numerous neurodegenerative diseases, including Alzheimer's disease, the BBB becomes significantly compromised, allowing harmful substances to enter the brain and potentially trigger neuroinflammation, a hallmark of neurodegenerative disease. Previous studies have indicated that the DP1 receptor in endothelial cells is crucial for vascular integrity. In addition, inhibiting DP1 receptor function has been shown to intensify vascular permeability within the BBB. Prostaglandin D2 (PGD2) binds to the DP1 receptor and is known to influence the barrier function of peripheral endothelial cells. However, the precise role of PGD2/DP1 signaling in preserving BBB integrity remains unclear. We hypothesized that the deletion of DP1 receptors in mice (DP1 knockout) would compromise BBB integrity when the mice are challenged with a high-fat diet, an established model of BBB deterioration. We observed that these DP1 knockout mice indeed displayed BBB deterioration and neuroinflammation, as evidenced by IgG leakage into the brain and increased astrocytic reactivity, a phenomenon that was absent in wild type littermate controls. These findings suggest that DP1 signaling is critical for maintaining BBB integrity, particularly in the context of obesity-related BBB impairment.

Project Mentors: Yeojung Koh, Department of Pathology, Dr. Andrew A. Pieper, Department of Psychiatry

**Measurement of Allostatic Load and Its Impact on Cancer Risk and Outcomes**

**Shirin Iqbal,** Neuroscience; Dr. Stephanie Schmit, Genomic Medicine Institute, Cleveland Clinic Lerner Research Institute

Cancer remains a major global health challenge, contributing substantially to morbidity and mortality. Extensive research has explored genetic predisposition, environmental exposures, and lifestyle factors in cancer development. Unlike these factors, which are mostly limited to a certain group of individuals and can directly cause cancer, stress affects a broader population. Stress is not exclusive to any group. While a long-term stress response and its associated allostatic load (AL) have been linked to cancer progression, research remains limited. Thus, the role of AL in cancer initiation and progression warrants further exploration.

Allostasis maintains physiological stability under chronic stressors. It involves mediators like glucocorticoids acting on receptors to produce short-term adaptive responses. However, when the effects of these mediators on target cells are prolonged, receptor desensitization and tissue damage may occur. When normal regulatory mechanisms fail, the cumulative neurobiological burden, known as AL, imposes “wear and tear” on the body, increasing vulnerability to disease.

This paper reviews the current state of the literature on AL and cancer. It will synthesize information about the most commonly used biomarkers for measuring AL and the association studies conducted to examine the relationship between AL and cancer risk and progression. This review will identify relevant biomarkers such as, salivary cortisol, alpha-amylase, and serotonin, which reflect neuroendocrine dysfunction, chronic inflammation, and immune suppression which have implications for cancer initiation and progression. Evaluation will also include, which biomarkers will provide the most success in measuring AL impacts and aims to synthesize existing literature to clarify the relationship between elevated AL and increased cancer risk, tumor characteristics, and disparities in cancer burden across population groups. The findings from this review could highlight the importance of incorporating stress-management interventions and biomarkers into cancer prevention, screening, and treatment protocols to improve patient outcomes and quality of life.

Project Mentor: Dr. Stephanie Schmit, Genomic Medicine Institute, Cleveland Clinic Lerner Research Institute

Capstone Instructor: Dr. Ashley Nemes, Department of Neuroscience

**Design of a device to mitigate trypanophobia during injection**

**Tanishka Isaac**, Department of Biomedical Engineering; **Jeremy Lau**, Department of Biomedical Engineering; **Lily Phelps**, Department of Biomedical Engineering; **Thomas Wong**, Department of Biomedical Engineering

Trypanophobia is the intense fear of needles. The condition is associated with a strong reaction in response to an impending injection, with symptoms including anxiety, palpitations, nausea, sweaty hands, and breathlessness. Trypanophobia is classified as a biopsychological condition and affects roughly two thirds of children and nearly a quarter of adults. The Covid-19 pandemic once again highlighted the relevance of trypanophobia, as many people avoided vaccination for reasons attributable to concerns regarding the injection process. A number of pharmacological and non-pharmacological approaches to trypanophobia exist, with non-pharmacological methods being preferable for their simplicity and lower risk. Most products currently available have yet to achieve significant market penetration, are manufactured in relatively small batches with electronic requirements, and are not distributed on large scales. The device that our team has prototyped over the past two semesters aims to leverage principles of spatial summation to augment the perceived pain during an intramuscular injection. A specially designed metal wafer that directly contacts the patient's arm is capable of delivering both thermal and mechanical stimulation, saturating the nerves in the surrounding area. As posited by the gate control theory of pain, these non-painful stimuli could reduce the perception of pain. The device is also capable of obstructing a patient's vision of the injection site while allowing the clinician to operate the syringe with no additional training. This simplistic approach to the often overlooked condition of trypanophobia has the potential to alleviate the anxiety induced by injections, thereby eliminating a barrier to the distribution of vaccines.

Project Mentors: Professor Colin Drummond, Department of Biomedical Engineering, Professor Matthew Williams, Department of Biomedical Engineering

## HA's effect on the tight junctions within RPE cells

**Kanna Iyyappan**, Biology

Hyaluronic acid (HA), a key glycosaminoglycan in the ocular extracellular matrix, plays a crucial role in maintaining epithelial barrier integrity, hydration, and elasticity. Dysregulation of HA has been implicated in retinal diseases such as age-related macular degeneration (AMD) and diabetic retinopathy, potentially through its effects on tight junctions in retinal pigment epithelial (RPE) cells. This study investigated the impact of high molecular weight (HMW-HA) and low molecular weight (LMW-HA) on tight junction stability in differentiated porcine RPE cells using electrical cell-substrate impedance sensing (ECIS). Results preliminarily demonstrated that both HMW-HA and LMW-HA increased tight junction resistance.

To expand our understanding of HA's role in RPE pathology, we are now extending our investigation to assess active Matrix Metalloproteinase-2 and -9 (MMP-2 and MMP-9) activity using a zymogram model. MMPs play a critical role in extracellular matrix remodeling and tight junction integrity, with heightened activity linked to barrier dysfunction in retinal diseases. By incorporating zymography, we aim to quantify enzymatic degradation in response to HA treatment, providing mechanistic insights into HA's regulatory effects on tight junctions. This addition will allow us to determine whether LMW-HA enhances MMP activity, leading to tight junction destabilization, or if HMW-HA exerts protective effects by reducing MMP-mediated degradation. Future studies will optimize experimental conditions to validate our findings and explore HA's therapeutic potential in retinal disease management.

Faculty Project Mentor: Professor Radhika Atit, Biology, CWRU

**Two Parallel WNK1 Signaling Mechanisms Altering Glioblastoma Cancer Stem Cell Phenotypes: Kinase-Dependent and Kinase-Independent**

**Ashley P. Jacobs**, Biochemistry; Erin E. Mulkearns-Hubert, Department of Cardiovascular & Metabolic Sciences, Cleveland Clinic

Cell-to-cell communication is needed for growth and survival and these processes are regulated by gap junctions. Gap junctions are made up of connexin proteins that serve to mediate protein-protein interactions as well as communication with the extracellular space. Despite these vital roles and connexin's context dependent function, here we present Connexin 43's (Cx43) protumorigenic role in glioblastoma cancer, the most common and aggressive primary malignant brain cancer. In this context we find Cx43 essential for glioblastoma cancer stem cell (CSC) survival and self renewal. Depletion of Cx43 has shown reduced MYC expression through reduced levels of the upstream signaling intermediate WNK lysine- deficient protein kinase 1. Our lab recently laid out a novel signaling axis downstream of Cx43 that includes WNK1 along with MYC and promotes tumor growth. However not much was understood about this WNK1 to MYC relationship. In this paper, we identify the WNK1 to MYC mechanism as kinase-independent, whereas other WNK1-associated genes influence glioblastoma through a WNK1 kinase-dependent mechanism. This highlights two possible parallel signaling pathways including a kinase dependent mechanism and a kinase independent mechanism both involving WNK1. We distinguish specific genes that follow each of the following signaling mechanisms. The WNK1 associated genes we looked into included MYC, CDK1, TGFA, ZEB1, PLK1, TGFB2, SLC39A10, and PAQR5.

Faculty Project Mentor: Erin E. Mulkearns-Hubert, Department of Cardiovascular & Metabolic Sciences, Cleveland Clinic

Capstone Instructor: Erin E. Mulkearns-Hubert, Department of Cardiovascular & Metabolic Sciences, Cleveland Clinic

**Effects of Cisplatin-induced APE2 Overexpression on MYH9 Function and Hearing Loss**

**Joelle Jeon**, Biology

Cisplatin is a potent chemotherapeutic agent widely used in the treatment of solid tumors, yet its clinical efficacy is constrained by dose-limiting toxicities, most notably irreversible sensorineural hearing loss, which disproportionately affects pediatric patients and significantly diminishes long-term quality of life. This study identifies the DNA repair enzyme apurinic/apyrimidinic endonuclease 2 (APE2) as a critical and previously unrecognized mediator of cisplatin-induced hearing loss (C-HL). Unlike its paralog APE1, APE2 is selectively upregulated in outer hair cells (OHCs) of the cochlea in response to cisplatin, where it rapidly translocates to mitochondria and interacts directly with MYH9, a non-muscle myosin implicated in mitochondrial structure and intracellular trafficking. This interaction, precisely mapped to the E853–A922 region of MYH9, initiates a cascade of mitochondrial fragmentation, bioenergetic collapse, and apoptotic signaling. Using a novel transgenic mouse model with inducible, OHC-specific overexpression of human APE2, we demonstrate that APE2 alone is sufficient to induce high-frequency hearing loss, stereocilia disorganization, and mitochondrial dysfunction, mimicking the pathological features of C-HL even in the absence of cisplatin. Conversely, APE2 knockdown via antisense oligonucleotides restores mitochondrial respiration, prevents cytochrome c release, suppresses p53 translocation to mitochondria, and activates a protective ATR-p53-mediated nuclear DNA damage response, ultimately rescuing cochlear cells from cisplatin-induced apoptosis. Collectively, these findings establish APE2 as a mechanistic driver of mitochondrial dysfunction in the auditory system and position it as a promising molecular target for the prevention of cisplatin ototoxicity without compromising the drug's anticancer efficacy.

Principal Investigator and Mentor: Dr. Jianjun Zhao, Assistant Professor, Medicine, CCLCM-CWRU

## A Comparative Study of Payment Systems (Cashless, Cardless, and Contactless) in the US and India: Pre- and Post-COVID-19

**Adhya Jhunjhunwala**, Business Management, Finance, and Marketing

The global payment system has recently gone through a shift mainly due to the improvement in technology and the COVID-19 pandemic. This research offers a comprehensive comparison of payment system changes in the United States and India, discussing three main types of payments: cashless, contactless, and cardless payments for specific time frames, such as pre-COVID, post-COVID, and future scenarios. This study is based on primary survey data collected from various segments of consumers in both countries and aims to determine how consumers' behavior, take-up rates, security perceptions, and, overall, the perception of the new payment technologies has changed. The results reveal some interesting differences across the regions and generations, with the focus on UPI and digital wallets in India while the US is moving more towards contactless cards and mobile payments. This research not only explains the factors that enhance or hinder the adoption of digital payment but also predicts the possible future trends that can benefit policymakers, financial institutions, and technology vendors who want to navigate or penetrate these markets.

Faculty Project Mentor: Jose Olavarria, Department of Banking and Finance

Capstone Instructor: Erika Olbricht, Department of English

**The meningeal lymphatic vasculature is dysfunctional in a mouse model of Fragile X Syndrome**

**Nathan Jiang,** Neuroscience; Dr. Antoine Louveau, Department of Neurosciences, Cleveland Clinic Lerner Research Institute

Fragile X Syndrome (FXS) stands out as the most common monogenic cause of ASD and arises from a genetic mutation in the fragile X messenger ribonucleoprotein 1 (*Fmr1)* gene, disrupting the production of the fragile X messenger ribonucleoprotein (FMRP) and leading to significant neurodevelopmental impairments. Autism spectrum disorders (ASD) are a complex neurodevelopmental condition characterized by challenges in social interaction, communication, and repetitive behaviors, affecting millions of individuals worldwide. Advances in neuroimmunology, particularly the discovery of the meningeal lymphatic vasculature (mLV), have unveiled its role in waste clearance and immune homeostasis in the brain. Interestingly, CNS fluid homeostasis and immune dysfunctions have been reported in FXS/ASD patients. Therefore, this system may intersect with mechanisms underlying FXS pathology, including neuroinflammation and disrupted cerebrospinal fluid (CSF) dynamics. Given that FMRP is expressed in lymphatic endothelial cells, our hypothesis is that FMRP regulates the function of the meningeal lymphatic vasculature in a cell-intrinsic manner.

To address this hypothesis, we used a mouse model of FXS in which the fmr1 gene is knocked down (Fmr1-KO). Using immunofluorescence analysis, we found that these mice display decreased diameter of mLV, in addition to mispatterning of junction proteins at mLV sprouts. Ultimately, functional assessments of this network revealed impaired drainage of CSF into the cervical lymph nodes. Furthermore, we employed a mouse model of lymphatic-specific deletion of fmr1 using the Cre-LoxP system. Two different mouse strains expressing lymphatic specific Cre drivers (either Prox1 CreERT2 or VegfR3 creERT2) were crossed with fmr1 Floxed mice, allowing for conditional deletion of fmr1 in lymphatic endothelial cells upon tamoxifen injections. Immunofluorescence and functional analysis revealed reproduction of the phenotype observed in the global Fmr1-KO. These results suggest that fmr1 is important for the function of the mLV in a cell intrinsic manner, shedding new light into the pathophysiology of FXS/ASD.

Project Mentor: Dr. Antoine Louveau, Department of Neurosciences, Cleveland Clinic Lerner Research Institute

Capstone Instructor: Dr. Ashley Nemes, Department of Neuroscience

## Cancer Risk and Epigenetic Changes in Vulnerable Populations Exposed to Environmental Pollutants

**Brianna Jimenez**, Biology

Cancer has been ranked among the top two leading causes of death in the United States for nearly a century, with environmental pollutants playing a critical role in increasing cancer susceptibility, particularly among vulnerable populations. Chronic exposure to both established and emerging pollutants, such as air pollution, heavy metals, pesticides, and endocrine-disrupting chemicals, has been increasingly associated with epigenetic modifications. These alterations, including DNA methylation, histone modifications, and microRNA dysregulation, contribute to cancer development by disrupting gene regulation and key cellular processes. Despite growing recognition of these epigenetic mechanisms, research gaps remain in understanding their longterm impact, reversibility, and the disproportionate burden they place on historically marginalized and low socioeconomic communities. This review synthesizes existing studies on pollutant-induced epigenetic alterations and their role in cancer risk, with a focus on identifying populations most vulnerable to these exposures. Understanding these mechanisms is essential for developing targeted cancer prevention strategies and informing environmental health policies to reduce disparities. Additionally, investigating the potential reversibility of these modifications through lifestyle, pharmacological, or policy interventions could offer new avenues for mitigating cancer risk in exposed populations. This review aims to highlight the disproportionate burden of pollution-induced epigenetic changes on vulnerable communities while emphasizing the need for more comprehensive studies to inform public health initiatives.

Capstone Instructor: Dr. Nancy Dilulio, Department of Biology, CWRU

## Dermatology AI Diagnostics

**Fabian Jimenez**, Computer Science; **Ran Jing,** Computer Science; **Arjun Thillairajah**, Computer Science; **Jacky Wang**, Computer Science; **Nia Worrell**, Computer Science

Skin diseases impact millions globally, yet access to timely dermatological care is often hindered by long wait times, limited specialists, and high costs. Dermatology AI Diagnostics is a web-based platform designed to provide preliminary skin condition assessments using artificial intelligence, offering a fast and accessible alternative for users seeking initial evaluations. The platform allows users to upload images of their skin concerns, which are processed by a convolutional neural network trained on extensive dermatological datasets. The system then provides the three most probable diagnoses, ranked by confidence scores, along with severity indicators that help users determine if immediate medical attention is needed. We evaluated multiple machine learning architectures and training datasets to determine the most effective approach, ultimately selecting a CNN model optimized for accuracy and efficiency. The front interface is designed to be intuitive and accessible across devices, integrating real-time image validation to assist users in capturing clear, high-quality images. The backend system processes images efficiently, optimizing model inference speed to provide near-instantaneous results. In addition to AI-driven analysis, the platform offers medical resource links and chatbot-assisted guidance to help users interpret their results and take appropriate action. Security and privacy are central to the system, with end-to-end encryption and anonymization protocols ensuring that user data is protected and compliant with data security regulations. The platform also includes an emergency detection feature that flags severe conditions and prompts users to seek immediate medical attention. By leveraging AI to bridge the gap between preliminary assessment and professional dermatological care, this system empowers users with early detection capabilities, helping to reduce unnecessary clinic visits while promoting informed decision-making about skin health.

Project Mentor: Shuai Xu, Department of Computer and Data Sciences

**Comparison of C8, C18, and HILIC stationary phase coverage of metabolites for vaginal mucosal metabolome profiling and biomarker discovery**

**Ariele Jinich**, Chemical Biology; Sausan Azzam, PhD, Center for Global Health and Diseases, Case Western Reserve University; Riley Eckert, Center for Global Health and Diseases, Case Western Reserve University; Adam Burgener, PhD, Center for Global Health and Diseases, Case Western Reserve University

Mucosal specimens collected from the female genital tract is a common sample type used for biomarker and immunological studies related to reproductive health. Microbiome and host-derived metabolites are an area of intense research due to the immune modulatory activities of these molecules in disease. The primary approach to metabolome mapping is through untargeted metabolomics approaches, using high performance liquid chromatography (HPLC) in tandem with mass spectrometry (MS). Metabolite identification by MS is heavily influenced by chromatographic approaches for separation, including reversed-phase (RP-LC) and hydrophilic (HILIC) liquid chromatography. The goal of this project is to evaluate three different chromatographic column types to compare metabolome coverage.

A subset of 25 samples was selected from the THRIVE HPV cohort including participants from the Winnipeg and Cleveland study sites. Samples include community state types (CSTs) I, III, and IV determined by 16S analysis of the microbiome, indicating the microbiome's dominant bacterial species. Samples were run on an LC protocol. Comparison of each chromatographic column was done based on the metabolites identified from each column per sample and net metabolite output per column. Metabolites were identified using an LC-MS/MS method with C8, C18 and HILIC chromatography columns. Data was processed using Compound Discoverer, and functional categories were determined using KEGG and PubChem compound databases.

The vaginal mucosal metabolome contains a variety of significant metabolites that are associated with mTORR signaling, central carbon metabolism, ABC transport, tumor formation, and other immune and inflammatory pathways. Analysis with C18 and HILI columns shows that the THRIVE cohort's metabolites include those associated with autophagy and IL-12 signaling pathways, as well as metabolites associated with inflammatory diseases. This data will be compared to the C8 metabolite output of the THRIVE participant samples, to determine the presence of significant differences in metabolites identified using a variety of LC chromatographic columns.

Project Mentor: Dr. Sausan Azzam, Center for Global Health and Disease, CWRU

Capstone Instructor: Dr. Adam Burgener, Center for Global Health and Disease, CWRU

## What Unexpected Costs Do Hospital Patients Pay for AI? The Ethics of Automation in Healthcare

**Winston John-Mark**, Cognitive Science

Artificial Intelligence (AI) and technological advances in large language processing are revolutionizing the ways companies are structured and operated. As artificial intelligence rapidly progresses, an increasing number of industries are integrating AI into their business models. This is especially true within the healthcare industry, as hospital organizations find ways to utilize AI technology in their services. Hospitals assert that these programs will enhance employee efficiency, improve patient care, and reduce operational costs. AI is being implemented for tasks such as triage and patient vitals monitoring and as a support tool for healthcare practitioners. Proponents argue that AI can be safely trained and utilized for these functions, allowing nurses to allocate more time to direct patient care, thereby reducing burnout and mitigating understaffing challenges. However, this rationale raises fundamental questions about hospital operations, as the pursuit of cost-cutting measures may conflict with the core values of patient-centered care that hospitals ought to reflect. I argue that the integration of AI, driven predominantly by cost-cutting and time-saving motivations, alters the focus of the healthcare industry from a patient-care-oriented model to a profit-centric healthcare system that overlooks the well-being of the patient. This capstone project is a directed literature review and thematic analysis of peer-reviewed articles published between 2020-2025 to explore AI implementation in healthcare, perspectives from employees and patients regarding AI use in hospitals, and also includes media analyses of recent public reactions to AI advancements. Implicit biases within AI systems, coupled with unregulated development and short-sighted implementation strategies, may exacerbate existing healthcare inequities, particularly for vulnerable populations. Consequently, the potential harm to hospital patients may outweigh the purported benefits of AI integration.

Project Mentor: Dr. Lynette Gerido, Department of Bioethics

Capstone Instructor: Dr. Erika Olbricht, Department of English

**Localization of Ribosome Assembly Proteins Upon Inhibition of Synthesis of Ribosomal RNA in S. cerevisiae**

**Isabella Torres,** Biochemistry; Anna Johnson, Biology;Ye Yao, Biochemistry; Dr. Alan Tartakoff, Department of Pathology

We investigated the localization of Mak11 and Noc1, two ribosome assembly factor proteins, in S. cerevisiae (yeast) both before and after rRNA synthesis is halted. In 1998, Oakes et al. discovered that deletion of the gene coding the Rpa12 subunit of RNA polymerase I caused cells to become temperature-sensitive for synthesis of ribosomal RNA. They also noticed that – at the restrictive temperature - several proteins involved in co-transcriptional modifications of rRNA (snoRNP proteins) redistributed throughout chromatin, where they formed particulate "mini-nucleolar bodies." We followed functional copies of Mak11 and Noc1 that were tagged with GFP, along with a fluorescent red version of the snoRNP protein, Sik1. We found that Sik1 formed mini-nucleolar bodies after incubation at the restrictive temperature; however, the other proteins (Mak11, Noc1) simply became increasingly visible throughout chromatin. Thus, the localization of many nucleolar proteins depends on synthesis of rRNA, but only a subset of nucleolar proteins forms particulate bodies after their relocation. Elimination of rRNA synthesis appears to fractionate the mixture of nucleolar proteins. This seems likely to reflect differences in their normal self-associative properties. Related observations could help understand the underlying causes of ribosomopathies.

Faculty Research Mentor: Dr. Nathan Howell, Department of Biochemistry
Capstone Instructor: Dr. Vivien Yee, Department of Biochemistry

## Do NBA Stars Get Favorable Foul Calls?

**Lucas Jones,** Economics and International Studies; **Ryan Miltenberger,** Economics and Statistics

Many National Basketball Association (NBA) fans have long believed that the best players in the league are awarded with favorable foul calls from referees when compared to other players in the league. This phenomenon is considered possible due to the subjective nature of how referees adjudicate fouls during NBA games. Prior literature on this topic has consistently found NBA star players as beneficiaries of referee and foul bias. Our research will attempt to further validate the work done in prior literature by utilizing a tiered star player system that separates all NBA players into levels based on fan, media and player voting, as well as implementing innovative controls such as team pace and player usage rate in our study. We have collected and observed panel data from 2017-2024 that looks at Personal Fouls Drawn per minute (PFD/min) for individual players across the first 3 quarters of NBA regular season games during this time period. Removing the fourth quarter, overtime, and playoff data ensures random referee assignment as well as the removal of intentional fouling that is seen at the end of games. Our data will be gathered from NBA.com and Basketball Reference and will be used to conduct a quasi-experimental regression analysis. We hypothesize that, on average, each NBA star player tier will be associated with an increased foul drawn rate from the tiers below it. The NBA and its fans place a heavy emphasis on the impact and notoriety of its star players, as they bring viewership, engagement, and revenue to the league that the NBA wouldn't see otherwise. Because of this, the results of this study could be prominent to anyone affiliated, associated, or interested with the NBA.

Project Mentor: Professor Mark Schweitzer, Department of Economics

Capstone Instructor: Professor Mark Schweitzer, Department of Economics

## Cold Sintering of Layered Perovskites

**Emma Joseph**, Materials Science; Dr. Alp Sehirlioglu, Department of Materials Science and Engineering, CWRU

The Cold Sintering Process (CSP) is a low-temperature (between 25 and 350℃) method of converting ceramic powder into a solid puck, reducing porosity and increasing density. This process reduces energy consumption and allows for the development of ceramic-polymer composites. The goal of this project is to develop a procedure to utilize the Cold Sintering Process to produce Dion-Jacobson phase layered perovskites for future use in ceramic-polymer composites. The material system of interest is $CsBa_xSr_{2-x}Nb_3O_{10}$ (x = 0, 0.5, 1.0, 1.5, 2.0), a Dion-Jacobson layered perovskite. The density of sintered samples can be tuned by adjusting the cold sintering parameters: pressure, temperature, hold time, and solvent concentration or composition. The densification mechanism behind cold sintering mirrors the geological phenomena describing rock deformation in wet environments over time, dissolution‑precipitation creep. A small amount of solvent is used to promote diffusion of particles leading to densification in place of higher temperatures seen in conventional sintering. The solvent promotes the dissolution of molecules near the points where multiple particles are in contact (particle-particle interface). Higher stress concentrations exist at these interfaces due to particle interactions compared to pores, creating a stress gradient. Dissolved molecules travel down the stress gradient from the particle-particle interface to pores where they will eventually precipitate, filling the pores to create a more dense and homogeneous sample.

Project Mentor: Dr. Alp Sehirlioglu, Department of Materials Science and Engineering, CWRU

## Designing a Reattachable Skeg for a Longer Lifetime

**Emma Joseph**, Materials Science; **Arianna Thornton,** Materials Science; **Benjamin Wellnitz**, Engineering Physics; Dr. John Lewandowski, Department of Materials Science and Engineering, CWRU

Skegs are small fins attached to the keel of rowing shells that play an important role in stabilization and increase directional control. Skegs are typically made of a polymer composite such as carbon fiber and are designed to break when a significant force is applied. While this prevents damage to the expensive boat hull, replacing broken skegs poses a significant cost in terms of both money and time to many rowing teams. Here we show the design and prototype of a re-attachable skeg that will break away from the boat when too much force is applied and will be unharmed during collisions. The design utilizes a hexagonal shear pin-like attachment to connect the skeg to the boat hull. The pin's geometry is designed to ensure the pin will fracture under a specific force and while the skeg remains undamaged. Easy retrieval is possible thanks to a rope attachment between the skeg and the shell. A replacement shear pin can then be inserted and the skeg reattached. This process is much faster and more convenient than replacing a broken skeg, which takes at least a full day. The pins are much cheaper than a new skeg and will save rowing teams significant money. Overall, the new skeg attachment technique which utilizes a hexagonal shear pin will allow rowing teams to spend their time and money on improving their rowing rather than fixing broken skegs.

Project Mentor: Professor John Lewandowski, Department of Materials Science and Engineering, CWRU

## Biometrics Tracking of Stroke Rehabilitation

**Cole Judson**, Biomedical Engineering; **Anna Mathis**, Biomedical Engineering,; **Abdul Melaiye**, Biomedical Engineering; **Mohit Patel**, Biomedical Engineering

Stroke is a leading cause of long-term disability in patients, of which one notable aspect is reduced hand and arm function and mobility. Nearly 40% of patients who survive a stroke experience lasting limitations in upper-limb mobility. This disability critically impacts the daily living of patients, creating a situation that limits the ability to perform daily tasks and reduces the overall quality of life. Early-stage physical therapy is crucial to regain function and mobility. Current clinical evaluation of hand rehabilitation include tests such as the Fugl-Meyer Assessment and the Wolf Motor Function Test that provide only a qualitative overview of hand function without tracking quantitative progress in the individual fingers or joints and are heavily based on a clinician's observation. This variability can lead to inconsistent evaluation and less effective ways of performing therapy. To address this issue, we designed a wearable device that measures both force output exerted by individual fingers as well as the position of each finger in space so that it can be used in tandem with standard practices to provide clinicians a complete overview of hand rehabilitation progress in stroke patients. Our design features wearable finger caps embedded with force sensitive resistors that transmit force data when compressed to an Arduino that processes the data in real-time to provide a time-related trend in force generation. This will be paired with bend sensors attached over the top of the fingers to determine the total range of motion of the joint. This wearable device will be designed with comfort and ease of use in mind, allowing full range of motion and ability to wear while performing assessments. By creating a device that provides specific and objective data, we hope to provide a more accurate rehabilitative assessment for clinicians to better support stroke patients in restoring hand function.

Project Mentor: Dr. Matthew Williams, Department of Biomedical Engineering, CWRU
Capstone Instructor: Dr. Matthew Williams, Department of Biomedical Engineering, CWRU

## A Comparative Analysis of Sepsis in Neonatal and Pediatric Intensive Care Units

**Nikhila Juluri**, Neuroscience

Sepsis remains a leading cause of morbidity and mortality in neonatal and pediatric intensive care units (NICU and PICU), causing organ dysfunction. Despite affecting both neonates and older pediatric patients, sepsis exhibits distinct clinical and pathophysiological characteristics across age groups, underscoring the need for tailored management strategies. This study aimed to address knowledge gaps by comparing the epidemiology, clinical presentation, and treatment responses of sepsis in NICU and PICU populations.

A retrospective review of electronic health records from University Hospitals (January 1, 2015–September 30, 2023) identified patients with microbiology culturepositive sepsis. Inclusion criteria required NICU or PICU admission with a gestational age ≥32 weeks and age ≤6 months, excluding those born at <32 weeks. De-identified data were stored in a REDCap database, including demographics, comorbidities, clinical presentations, microbiological profiles, therapeutic interventions, and outcomes. Outcomes included mortality (ICU, hospital discharge, 30-day, and 1-year survival), nosocomial infection rates, ICU and hospital length of stay, and disposition upon discharge. Statistical analyses compared NICU and PICU groups.

There were more microbiologically confirmed sepsis patients in the PICU than NICU (NICU: n=63, PICU: n=42).

Nosocomial infections occurred in 60.3% of NICU patients and 50.0% of PICU patients. Mortality was higher in the PICU (9.5% vs 3.2%), with fewer PICU patients surviving to hospital discharge (88.1% vs. 95.2%). ICU length of stay (LOS) was comparable between groups (12.68 vs. 13.01 days), though overall hospital LOS varied more.

The Pediatric Surviving Sepsis Guidelines recommend blood cultures and WBC counts; WBCs were obtained in 81.0% of NICU vs. 71.4% of PICU patients, and blood cultures in 76.2% vs. 69.0%.

These findings highlight age-specific variations in sepsis presentation, nosocomial infection rates, and diagnostic strategies, emphasizing the need for improved, evidence-based protocols.

Project Mentor: Dr. Kenneth Remy, MD, FCCM, Division of Pediatric Critical Care Medicine (Case Western Reserve University School of Medicine, and University Hospitals)

Capstone Instructor: Ashley Nemes, Department of Neuroscience

## Automating LTspice Simulations with Python

**Karungi Kabaseke**, Electrical Engineering

This project explores an automated approach to frame-by-frame circuit simulation using LTspice and Python. The goal was to enable dynamic parameter control across successive simulations, allowing the circuit to retain its electrical state between frames without manual reconfiguration. This method addresses a common challenge in electrical engineering simulations—ensuring continuity across time segments while integrating external input variability.

Grounded in a standard RLC test circuit, the project developed Python scripts that extract critical values from each simulation's output log, such as inductor current and capacitor voltage. These values are then reapplied as initial conditions for the next frame, enabling a simulation pipeline that mimics continuous behavior. The system automates this loop through netlist updates and batch execution of LTspice, supporting simulations that respond in real-time to shifting conditions.

This methodology serves as a proof-of-concept for simulation-driven modeling in cases where full continuous simulations may be computationally intensive or inflexible. The use of Python enables modular, reusable workflows that can be adapted to more complex circuits in the future. Although the project focused on validating this approach with simple circuits, its implications extend to broader applications in electrical engineering design and testing.

The work contributes to existing efforts in automating simulation environments and provides a scalable foundation for future development of emulation tools. It demonstrates how script-driven control of LTspice can enhance both accuracy and efficiency in electrical simulations—particularly in research environments that require responsiveness to external parameters.

Faculty Project Mentor: Dr. Kenneth Loparo, Electrical, Computer, and Systems Engineering, Case Western Reserve University

## Dielectric Elastomer Actuator Design For Underwater Propulsion

**Jeffrey Kagle,** Mechanical Engineering; **Jarod Lau**, Mechanical Engineering; **Katharine Lobas**, Mechanical Engineering

The development of novel methods for underwater propulsion is crucial for advancing underwater exploration. Biologically inspired designs, coupled with soft-robotic technologies, offer promising avenues for creating more efficient propulsion systems. One such promising approach involves dielectric elastomers (DEs), which must be integrated into dielectric elastomer actuators (DEAs) to enhance their performance and practicality. In this study, we evaluated a range of softactuation and movement techniques and identified a liquid DE actuated by rotary motion as the optimal design. This approach was selected for its superior energy efficiency, deformability, and the simplicity of motion it affords. Based on this design, we fabricated a DEA and conducted simulations to assess its movement. The results were then compared with theoretical calculations to evaluate the actuator's efficiency and effectiveness.

Project Mentor: Changyong Cao, Department of Mechanical and Aerospace Engineering

Capstone Instructor: Majhid Rashidi, Department of Mechanical and Aerospace Engineering

**Investigating Theory of Mind in Bilingual Children With or Without Childhood-Onset Schizophrenia Through False-Belief Tasks**

**Faith Kandie**, Cognitive Science

Childhood-onset schizophrenia (COS) is a rare psychiatric condition where hallucinations and delusions are present before the age of 13. Individuals with COS are known to have social, cognitive, and linguistic deficits which ultimately interfere with their Theory of Mind (ToM). ToM is the ability to understand other people's mental states, such as their desires, perceptions, and beliefs. Since ToM develops between the ages of 2 and 5, deficiencies in cognitive and social development can significantly interfere with one's interpersonal interactions. Prior research suggests that bilingualism offers positive effects on children's executive functioning, cognitive performance, and intelligence, with some evidence indicating it may mitigate symptoms of schizophrenia. However, its potential impact on ToM deficits in children with COS remains unexplored. This research aims to examine bilingualism's impacts on ToM impairments in children with COS through a study design. Using false-belief tasks, a prominent method for assessing ToM, performance will be compared between bilingual and monolingual children diagnosed with COS. Given bilingualism's cognitive benefits, it is hypothesized that while ToM deficits will exist in both groups, bilingual children may demonstrate less detrimental effects to their ToM than their monolingual counterparts. Through this investigation of the interaction between COS, bilingualism, and ToM, a deeper understanding of cognitive development in COS children can be achieved. Children with COS often struggle to form meaningful connections which can impact their wellbeing as they continue to grow and develop. New insights can lead to better interventions and increased support in their cognitive and social development. Additionally, research can contribute to the understanding of early-onset disorders in neurodivergent populations.

Faculty Project Mentor: Fey Parrill, Department of Cognitive Science

Capstone Mentor: Fey Parrill, Department of Cognitive Science

## Characterizing strain diversity of *Lactobacillus crispatus* in the vaginal microbiome

**Kaitlyn Kao**[1]; Alyssa Hamm[2], MS; Gina Lewin[2], PhD[1] Department of Biology, Case Western Reserve University; [2] Center for Global Health and Diseases, Department of Pathology, CWRU School of Medicine

Bacteria play a crucial role in maintaining human health. For example, the health of the female genital tract is influenced by its microbiota, which impact the oxygen and nutrient availability, the pH, and the local immune status of the vagina. *Lactobacillus crispatus* is one of the most crucial bacteria that can support vaginal health, and its presence is inversely associated with bacterial vaginosis (BV), a prevalent condition linked to reproductive health issues and increased risk for sexually transmitted infections. In order to support women's health, it is important to understand the factors that promote a *Lactobacillus*-dominant microbiome. My previous work showed differences in colony morphology and growth patterns among different *Lactobacillus crispatus* strains isolated from different individuals. Here, I hypothesize that there is strain diversity within the *Lactobacillus crispatus* species within the vaginal microbiome of a single woman, and this diversity contributes to her vaginal health. To begin to address this hypothesis, my goal is to characterize the intrapersonal phenotypic and genotypic diversity of *Lactobacillus crispatus* from a single vaginal swab. First, I performed a growth curve on five *L. crispatus* isolates from a single vaginal swab and found differing growth patterns among the strains. I also found differences in the pH of the *L. crispatus* cultures, which may indicate differences in lactic acid production. Second, I sequenced the genomes of these isolates and compared their genomes to each other. Although the strains are closely related, they have sequence differences. These results show phenotypic and genetic variance across strains of *Lactobacillus crispatus* within an individual, deepening our understanding of how this species promotes optimal vaginal health.

Faculty Project Mentor: Gina Lewin, PhD, Department of Global Health and Diseases, CWRU School of Medicine

**Modulating Frequency and Duty Cycle to Optimize Functional Neuromuscular Stimulation Cycling Performance in Patients With Spinal Cord Injury: A Clinical Study**

**Kanthi Karumbunathan**[1,2]; Lisa Lombardo[2]; Kevin Foglyano[2]; Ronald Triolo[1,2] Case Western Reserve University, Department of Biomedical Engineering[1] Louis Stokes Cleveland VA Medical Center[2]

For individuals with spinal cord injury, functional neuromuscular stimulation (FNS) is an essential therapy used to mitigate secondary complications of paralysis such as muscle atrophy, cardiovascular deconditioning, and bone demineralization, while also supporting mental well-being. FNS works by applying electrical pulses to motor neurons in order to elicit contraction of paretic or paralyzed muscles. Through controlled modulation of stimulation patterns, contractions can be used to recruit muscles in coordinated, functional movements such as walking, rowing, or cycling. In both clinical and community settings, cycling is one of the most common exercise modalities for FNS therapy. However, FNS cycling faces two primary limitations: minimal power output and rapid onset muscle fatigue. These limitations detract from potential physiological benefits. Optimizing stimulation patterns – particularly frequency and duty cycle – may help mitigate fatigue and improve performance. While higher frequencies of stimulation can produce greater power, they are typically associated with faster fatigue. This study tests whether a reduced duty cycle, or less muscle activation time per revolution, at a high stimulation frequency can offset fatigue while preserving power gains. We evaluated this through two stimulation strategies: stimulation at 25 Hz with a standard duty cycle, and stimulation at 60 Hz with a reduced duty cycle. 10-minute cycling trials were conducted on both a participant using implanted electrodes and one using surface electrodes. The protocol was performed on a motorless, indoor recumbent cycle. Outcome measures included mean power output, total work, and cadence to assess the efficacy of frequency and duty cycle modulation on fatigue and performance. Findings will inform more effective stimulation strategies to improve the efficiency of FNS cycling in patients with spinal cord injury and suggest further avenues for research.

Faculty Project Mentor: Lisa Lombardo[2]; Kevin Foglyano[2]; Ronald Triolo[1,2]

## Behind-the-Ear EEG Monitoring Device for Temporal Lobe Epilepsy

**Aarthi Rajan**[1], **Tyler Lin**[1], **Niveda Kasthuri**[1], **Ethan Roman**[1]

1. Department of Biomedical Engineering, Case Western Reserve University, Cleveland, OH.

Temporal lobe epilepsy (TLE) is the most common form of epilepsy, affecting approximately 50 million people worldwide. TLE seizures occur spontaneously and originate in the temporal lobe, although they can affect structures and networks in other regions of the brain. Patients diagnosed with TLE experience a wide range of cognitive and emotional symptoms including hallucinations, panic, anxiety, and fear. Diagnoses require week-long stays in hospital epilepsy monitoring units which come at high costs and discomfort to the patient. Epileptic seizures do not end here, however, and it is important to monitor patients to detect seizure onset. Though at-home monitoring devices exist, few are FDA-approved and most are cumbersome and restrictive. Our behind-the-ear device presents a long-term continuous monitoring option, addressing user features of comfort, non-invasiveness, portability, and integration with daily activities. The device will be encapsulated in a durable and flexible 3D-printed housing. Silver/silver chloride electrodes placed on the outer ear and temporal bone will be used to capture EEG signals. These signals are then passed through a two-stage signal acquisition circuit to the Arduino Nano 33 Sense Rev2 microcontroller for processing. For seizure detection, we perform a Fourier transform (FT) and analyze spectral data to extract features, including power spectral density and statistical parameters such as maximum and minimum amplitude. These features are used to train a k-nearest neighbors (KNN) model, which is used for binary seizure classification. Additionally, we make use of the on-board Bluetooth low energy (BLE) module to connect with a phone app, which will allow the user to track seizure occurrences and override false alarms.

Faculty Mentor(s): Dr. Matthew Williams and Dr. Colin Drummond, Department of Biomedical Engineering, Case Western Reserve University.

## Hormonal Contraceptives and BRCA1/2 Mutation Carriers: Assessing Breast and Ovarian Cancer Risk

**Skylar Katz,** Biology

Hormonal contraceptives (HCs) are commonly used as an effective method of both birth control and management of various reproductive health conditions. However, their influence on cancer risk, particularly among BRCA1 and BRCA2 mutation carriers, remains an area of uncertainty. Previous studies conducted on this association, particularly for female-specific cancers, have shown that oral contraceptives (OCs) have been associated with a reduced risk of ovarian cancer, while their impact on breast cancer risk varies. Research has suggested that HC use may increase breast cancer risk in BRCA1 mutation carriers, with certain factors such as duration of use, region, and lifestyle contributing to these risks. Meanwhile, BRCA2 mutation carriers experience little to no change in breast cancer risk. These assessments were compared to oral contraceptives and their impact on the general population. This paper conducts a comprehensive literature review examining the association between hormonal contraceptives and their influence on breast cancer risk in BRCA1/2 mutation carriers. Specifically, it investigates the biological mechanisms and role of hormonal pathways in linking BRCA1/2 mutations to cancer development as well as current clinical recommendations for contraceptive use in this high-risk population. Through this analysis, significant gaps in research are analyzed, such as the need for newer, lower-dose contraceptive formulations and individualized risk assessment strategies for high-risk individuals.

Faculty Mentor/Capstone Instructor: Dr. Nancy Dilulio, Department of Biology CWRU

## Magnetic Nanoparticle Optimization for Foam Filtration of Pharmaceutical Pollutants

**Adeeb Khan**, Chemical Biology

This project investigates the use of iron oxide nanoparticles, synthesized from rust, for creating magnetic foam composites to remove pharmaceutical pollutants from freshwater. Conventional treatments are often ineffective for filtering pharmaceutically active compounds, and current adsorption foams lack reusability.

Magnetic foams enable efficient pollutant capture and recovery using external magnets. Nanoparticles were characterized by electron microscopy and magnetic particle spetrometry, while foam structure was analyzed using scanning electron microscopy. Methylene blue adsorption tests showed a four-fold increase in efficiency within 15 minutes and stable performance across three reuse cycles.

The aim is to enhance freshwater filtration technologies by improving removal efficiency and material reusability.

Research Mentor, Principal Investigator: Anna Cristina Samia, Department of Chemistry

**Cognitive Impairment in Young Adults with Large Vessel Occlusion Stroke: A Critical Predictor of Functional Outcomes**

**Mustafa Khan**, Maryam Khan, J. William Handshoe, Yadi Li, Kriti Bhayana, Benjamin Coors, Andrew Schuster, Maariyah Kharal, M. Shazam Hussain, G. Abbas Kharal

Researcher/Presenter: Mustafa Khan, Neuroscience B.S major, CWRU

**Introduction:** Large vessel occlusion-acute ischemic stroke (LVO-AIS) is the most disabling subtype of ischemic stroke (IS) and disproportionately affects older adults. However, approximately 18% of IS cases in young adults (ages 18–50) are also caused by LVO-AIS. These patients often delay seeking treatment, resulting in significant and disabling deficits. While cognitive impairment (CI) following LVO-AIS is well-documented in older populations, little is known about its prevalence and impact in young adults. This study investigates the burden of CI in young adults with LVO-AIS and its influence on functional outcomes.

**Methods:** Data were analyzed from the Cleveland Clinic Young Adults Retrospective Cohort Study, which included young adults with LVO-AIS from January 2017 to December 2021. Demographics, stroke etiology (TOAST classification), treatment outcomes, and cognitive performance were assessed. Inpatient cognitive assessments evaluated deficits in attention, executive function, communication, judgment, problem-solving, and motor planning.

**Results:** Among 1220 young adults with IS, 214 (17.5%) had LVO-AIS and met inclusion criteria. The median age was 40.6 (SD 7.0) years, and 49.5% were female. CI was identified in 78 patients (36.4%). Those with CI were older (42.1 vs. 39.7, $p=0.008$), presented with more severe strokes (initial NIHSS 11 vs. 6, $p=0.006$), experienced less neurological recovery at discharge (NIHSS 5 vs. 1, $p<0.001$), and had worse functional outcomes at discharge (mRS 3 vs. 1, $p<0.001$) and at 90 days (mRS 2 vs. 1, $p<0.001$).

**Conclusion:** CI affects over one-third of young adults with LVO-AIS and is a critical determinant of long-term functional outcomes. These findings underscore the urgent need for early cognitive screening and targeted rehabilitation strategies in young stroke patients. Addressing CI in this population could dramatically enhance recovery, reduce disability, and improve quality of life, thereby reshaping care paradigms for young stroke survivors.

Faculty Project Mentor: Dr. Ghulam Abbas Kharal, MD; Neurological Institute Cerebrovascular Center at Cleveland Clinic (Main Campus)

Capstone Instructor: Dr. Ashley Nemes, Department of Neuroscience at CWRU

## Functional Characterization of GABRB3 Variants

**Shahyan,** Neuroscience

GABRB3 encodes the β3 subunit of the $GABA_A$ receptor, a key inhibitory neurotransmitter receptor critical to maintaining excitation-inhibition balance in the central nervous system. Mutations in GABRB3 are implicated in several neurodevelopmental disorders, including epilepsy, autism, and intellectual disability, largely due to their disruption of receptor folding, trafficking, and surface expression. In this study, we examined five pathogenic GABRB3 mutations—B3M1, B3M2, B3M3, B3M4, and B3M5—to determine their effects on membrane protein expression and trafficking. We employed total protein expression and surface biotinylation assays, followed by Western blot analysis. While total expression assays measured overall protein abundance, surface biotinylation selectively labeled membrane-localized receptors, enabling distinction between intracellular retention and trafficking impairment. Our findings suggest that several mutations potentially markedly reduce surface expression, potentially due to misfolding, ER retention, or enhanced degradation via the ER-associated degradation (ERAD) pathway.

To further validate these findings and understand the mechanisms underlying impaired trafficking, future experiments will include RT-qPCR to ensure that changes in protein levels are not due to altered mRNA expression. Additionally, cycloheximide (CHX) chase assays can be used to assess the stability and degradation kinetics of mutant proteins, providing insights into their turnover rates. These complementary approaches will help establish a clearer mechanistic link between mutation-induced misfolding and the observed deficits in receptor expression. Ultimately, these results may inform the development of pharmacological chaperones or proteostasis regulators as therapeutic strategies to restore receptor function in GABRB3-associated diseases.

Faculty Mentor: Dr. Tingwei Mu, Department of Physiology and Biophysics

Capstone Instructor: Dr. Ashley Nemes-Baran

## Tailoring School Support for Elementary Students Recovering from mTBI

**Avantika Khanna**, Cognitive Science, Case Western Reserve University

Traumatic brain injuries (TBIs) in school-aged children, particularly those occurring during middle childhood (ages 6-10), present significant challenges for cognitive, social, and academic development. Despite TBIs accounting for approximately 40% of all pediatric brain injuries in the United States, many affected students do not receive adequate educational support due to under-detection and misclassification within special education systems. Existing frameworks, namely IEPs and 504 Plans, also often fail to capture the evolving nature of TBI symptoms, leading to a discrepancy between the number of children needing accommodations and those receiving them.

This study explores how educational and institutional resources can be better allocated and tailored to support elementary school students returning to school after mild TBIs (mTBI). Using a combination of literature review, policy analysis, and participant data, this research evaluates existing school-based interventions and identifies gaps in support. This study also assesses the effectiveness of BrainSTEPS, a structured program that provides long-term academic and cognitive support for students recovering from brain injuries. Preliminary findings suggest that while BrainSTEPS improves individualized accommodations, its impact is limited by a lack of widespread educator training and inconsistent implementation across schools.

This research highlights that a one-size-fits-all approach fails to address the evolving nature of TBI symptoms. Schools often lack the necessary training to identify executive function impairments, cognitive fatigue, and emotional regulation difficulties, leading to a misinterpretation of students' struggles. This paper proposes a tiered support framework that integrates BrainSTEPS principles into general education settings, advocating for scalable, cost-effective solutions such as teacher training, peer mentoring, and flexible academic accommodations. By leveraging existing resources, implementing low-cost strategies, and expanding awareness of TBI-related challenges, the research aims to bridge the gap between policy and practice, ensuring a more effective transition for mTBI-recovering elementary students back to school.

Project Mentor: Dr. Angela Ciccia, PhD, Department of Communication Sciences, Case Western Reserve University

**Immunomodulatory Effects of Polymalic Acid on Dendritic Cell Activation, Cytokine Production, and Metabolic Function (Polymalic Acid (PMA) Immunomodulation, Dendritic Cell Activation and Metabolism, Cytokine Production and Surface Marker Expression)**

**Taravat Khodaei,** PhD student, Biomedical Engineering; **Viveka Rabara,** Undergraduate Student, Systems Biology BS

Polymalic acid (PMA) is a biodegradable polymer with potential immunomodulatory effects, particularly in dendritic cell (DC) activation and function. This study aimed to evaluate the impact of PMA on DC immune responses by assessing phenotypic activation markers, cytokine production, and metabolic activity. DCs were treated with PMA at concentrations of 0.1, 0.05, 0.025, and 0.01 mg/mL, and malic acid (MA), used as a control, was applied at slightly higher concentrations within the same range to adjust to the polymer molecular weight. Flow cytometry was employed to analyze the expression of key activation markers, including CD80, and CD86, to determine the extent of DC maturation. Also, CD206 and CD163 markers were studied to study DCs proinflammatory or anti-inflammatory nature. Enzyme Linked Immunosorbent Assay

(ELISA) was used to quantify cytokine secretion, such as IL-6, and IFN-g, to assess pro-inflammatory responses. Additionally, metabolic profiling was conducted using the Seahorse XF assay to evaluate oxidative phosphorylation and glycolytic activity, providing insights into the metabolic shifts induced by PMA and MA treatment. The results revealed dose-dependent effects on DC activation, with differences observed between PMA and MA in their ability to modulate immune responses. These findings contribute to the understanding of PMA and MA as potential biomaterials for immunotherapeutic applications, highlighting their role in shaping DC function through both surface marker expression and metabolic reprogramming.

Project Mentor: Abhinav Acharya, Department of Biomedical Engineering, School of Medicine

## At Home Monitoring Device for TLE Event Detection

**Layasri Ranjith,** Biomedical Engineering;**Ved Shivade,** Biomedical Engineering; **Jai Masturzo,** Biomedical Engineering; **Anish Khot,** Biomedical Engineering

Temporal lobe epilepsy (TLE) is a chronic neurological condition characterized by recurring seizures that originate in the temporal lobe of the brain (Cleveland Clinic, 2024). TLE is the most common form of epilepsy in adults and may have origins in genetics, temporal sclerosis, or traumatic brain injury (Moran, 2001). Due to the unpredictable nature of TLE resulting in rapid changes to consciousness or movement, it has a significant impact on quality of life, especially when symptoms can occur with no warning (Fisher et al, 2014). As a result, patients must undergo extensive monitoring to guide surgical or pharmaceutical interventions (von der Brelie, 2013). Current diagnostic tools subject patients to extensive stays in standardized clinical settings. Recent studies have demonstrated the potential feasibility of behind-ear monitoring systems for at-home use as an alternative to uncomfortable and highly visible inpatient cranial EEG monitoring systems (Gu et al, 2018). An at home, non-invasive, device that allows patients with TLE to maintain normal activities of daily routines while providing clinicians with continuous data for better management of TLE medications , and better prediction of TLE events. Electrodes are held in place behind the ear using an over-the-ear hook and are used to record and transmit EEG signals. Once the signal is processed using a filter and an amplifier, the microcontroller sends the processed data to a phone app, which continuously analyzes the processed data using a machine-learning algorithm to determine if a seizure event has occurred. Our prototype focuses on developing the machine learning algorithm to classify seizure events and verifying communication pathways between the electrodes and the microcontroller. The device also integrates qualitative patient feedback using a patient survey. Thus, this wearable device presents an exciting platform for clinicians to more effectively manage the condition, prescribe medication, and detect TLE events.

Faculty Project Mentor: Dr. Colin K. Drummond, Department of Biomedical Engineering, CWRU

Capstone Instructor: Dr. Matthew Williams, Department of Biomedical Engineering, CWRU

## Design of an Abdominal Binder with Integrated Fit Indicator

**Albert Kim**, Biomedical Engineering; **Andrew Shereshevsky,** Biomedical Engineering; **Anne Straits,** Biomedical Engineering; and **Nicole Zhou,** Biomedical Engineering

Abdominal binders are often used in post-surgical care after major abdominal surgeries such as exploratory laparotomy, cesarean section, bariatric surgery, hysterectomy, or spinal surgery to relieve pain, improve physical function, and provide support to the abdomen and incision. However, their efficacy is debated due to patient compliance challenges. Over 4 million abdominal surgeries occur annually where patients use a post-operative abdominal binder, but there is no quantitative way for them to gauge the tightness of the garment or the amount of compression it applies to accurately reproduce the proper fit demonstrated to them by a healthcare provider. This is problematic because failure to accurately secure the abdominal binder may lead to preventable complications requiring invasive re-exploration or intensive care management.

A quantitative method is needed to replicate the correct fit demonstrated to patients by healthcare providers when patients don and doff their binders at home. The device we are developing consists of a force sensor integrated within an abdominal binder and a separate enclosed device that can store pressure values and output visual feedback to the user. When the sensor is connected to the device, an Arduino UNO microcontroller will read the pressure and store it with the press of a metal push-button, which has RGB lighting. As the pressure changes, the new pressure will be compared to the stored value and the color of the push-button will correspond to the fit of the binder. The stored value can be reset by three presses of the button within a specified time frame.

Our objective is to develop a device capable of accurately and effectively informing patients whether their abdominal binder is applied within the optimal range specified by their healthcare provider.

Project Mentors: Professor Colin Drummond, Department of Biomedical Engineering, Professor Matthew Williams, Department of Biomedical Engineering

Faculty Sponsors: Professor Colin Drummond, Department of Biomedical Engineering, Professor Matthew Williams, Department of Biomedical Engineering

**Relative Intraocular Pressure Lowering Efficacy of Latanoprost, Latanoprostene Bunod, and Latanoprost-Netarsudil in Mice**

**Christopher H Kim**, Biochemistry; Jiwon Jang, Charles W Guo[1], Sophie M Baillargeon[1], Douglas J Rhee, MD[2,3]

[1] School of Medicine, Case Western Reserve University, Cleveland, OH [2] Department of Ophthalmology and Visual Sciences, School of Medicine, Case Western Reserve University, Cleveland, OH [3] Department of Ophthalmology and Visual Sciences, School of Medicine, Case Western Reserve University, Cleveland, OH

For patients diagnosed with primary open-angle glaucoma (POAG), prostaglandin analogues (PGAs), such as latanoprost, are commonly used for initial therapy. PGAs primarily increase uveoscleral outflow of aqueous humor. Advancements in POAG treatment led to medications like latanoprostene bunod (LBN) and latanoprost-netarsudil (LAT-NET). LBN contains latanoprost and butanediol mononitrate, which releases nitric oxide in the eye. LAT-NET combines latanoprost and a rho kinase (ROCK) inhibitor, enhancing paracellular flow through the juxtacanalicular trabecular meshwork by inhibiting ROCK-mediated actin-myosin cytoskeleton regulation and affecting the extracellular matrix (ECM).

Currently, no established study directly compares LAT, LBN, and LAT-NET. Some studies suggest LBN may outperform LAT, but they used experimental models that don't fully replicate pathophysiology of POAG or used non-therapeutic doses. This study aims to compare LAT, LBN, and LAT-NET in a mouse model more closely resembling POAG, focusing on clinically significant doses. This comparison will help understand the additive effect of the ROCK inhibitor in LAT-NET alongside the PGA's intraocular pressure (IOP)-lowering effect. We hypothesize that LBN and LAT-NET are more effective than latanoprost alone.

In the study, eyes of 6-8 week-old mice were randomly assigned to treatment groups: LAT (0.005%), LBN (0.024%), and LAT-NET (0.005% latanoprost/0.02% netarsudil). The contralateral eye received commercially available artificial tears containing benzalkonium chloride (BAK) (0.01%) as a vehicle control. Each mouse was treated for 4 weeks before enucleation for analysis. Preliminary data show LAT-NET treated eyes saw significantly reduced IOP ($p<0.05$, $n=4$) on days 14, 21, and 28 compared to their contralateral control eye. LAT-NET also demonstrated greater IOP reduction (-11.12%, $n=4$) at day 28 compared to LAT (-8.33%, $n=4$) and LBN (-7.29%, $n=5$). Immunohistochemistry results are pending, with further treatments planned to reach the sample size of $n=15$ per group.

Faculty Project Mentor: Douglas J. Rhee, MD, Department of Ophthalmology

Capstone Instructor: Vivien C Yee, PhD, Department of Biochemistry

## PR-B Expression and Degradation

**Ellen Kim,** Nutritional Biochemistry and Metabolism

In uterine myometrial cells, progesterone (P4) acting via its type B nuclear receptor (PR-B) exerts a potent "block" to labor, and loss of this P4/PR-B signaling induces labor. In humans, despite an abundance of the P4 ligand, immediately prior to parturition, this "block" is lost via unknown mechanisms. Carbobenzoxy-L-leucyl-L-leucyl-L-leucinal (MG-132) is a synthetic proteasome inhibitor. We hypothesize that the treatment of myometrial cells with MG-132 will increase the abundance of the PR-B protein. Understanding the relationship between PR-B and MG-132 will allow us to explore the kinematics of PR-B expression and degradation pathways.

Immunohistochemistry (IHC) assays were performed on an immortalized human myometrial cell line (hTERT-HM$^{AB}$). hTERT-HM$^{AB}$ cells have an inducible transgene construct for PR-B, triggered by the chemical GSL. Cells were treated with P4 ligand and varying doses of GSL. Cells were also treated with and without MG-132 and probed with an antibody specific to the PR-B protein. IHC data indicate increased positive PR-B signaling in cells treated with high amounts of both GSL and MG-132. Positive staining decreased slightly in cells treated with MG-132 and lower amounts of GSL.There was also a decrease in positive staining when the MG-132 was removed from treatment.

In response to the presence of various concentrations of GSL during treatment, we observed an increase in PR-B positive staining induced by an increase in GSL. Additionally, in response to the presence of MG-132 during treatment, we have observed a further increase in PR-B positive staining. MG-132 is a potent proteasome inhibitor and appears to allow for PR-B protein accumulation in both the cytoplasm and nucleus of myometrial cells, which may help us in understanding the role of PR-B throughout the cell. Through these experiments, we aim to understand the complexities of PR-B protein degradation and signalling in pregnancy and parturition.

Faculty Mentor: Beverlee Wood, Department of Physiology and Biophysics

Principal Investigator: Sam Mesiano, Department of Reproductive Biology

**Glomerular dissection allows high-throughput RNA sequencing of single podocytes**

Najeong Kim, Darshan A. Jadhav, Nestor H. Garcia and Agustin Gonzalez-Vicente

Fig 1: Nephrin (2µg protein/lane)

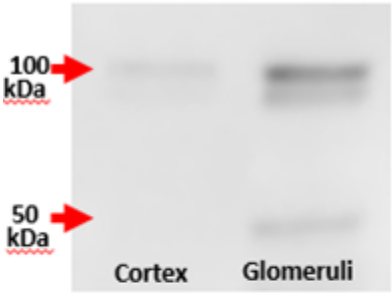
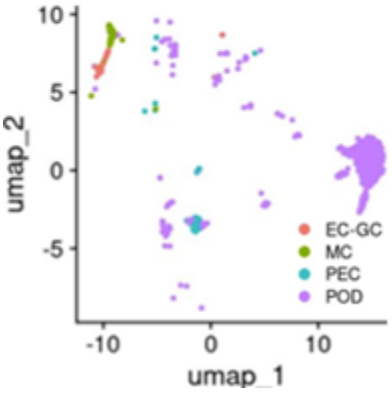



Fig 2: Projection of glomerular cells




Podocytes (POD) are essential for maintaining the integrity of the glomerular filtration barrier. Persistent insult to POD leads to proteinuria and eventual progression to chronic kidney disease. RNA sequencing (RNAseq) at single-cell resolution is an important tool in kidney research. However, high-throughput RNAseq of POD has proven challenging, as this cell type represents a small percentage of the total kidney cells and is underrepresented in cell suspensions obtained by enzymatic digestions. We developed a method to maximize podocyte recovery in single-nuclei (sn) RNAseq experiments. Glomeruli were microdissected from rat kidneys. Nuclei suspensions were obtained by cellular fractionation. Libraries were prepared with 10X Chromium X technology and sequenced on the Illumina NovaSeq X platform. Western blots (Fig 1) of 77 glomeruli show enrichment for the slit-diaphragm protein nephrin, compared to whole kidney cortex. We also recovered 22.5 ng RNA from 30 glomeruli with a 28S/18S ratio >1.8. Subsequently, we prepared two sn-libraries, using ~180 (Rat1) and ~90 (Rat2) glomeruli, from which we recovered 6590 and 1022 sn-transcriptomes, respectively. We quality-controlled and clustered cells in Seurat (V5) and used label transfer from a reference human kidney atlas (PMID: 37468583) to assign cell types (Figure 2).

The number of glomerular cells recovered was as follows: POD 1534 (22.2%), parietal epithelial cells (PEC) 96 (1.6%), mesangial cells (MC) 61 (0.9%) and glomerular capillary endothelial cells (EC-GC) 36 (0.5%). As a comparison, the reference atlas from human biopsies contains 2.1% POD, 1.1% PEC, 0.4% MC and 1.3% EC-GC. In addition, using 80 biopsies, the reference atlas recovered on average 73 POD/specimen, while our pilot study recovered 759 POD/specimen. Collectively, these findings demonstrate that our protocol enriches POD proteins and yields high-quality RNA suitable for sequencing. Isolated glomeruli also resulted in a more than tenfold increase in sn-POD transcriptomes per sample compared to kidney biopsies. Further development of this methodology will support high-throughput sequencing of POD with small sample sizes.

Faculty Mentor: Agustin Gonzalez-Vicente, Physiology & Biophysics

**Where's Your Pension Money Going? How California Law AB 2833 on Fee Transparency Affects Your Savings**

**Annika Minotti**, Economics with Concentration in Quantitative Methods & Political Science, CWRU; **Luke Kishna**, Economics & Biology, CWRU

Pension funds are an investment vehicle investing in traditional and alternative assets to pay pensions to workers upon retirement. Among the alternative assets pensions invest in, private equity (PE) has generated the highest returns, distracting pensioners from the pitfalls of the asset class, namely high fees. California Law AB-2833 was enacted in 2017, forcing California public pensions to disclose the fees paid to alternative asset managers, including PE firms. As the PE asset class swells and returns have been dampened by crowding out, PE will be subject to increased scrutiny from its investors. This legislation provides an opportunity to investigate the relationship between pension fund managers and pensioners, seeing if potential scrutiny influences the decisions of pension managers.

Our research examines whether AB 2833 led California's pension funds to reduce PE allocations or if managers continue prioritizing these investments despite disclosure requirements. Using a difference-in-difference methodology, we analyze panel data covering pension funds from 2001 to 2023. By comparing California's funds before and after the law's enactment against funds in other states not subject to the regulation, we aim to isolate the law's impact. Fund and year fixed effects control for unobserved differences across funds and time.

We expect our findings to show that AB 2833 reduces PE allocations by increasing transparency and scrutiny over fees. However, if PE continues to deliver strong returns, managers may maintain or even increase allocations despite disclosure mandates. If our hypothesis holds, it suggests transparency laws influence pension fund investment decisions, potentially aligning fund managers' strategies with pensioners' interests. These insights can help policymakers assess the effectiveness of similar regulations and guide pension fund managers in balancing pensioner trust with performance objectives.

Project Mentor: Professor Jenny Hawkins, Department of Economics

## Exploring the Reliability of Resting State Functional Connectivity as a Marker of Violence Proneness in Neurocriminology: A Systematic Review

**Helen Kliewer**, Cognitive Science; Dr. Adam Croom, Department of Cognitive Science

Violence remains a critical public health concern, with emerging evidence suggesting that biological mechanisms particularly resting state functional connectivity (RSFC) play a key role in aggression. However, the extent to which specific RSFC patterns consistently predict future violence across diverse populations, or how they may be altered through targeted interventions, remains unclear. To address this gap, we conducted a systematic review and meta analysis (following PRISMA guidelines) of 19 fMRI studies investigating RSFC correlates of anger and aggression. Using activation likelihood estimation (ALE), the results showed that violence prone individuals, compared to controls, exhibited significantly increased activity in the right amygdala ($Z = 4.3185$ $p = 0.00000785$), orbitofrontal cortex ($Z = 3.9629$ $p = 0.00000788$), and ventral striatum ($Z = 3.6998$ $p = 0.00000621$). Furthermore, diminished connectivity between the prefrontal cortex and amygdala was strongly linked to reactive violence, while heightened connectivity among the orbitofrontal cortex ventral striatum angular gyrus mid occipital cortex and cerebellum was associated with proactive aggression and revenge. These findings underscore distinct neural circuitries involved in different forms of aggression and highlight opportunities for refining intervention strategies aimed at mitigating violence risk.

Faculty Project Mentor: Dr. Adam Croom, Department of Cognitive Science

Capstone Instructor (if applicable): Dr. Adam Croom, Department of Cognitive Science

## Using Music Therapy to Support Family Members with Complex Decisions in the Intensive Care Unit

**Alex Klinck**, Neuroscience; Sasicha Gartenbush, Nursing; Paul Tuschman, MSSA, Dr. Grant Pignatiello, Department of Nursing

Surrogate decision-makers (SDMs) of ICU patients often experience substantial anxiety and depressive symptoms when making healthcare decisions that carry life-and-death consequences. Standard interventions to address this issue typically focus on providing informational support, and have shown limited effectiveness for reducing distress. Our previous research, teaching SDMs psychotherapy-based strategies to help manage their distress, was able to significantly lower depressive symptoms. This prompted our investigation into discovering other ways to help SDMs in managing their distress.

Music Therapy (MT) has emerged in recent years as a promising tool for a wide range of patient populations, treating agitation, pain, anxiety, and depression. Although the exact neuroscience mechanisms are unknown, MT interacts with multiple neural circuits involving language, memory, emotion, and pain. To ascertain MT's potential, we enrolled SDMs from multiple ICUs at a local academic medical center. We quantitatively assessed anxiety, depression, and sleep health in a control group (UC) which received no additional support beyond standard ICU communication practices. We are performing the same assessments with an interventional group that is receiving MT, as well as conducting qualitative interviews to further gauge MT's effectiveness. Preliminary data suggests elevated distress with little improvement after UC. Data collection and analysis for the intervention group is ongoing. We aim to demonstrate that MT is a feasible and effective treatment in reducing ICU SDMs' anxiety and depressive symptoms, ultimately empowering SDMs to better make these critical healthcare decisions.

Project Mentor: Dr. Grant Pignatiello, Department of Nursing

Capstone Mentor: Dr. Ashley Nemes-Baran, Department of Neurosciences

## At-Home Monitoring of Syncopal Events

**Michael Kong[1], Denzel Salas[1], Yang Shang[1], Melanie Uroda[1], Stephanie Wang[1]**, Colin Drummond[1], Matthew Williams[1]

[1]Department of Biomedical Engineering, Case Western Reserve University, Cleveland, Ohio

Syncope is a common condition characterized by transient and spontaneous loss of consciousness. It can result from cardiac arrhythmias, the vasovagal reflex, orthostatic hypotension, and many other conditions. Of these, cardiac abnormalities are the most life-threatening and can be difficult to diagnose in the clinic. Electrocardiogram (ECG) signals are vital in the screening and diagnosis of cardiac etiologies of syncope but can only detect abnormalities when they occur. Since the timing of syncopal episodes can be unpredictable and transient, screening is ideally conducted continuously over a long period of time, allowing for an increased likelihood of arrhythmia and episodes to occur during the recording time frame. Ambulatory/at-home monitoring of ECG has become a standard of care for screening of cardiac-related syncopal events, with the Holter monitor being the most mature and commonly used implementation given its effective, reliable, and noninvasive nature. While modern Holter monitors can record ECG signals continuously or alternatively during a short window around a syncopal event, they have limited battery capacity and do not address the largest risk of acute injury and death from syncope—falls. Our syncope device is a Holter-based chest monitor that aims to measure ECG continuously for 18–24 hour periods every day, with a capacity for up to a week. Users are alerted to potential arrhythmias and syncopal episodes, as detected by a deep learning algorithm, to help patients avoid falls. This extended recording capability is designed to increase the likelihood of detecting cardiac rhythms associated with syncopal events (external validation: AUROC > 0.7, n = 14552), allowing for user notification and related injury prevention. By enhancing at-home screening methods, our device aims to support early identification and proactive management strategies for syncope-prone patients.

Project Mentors: Professor Colin Drummond, Department of Biomedical Engineering, Professor Matthew Williams, Department of Biomedical Engineering

Faculty Sponsors: Professor Colin Drummond, Department of Biomedical Engineering, Professor Matthew Williams, Department of Biomedical Engineering

## Manually Machined Mechanical Pencil

**Devin Korybski**, Mechanical and Aerospace Engineering

This project explores the design and manual manufacturing of a functional mechanical pencil as an exercise in design for manufacturing. The goal is to develop a working prototype using basic machining processes—such as turning, milling, and drilling—while emphasizing material selection, tolerancing, and ease of assembly. Mechanical pencils are typically mass-produced via automated methods, but this project investigates how manual machining constraints influence design choices, ensuring functionality without relying on advanced manufacturing techniques.

By restricting fabrication to manual processes, the project highlights the relationship between design decisions and manufacturability. This often overlooked relationship is the key to the successful transition from prototype to mass production. Additionally, it serves as a practical demonstration of machining skills and iterative problem-solving, key competencies in mechanical engineering.

There are three stages to this project: research and conceptual design, detailed design, and manufacturing. The first stage starts with research into the various mechanisms used within mechanical pencils and choosing a design with a suitable level of complexity for the scope of this project. Once a direction for the design is decided, the second stage involves the use of CAD to finalize the exact geometry of the mechanical pencil, then create technical drawings with the necessary tolerances to machine the parts. In the last stage, these technical drawings will be used to machine the parts within Thinkbox. At this point, iterations will likely be made to adjust for complications that arise in the manufacture or assembly of the final product. The expected deliverables for this project will include one functional mechanical pencil and all related technical part and assembly drawings.

Capstone Instructor: Majid Rashidi, Mechanical and Aerospace Engineering

**Possible activation of leukotriene pathway in ARPE-19 cell after their exposure to pseudo-LTC**

**Carolyn Koutures**, Biochemistry B.A.

Leukotrienes are pro-inflammatory lipid mediators that play a crucial role in the innate immune system, mediating the immune response to pathogens and danger pattern recognition signals. They are derived from arachidonic acid with 5-lipoxygenase being the key enzyme involved. Pseudo leukotrienes structurally resemble genuine leukotrienes, therefore, in this study, we aim to identify whether pseudo leukotrienes can induce the leukotriene pathway signaling by upregulating 5-lipoxygenase, thus activating leukotriene biosynthesis in ARPE-19 cells. We hypothesized that pseudo leukotrienes can upregulate 5-lipoxygenase and activate leukotriene biosynthesis in ARPE-19 cells by binding to Cys LTR1 and CysLTR2 receptors, thus in turn promoting downstream signaling. This study used ARPE-19 cells to perform cell culturing, cell treatment with pseudo-LTC, SDS-PAGE (denaturing) followed by Western blotting. Along with LCMS. As a result of treating ARPE-19 cells with 500 nM ϕLTC solutions, significant results were observed in the receptors Cys LTR1 and GPR-17 as well as FLAP and 5-LOX, which both play an important role in leukotriene biosynthesis. Given our results of a significant two-fold increase in Cys LTR1 expression, our hypothesis that leukotriene biosynthesis would activate is supported. The significant increase in 5-lipoxygenase expression also supports our hypothesis that pseudo leukotrienes could upregulate the expression of 5-lipoxygenase.

Faculty Mentor: Mikhail Linetsky, Department of Chemistry

Capstone Instructor: Vivien Yee, Department of Biochemistry

## Hand Weakness Assistance Device

**Eamon Kraft[1], Lily McCloskey[1], Lexi Miskey[1], Kate Menzer[1], Shao Xiang[1]**
[1] Biomedical Engineering

The ability to perform activities of daily living (ADLs) is essential to maintaining independence in the geriatric population (ages 65+). Decreased hand grip strength (HGS) can frequently lead to difficulty completing ADLs, fearing injury, and lacking confidence. Conversely, evidence exists for the association of greater HGS and an increased quality and longevity of life for geriatric patients. Current devices on the market tend to perform well with stability support but can be inconvenient during donning and doffing, and are not multi-functional. Our innovation aimed to be easy to don and doff, reactive to external cues, and helpful for grip maintenance. The device provided support and strength to allow the grip to be sustained for extended time periods; while still requiring force input from the user to help maintain the grip, therefore decreasing the likelihood of muscle atrophy. Materials include a force-sensing resistor, a glove, a linear actuator, and fishing lines, creating a faux-tendon exoskeleton system to pull the user's fingers into a fist. The force-sensing resistor on the fingertip of the index finger receives user input and triggers the electronic pathway, resulting in the motion of the faux-tendons, to form the hand into a fist. The mechanical design included materials and mechanisms meant to simulate hand and wrist tendon movement that assist with completing ADLs. The electrical design included sensor inputs with a microcontroller-controlling actuator to allow for autonomy while using the device. Overall, the goal of this device was to extend grip duration and improve HGS in the geriatric population, and allow them to complete ADLs independently.

Faculty Sponsors: Dr. Colin Drummond, Department of Biomedical Engineering; Dr. Matthew Williams, Department of Biomedical Engineering, Case Western Reserve University
Graduate Student Mentor: Jordan Smith, Department of Biomedical Engineering, Case Western Reserve University

## Correlating Fire Behaviors in Micro- and Partial Gravities Using Microgravity Data

**Nathan Kralik**, Department of Mechanical and Aerospace Engineering

The aim of this project is to use microgravity data from experiments conducted on the International Space Station (ISS) to develop a correlation for predicting flame behavior in partial gravity. The raw experimental data will be taken from NASA's Physical Sciences Informatics (PSI) database and will be analyzed using a variety of coding tools. This resulting data will then be used to determine a working correlation between the microgravity environment and partial gravity. This project is of the utmost significance because understanding flame behavior in partial gravity is vital for regulating fire safety on any future missions to the Moon or Mars. Since fire behaves differently depending on gravity, a fire safety test performed on Earth may not translate to adequate levels of safety on another celestial body. To perform this analysis, a series of coding tools will be developed in MatLab, which will turn the raw data from PSI, which is a series of images and videos of a flame, into relevant numerical data. The functionality of the coding tools includes flame location tracking over time, measurement of the flame size over time, and calculation of flame extinction velocities. These tools will then produce the desired results of flame spread rate, flame size, and the extinction limits for burning of different materials under different conditions. A correlation can then be determined predicting flame behavior in microgravity as a function of material and environmental conditions. Finally, during the graduate thesis portion of this project, this correlation will be adapted to a model predicting flame behavior in partial gravity as a function of these same conditions.

Faculty Project Mentor: Ya-Ting Liao, Department of Mechanical and Aerospace Engineering

Capstone Instructor: Majid Rashidi, Department of Mechanical and Aerospace Engineering

## Third Party Course Review Platform

**Addy Krom,** Computer Science; **Leonardo Rodriguez,** Computer Science; **Mufu Tebit,** Computer Science; **Hart Williams,** Computer Science

In recent years, the number of online learners and online courses has grown exponentially. The sheer volume of options can make it difficult for learners to find high-quality, relevant courses tailored to their interests. This project aims to develop an independent platform that aggregates course data and user-generated feedback from popular websites like Coursera and Udemy, enabling learners to make informed decisions through unbiased reviews, ratings, and discussion. Our project addresses these shortcomings by combining routine data scraping, user discussions, and relevance-based search algorithms that weigh review quality and quantity. Our goal is to enhance review accessibility and integrity in the growing course industry.

To achieve this, we built a full-stack web application made up of microservices designed for flexible data handling. To acquire data we routinely execute an ETL job (extract transform load). We web scrape the data from Coursera and Udemy using their APIs exposed in their network requests. Due to the nature of the scale of data being requested, we cater our scraping methods per website safeguards. After scraping the course data, we normalize the data into a consistent format across course platforms. Post normalization, we add text embeddings/vectors to their representation and store this data in a Postgres database via our data layer API. This data layer API contains all our routes, communicates with our DB, and also handles vectorization via requests to our Ollama embedding service. Vectorization allows users to semantically search through our courses and discussions. Finally, given the nature of crowdsourcing reviews, we perform telemetry data collection to monitor our services and identify possible bad actors. By leveraging a fully open-source tech stack, we've built a robust and transparent platform that empowers users to explore and review online courses with confidence.

Capstone Instructor: Shuai Xu, Department of Computer and Data Sciences

## Analyzing Metal Mesh Filters with Transmission Line Models

**David Kuhtenia**, Physics

Millimeter-wave detectors used to measure the CMB require cryogenics to work well. In addition, other frequencies of radiation that enter the system (such as blackbody radiation from warmer parts of the system) need to be filtered out. One common type of filter is a filter where metal is deposited on a substrate dielectric, known as metal mesh filters. It is possible to use a transmission line model to analyze the different types of filters. To parametrize the metal mesh filters Ansys HFSS can be used to simulate the flow of EM waves through the filters and find the equivalent transmission line parameters. This project focused on creating a library to analyze HFSS data for many different filter geometries and transmission line circuits. The effects of lossy materials and shape imperfections were explored.

Mentor: Dr. John Ruhl, Department of Physics

Capstone Instructor: Dr. Idit Zehavi, Physics department

## Race, Socioeconomics, and Early Autism Access in Urban Children

**Ananya Kumar**, Psychology

Early autism diagnosis and intervention are critical for improving long-term outcomes, yet disparities persist in urban communities based on race and socioeconomic status (SES). This study explores how race and SES impact the likelihood of receiving an autism diagnosis before age four, identifying key barriers that minority and low-SES families face in accessing timely and evidence-based interventions. These barriers include healthcare access limitations, provider bias, and cultural stigmas, all of which contribute to delayed diagnoses and reduced utilization of interventions such as Applied Behavior Analysis (ABA) and speech therapy. Additionally, healthcare providers' perceptions of race and SES influence referral patterns, which further exacerbates disparities in care. By examining targeted community-based programs and policies that have successfully improved service accessibility, this research highlights potential strategies for reducing inequities in autism diagnosis and intervention. Findings emphasize the need for policy reforms and culturally responsive approaches to ensure equitable autism care for children in urban settings.

Mentor/Capstone Instructor: Sharon Milligan, Social Work, Mandel School of Applied Social Science

**MedSAM for segmentation of histological primitives on digitized kidney pathology images**

**Suraj Kumar,** Biomedical Engineering**;** Brennan Flannery, Department of Biomedical Engineering; Satish E. Viswanath, Department of Biomedical Engineering

Chronic Kidney Disease (CKD) results from impaired blood and urine filtration, ultimately leading to kidney failure. Glomeruli, capillary bundles in kidney tissue, regulate the body's balance of substances such as proteins and ions. Accurate evaluation of glomeruli is essential for assessing CKD severity and progression. Automating glomerular analysis is in turn contingent on accurate localization and segmentation of these structures. We propose a segmentation framework that leverages a foundational medical image segmentation model (MedSAM) to segment histological primitives such as glomeruli on multi-stain kidney pathology images.

Our cohort comprises a subset of data (N=25) from the Kidney Precision Medicine Project (KPMP, MN=3195)), pre-processed with HistoQC to eliminate poor-quality slides. Glomeruli were then manually annotated for three stain types (10 Periodic acid–Schiff, 5 Squamous Intraepithelial Lesions, and 5 Toluidine Blue) using QuPath. Images were split into 1024x1024 pixel tiles at 20x magnification. A foundational vision transformer model for medical imaging (MedSam) was used to segment glomeruli on the KPMP subset. MedSAM requires both the medical image and a bounding box for the target structure. We used manual annotations to generate these bounding boxes, then applied MedSAM to produce glomerular segmentation masks. Performance was evaluated using Dice Score across the entire cohort and for each stain type individually.

Results showed strong overall performance with a mean Dice score of 0.820 ± 0.099 across all stain types. Stain-specific performance was relatively consistent: SIL (0.843 ± 0.102), PAS (0.824 ± 0.087), and TOL (0.787 ± 0.101). MedSAM clearly demonstrates potential as a preliminary screening tool for multi-stain glomeruli segmentation. Future work will develop a "MedSAM-in-the-loop" approach to transfer MedSAM's capabilities to smaller networks that can perform kidney primitive segmentation without requiring bounding box inputs.

Project Mentor: Satish Viswanath, Department of Biomedical Engineering

## Magnetoplasmons in Altermagnets

**Austin Kuntz**, Department of Physics, Case Western Reserve University

Altermagnets are an emerging class of magnetic materials that exhibit characteristics of both ferromagnets and antiferromagnets. They feature alternating spin configurations that result in zero net magnetization, but certain broken crystal symmetries lead to electron dispersion relations that are both anisotropic and spin-dependent. This structure crucially results in a nonzero Berry curvature, which describes the phase shift from transforming a quantum system adiabatically. This grants electrons additional velocity in much the same way a magnetic field does. The present work explores the dynamics of plasmons in altermagnetic materials as a result of this anomalous velocity. Magnetoplasmons—collective oscillations of electron density, potentially in a magnetic field—are influenced by boundary conditions from the unique band structure of altermagnets. The study focuses on the Berry flux of altermagnets as a measure of their effect on the dynamics, and how this results in directional plasmon frequencies. The nature of the Berry curvature in certain materials is explored, providing insights into what materials may provide more or less energy splitting. I investigate how this affects the equations of motion dictating surface plasmons, giving a direction dependence. Determining these relations is not only of fundamental interest but also has potential implications for the development of future spintronic and plasmonic devices; these effects typically require magnetic materials, so creating them without stray magnetic fields may prove useful.

Faculty Mentor: Dr. Shulei Zhang, Department of Physics

Capstone Instructor: Dr. Idit Zehavi, Department of Physics

## Exploring Initial Mechanisms in the Cystic Fibrosis Pancreas

**Elizabeth Kuznetsov**, Nutritional Biochemistry and Metabolism

Pancreatic fibrosis is an early diagnostic feature of the common inherited disorder cystic fibrosis (CF). Many people with CF (pwCF) are pancreatic insufficient from birth and the replacement of acinar tissue with cystic lesions and fibrosis is a progressive phenotype that may later lead to diabetes. Little is known about the initiating events in the fibrotic process, though it may be a sequelae of inflammation in the pancreatic ducts resulting from loss of CFTR impairing normal fluid secretion. We previously identified activated stellate cells as an in utero marker of CF pancreatic disease. Here we use the sheep model of CF (CFTR−/−) to examine the evolution of pancreatic disease through gestation using immunohistochemistry.

Project Mentor: Shih-Hsing Leir, Genetics and Genome Sciences, Department of Genetics and Genome, Case Western Reserve University School of Medicine

## Multi-Standard Implanted Receiver for Testing the Efficacy of Digital Modulation

**Ben Kwiatkowski,** Biomedical and Electrical Engineering; **Andrew Smith**, Biomedical and Electrical Engineering; **Brian Nguyen,** Electrical and Computer Engineering

Wireless communication with implanted antennas requires low power, effective signal modulation. Examples of digital signal modulation include On-Off Keying (OOK), Amplitude Shift Keying (ASK), and Frequency Shift Keying (FSK), which each have some advantages and disadvantages. OOK modulation and demodulation circuits are simple in design and use less power than other designs. ASK modulation can be more reliable in noisy environments, but uses even more power. FSK modulation uses a similar amount of power, with even better reliability in noisy environments. We have designed an implantable receiver printed circuit board (PCB) adapted from a OOK-demodulating receiver that is capable of demodulating signals modulated in OOK, ASK, and FSK modes. This design is printed on a PCB for testing purposes, but will have the ability to be scaled down in the future for implantability once demodulation behavior is verified. This design can be used to test the efficiency of OOK, ASK, and FSK modulation in an implanted data transmission system, and allow for communication between multiple implanted devices using these modulation types.

Project Mentor: Dr. Steve Majerus, Department of Electrical, Computer, and Systems Engineering, Case Western Reserve University.

## Design and Test of a Low-Cost Espresso Machine

**Katelyn Lamm; Lindsay Lloyd; Sydney Schenk; Maria Tuepker,** Mechanical Engineering, Case Western Reserve University

The purpose of this project is to create an affordable espresso machine that is capable of delivering the same quality of espresso as a high-end espresso machine. The project can be defined by three primary goals: the design and fabrication of a low-cost espresso coffee maker, the ability to make a minimum of one cup of espresso at a time, and the ability to maintain consistent pressure and temperature through the brewing process. To accomplish this goal and deliver a working prototype, the team utilized a motor, sprockets, screw, and plunger to transform rotational motion into translational (linear) motion that could be used to build up pressure in the primary brewing chamber. Additional manufacturing of connection pieces between numerous valves to allow for water inflow and sealing of the pressure vessel was also necessary. After initial design and manufacture, it was necessary to thread and seal connections upon assembly with Loctite, as well as weld to ensure a fully sealed and resilient pressure vessel. The pressure within the primary brewing chamber is measured using a pressure gauge. This gauge was used upon testing to confirm a consistent pressure between 9 and 10 bar for optimal brewing. A gravity-fed water reservoir contained a heater that was allowed to reach a constant temperature before water was suctioned into the primary brewing chamber. Various testing mechanisms were used to ensure consistent, quality espresso pulls. The ability of the assembly to hold pressure was tested and confirmed using both cold and hot water. In addition to testing that pressure was maintained, the temperature of the brew as well as the timing of the brew, were tested for consistency. Cold water testing was performed for safety, while hot water testing was used to establish the quality of the brew.

Project Mentor: Dr. Majid Rashidi, Department of Mechanical and Aerospace Engineering, Case Western Reserve University

**Determining the Relationship Between Transgene Activity and Structural Disassembly in a Luciferase Encoded DNA Origami Nanoparticle**

**Christie Lanfear**, Chemistry; Kevin Liu; Kayla Neyra; Divita Mathur, Department of Chemistry

Delivering genetic material into cells can facilitate targeted gene therapy for gene sequence mutations. DNA-origami nanoparticles (DONs) are well established 'vehicles' for gene delivery, enabling intracellular protein expression. DONs are composed of a single-stranded DNA (ssDNA) scaffold strand which is 'folded' using short complementary oligonucleotides—staple strands—in a 'self-assembly' process. To deliver genes via DONs, one can encode a gene of interest into the scaffold strand and then create a custom shaped DON. This project utilizes a bacterial cell-free transcription-translation (TXTL) system and Förster Resonance Energy Transfer (FRET) to characterize and provide insight on the unraveling of DONs during gene transcription. TXTL systems are facile analytical methods containing the cellular machinery necessary for transcription and translation of genes without the hassle of cell culturing. FRET is a distance-sensitive optical phenomena between a donor and acceptor molecule. We hypothesize that before DON is processed by TXTL for protein expression the FRET signal will be high but will decrease as protein expression takes place, indicating DON unraveling. A variant of the *Renilla luciferase* gene with a T7 promoter was chosen as the gene of interest. Asymmetric polymerase chain reaction (aPCR) was used to synthesize the luciferaseencoded scaffold strand, followed by gel electrophoresis-based purification. The ssDNA scaffold was combined with staple strands and buffers in a thermocycler to assemble the DON, called a 12-helix bundle. Transgene activity was analyzed in the TXTL system by measuring luminescence intensity upon adding the luciferase substrate—NanoGlo. For FRET measurements, the DON structure was functionalized with a fluorophore pair (Cyanine 3 and Cyanine 5). Herein I show successful assembly and expression of luciferase encoded 12-helix bundle. Next steps will test the hypothesis that the geneencoded DON will yield protein expression with an inverse relationship to FRET, ultimately providing insight on the nature of DONs intracellular unraveling.

Project Mentor: Divita Mathur, Department of Chemistry

**Morbid Orchids: Investigating the floral volatile chemistry of the fetid flowers of the genus *Orchidantha***

**Mose Langway**[1], Sarah Qing[2], Robert Raguso[3] Jana Leong-Škorničková[2], and Elliot M. Gardner[4] 1 Biology and Chemistry dual major, Case Western Reserve University, Cleveland, Ohio, USA 2 Singapore Botanic Gardens, National Parks Board, Singapore 3 Department of Neurobiology and Behavior, Cornell University, Ithaca, New York, USA 4 Department of Biology, Case Western Reserve University, Cleveland, Ohio, USA

*Orchidantha* is the sole genus in the plant family Lowiaceae (Zingiberales). This genus of 32 species has a range confined to tropical Southeast Asia between southern China and Borneo. The herbaceous portion of plants in the genus is nearly uniform, comprising a short herb with spear-shaped leaves. The flowers of *Orchidantha* give the genus its name, as their modified lower petal, or labellum, resembles that of an orchid. However, *Orchidantha* inflorescences lie close to the forest floor, and their flowers invite dung beetles, carrion beetles, and possibly others with their appearance and odor. Most *Orchidantha* flowers produce smells mimicking rotting flesh, dung, or mushrooms. To analyze these floral scents, volatiles were collected using a dynamic headspace method by drawing air surrounding an enclosed flower into a tube packed with Tenax TA. Volatiles were analyzed using thermal desorption followed by gas chromatography/mass spectrometry(GC/MS). Mass spectra and standardized Kovats retention indices were used to identify putative floral volatile components of 100 samples collected from 17 species. A wide variety of profiles and individual volatile chemicals were found to be produced by the flowers, including most notably many short chain fatty acids(SFCAs), dimethyl di and trisulfides, terpenes, and phenolic compounds. I identified six major odor classes among the 17 species analyzed. By comparing these profiles to the profiles of possible analogues, I was able to match the flowers to their mimics. I found mimicries of four models that attract potential pollinators: Feces (6 species), carrion (3 species), rotting fish (2 species), and fungus (5 species). One species had mild smelling flowers without any obvious mimicry. This summer, I will be travelling to Sabah, Malaysia, where many species of *Orchidantha* are native, to observe pollination and collect pollinator species in the field.

Project Mentor: Elliot Gardner, Department of Biology

**Kinetics of Hematite Reduction to Magnetite During Metamorphism**

**Tyler Larkin, James Van Orman**, Department of Earth, Environmental, and Planetary Sciences, Case Western Reserve University

Iron formations formed as deep-sea chemical sediments during Earth's early history, and make up a small but significant portion of Earth's crust. During their lifetimes, these formations undergo metamorphic reactions; however, without an accurate understanding of the rocks' response to the conditions under which these reactions take place, geologists cannot read the histories of these rocks accurately. During metamorphism in Earth's interior, iron formations experience conditions that are more reducing than those under which they formed in the ocean. Under these conditions, the hematite ($Fe_2O_3$) that is a primary sedimentary mineral may transform to magnetite ($Fe_3O_4$). We will present experimental data on the kinetics of this iron oxide reduction reaction under conditions relevant to iron formation metamorphism. The experiments were performed using natural gem-quality hematite single crystals embedded in a reducing medium (wüstite ($Fe_{1-x}O$), iron, or graphite). These reaction couples were placed into a piston cylinder or multi-anvil apparatus and annealed at constant pressure and temperature over a range of conditions. Afterward, the reaction couples were extracted, polished, and examined using scanning electron microscopy to determine the thickness of magnetite layers formed during the simulated metamorphic conditions. The thickness of the magnetite layer varied linearly with the square root of the run duration, indicating that the growth rate was controlled by diffusion through the growing layer. The diffusive reaction rate coefficients were fit to an Arrhenius expression to determine the temperature and pressure dependence. This expression provides a predictable algorithm for hematite reaction rates during metamorphism, allowing us to predict the time required for partial or full reduction of this mineral over a broad range of metamorphic conditions.

Project Mentor: James Van Orman, Department of Earth, Environmental, and Planetary Sciences

## Keystroke detection AI system to combat HID attack

**Minh Hien Le**, Computer Science; **Tu Pham**, Computer Science; **Matt Le**, Computer Science; **Shaun Nunoo**, Computer Science

This research addresses the cybersecurity threat of malware attacks that simulate user keystrokes through Human Interface Devices (HIDs), which can bypass traditional security measures. With multiple malware incidents occurring worldwide daily, an effective detection method is urgently needed. Our project develops an intelligent system that differentiates between genuine user input and keystroke patterns generated by malicious devices like USB Rubber Ducky. Using statistical methods and machine learning techniques, the system analyzes inconsistencies in keystrokes to identify anomalies effectively. We leveraged the K-Nearest Neighbors (KNN) model to examine temporal patterns and typing irregularities to detect subtle differences between human and automated execution. Our system integrates an ESP8266 Wi-Fi module for remote access and an ATmega32U4 microcontroller that simulates malicious keystroke injection, while a keystroke detection program records and analyzes input parameters regardless of source. Initial cross-validation testing demonstrates impressive accuracy rates of approximately 99.5% with optimal configuration. We expect to deliver a system that can accurately detect fraudulent inputs and blacklist the device to prevent further actions. This project will contribute significantly to malware detection by providing a proactive defense mechanism that can detect and mitigate HID-based threats in real time, enhancing the overall system security and resilience against evolving cybersecurity challenges.

Faculty Mentor: Shuai Xu, Department of Computer and Data Sciences

## Haptic Feedback for Wearables

**Aidan Nathan**, Biomedical Engineering; **Evelin Urbancsok**, Biomedical Engineering; **Jihye Lee**, Biomedical Engineering; **Xianzhe Tan**, Biomedical Engineering

This presentation outlines the design, development, and validation of a haptic feedback wristband designed to serve as a navigation aid for individuals who are visually impaired. Our device aims to provide directional guidance using vibrotactile cues, allowing users to navigate environments without relying solely on a cane or other physical guidance system. By strategically placing haptic motors around the wrist, the device conveys directional information through distinct vibration patterns, helping users orient themselves and move safely through unfamiliar spaces.

In addition to directional guidance, our design plans to incorporate an obstacle detection feature using an infrared sensor. When an object is detected in the user's path, the wristband will issue a distinct pulsing vibration to alert the user. This enhancement aims to improve spatial awareness and safety in real-world environments.

The overall goal of this project is to upgrade the wristband's material and motor placement to improve signal clarity while testing the effectiveness of haptic cues for navigation and obstacle avoidance. The validation plan will focus on ensuring that users can reliably interpret directional feedback and detect potential obstacles, ensuring the device accurately achieves its goal of providing a functional and intuitive alternative to traditional physical mobility aids.

Faculty Mentor 1: Colin Drummond, Department of Biomedical Engineering

Faculty Mentor 2: Matthew Williams, Department of Biomedical Engineering

## A Literature Review of the Etiology, Prevalence, and Craniofacial Influences on Sleep-Disordered Breathing in Adolescents

**Julia Lee**, Biology

There is growing recognition that Obstructive Sleep Apnea Syndrome (OSAS) affects some patients in every orthodontic practice in dentistry. As a result, sleep questionnaires like the Pediatric Sleep Questionnaire (PSQ) are being used more frequently to identify individuals at risk for OSAS. Moreover, several literature studies explore the size, shape, and volume of the upper airway, as well as the relationship between these morphologic measures and craniofacial morphology. While research exists on PSG and its relation to craniofacial hard and soft tissue morphology in patients with confirmed sleep disorders, no studies have focused on PSG in orthodontic patients seeking care. This research project aims to review and analyze existing studies on the etiology, prevalence, and incidence of sleep-disordered breathing (SDB) in adolescents. The literature review will examine several factors discussed in previous studies, including the types of SDB, such as Obstructive Sleep Apnea Syndrome (OSAS) in pediatric populations. Additionally, the project will compare at-home unattended overnight polysomnography (PSG) with laboratory-based PSG, focusing on differences in accuracy and cost. Lastly, it will explore how variations in craniofacial morphology, such as mandibular retrognathia, impact airway function and the risk of SDB. The methods used to assess craniofacial features, including imaging techniques and longitudinal growth studies, will also be reviewed.

Project Mentor: Dr. Mark Hans, Department of Orthodontics

Capstone Instructor: Dr. Barbara Kuemerle, Department of Biology

**Effect of Buffered Anesthetic on Physiological Reactions during Dental Injection in Young Children under Deep Sedation**

**Nara Lee**, Neuroscience

Buffered local anesthetics have been proposed as a solution to the discomfort and delayed onset caused by the low pH of standard lidocaine formulations, but their efficacy in pediatric patients remains unclear. This project investigates how buffered lidocaine affects pain signaling and physiological responses during dental surgeries in young children, a population that cannot reliably self-report pain and often requires alternative assessment methods. In this study, twenty children aged 3 to 6 received both buffered and non-buffered lidocaine across different quadrants of the mouth in a randomized, double-blind, split-mouth design while undergoing dental surgery under deep sedation. Pain was assessed using the Modified Behavioral Pain Scale, and physiological measures such as heart rate, blood pressure, and oxygen saturation were monitored throughout treatment. Buffered lidocaine was associated with noticeably lower behavioral pain scores, smaller spikes in heart rate, and more stable blood pressure readings during injections and invasive procedures. These findings support the idea that buffering lidocaine reduces nociceptive signal propagation through trigeminal pathways and decreases downstream activation of the autonomic nervous system. The implication of these findings is that buffered anesthetics may offer a more effective standard for pediatric dental care by improving both subjective and physiological pain responses, minimizing discomfort during procedures, and potentially reducing long-term dental anxiety in young patients.

Project Mentor: Dr. Ying An, School of Dental Medicine

Capstone Instructor: Dr. Ashley Nemes-Baran, Department of Neuroscience

**Length Characterization of Grafted Type I Collagen Fibrils for Improved Soft Tissue Integration of Dental Implants**

**Nicholas Leonard**,[1] Leena Polomo,[2] Steven J. Eppell[1]

[1]Department of Biomedical Engineering, Case Western Reserve University

[2]Ashman Department of Periodontology & Implant Dentistry, NYU

Traditional implanted biomaterials lack significant integration with native soft body tissues. This often results in devices loosening over time and eventually failing. Our lab combats this by grafting type I collagen fibrils normal to material surfaces in a biomimetic fashion. We hypothesize this will improve soft tissue integration and mechanical fixation after implantation. The purpose of this project is to characterize the distribution of these presenting fibril lengths. This will be accomplished by measuring the ultimate tensile strength (UTS) of two functionalized and crosslinked surfaces separated by stainless steel shims of varying thicknesses. By determining the separation distance and rate at which the UTS diminishes, the distribution of fibril lengths can be determined. We expect that as shims increase in thickness, shorter fibrils won't crosslink causing the UTS to slowly decrease. Eventually a rapid drop off should occur corresponding with the fibril length mode. Understanding these distribution defining parameters is crucial for analyzing the mechanics and viability of our treatment as longer fibrils generally correspond to stronger soft tissue integration. Additionally, this metric will serve an important role in evaluating future procedure modifications and optimizations.

Project Mentor: Prof. Steven Eppell, Department of Biomedical Engineering, Case Western Reserve University

## Dauntless Shaft: A Procedural Dungeon-Crawling RPG

**Frank Li**, Bachelor of Science, Computer Science, Department of Computer Science and Data Science, CWRU; **Jerome Wu**, Bachelor of Arts, Computer Science, Department of Computer Science and Data Science, CWRU; **Changhao Wang**, Bachelor of Arts, Computer Science, Department of Computer Science and Data Science, CWRU; **Michael Shen**, Bachelor of Arts, Computer Science, Department of Computer Science and Data Science, CWRU

This project focuses on the development of Dauntless Shaft, a top-down RPG designed game implemented with Unity. This game integrates roguelike exploration, combat activities for multiple angles and turn-based, and map generation on procedural basis. The objective of this game is to create an engaged underground world exploring experience with players go though and navigate in the dynamic environments. Players can also manage inventory and enhance their characters through randomized equipment and stat-based combat.

In order to achieve this, we developed mechanics including a structured inventory system combined with categorized equipment slots. This game system is also able to generate equipment based on rarity and attributes. The game generates the map with a multi-walker algorithm. These features create replayability by creating unique dungeon layouts each time with varying enemy placements, environmental hazards, and item distributions. The combat system has evolved into a turn-based format, emphasizing strategic decision-making through equipment selection and stat management.

Project Mentor: Shuai Xu, Department of Computer and Data Sciences

## The Future of Artificial Intelligence in Mental Healthcare

**Nicholas Li**, Cognitive Science

Artificial intelligence (AI) is being increasingly utilized as a preliminary mental health screening tool, leveraging natural language processing (NLP) and machine learning to accurately assess psychological distress and guide individuals toward appropriate care. While AI offers scalability and efficiency in a system where proper mental health resources are often limited, it also presents significant cognitive and ethical challenges. From a cognitive perspective, AI lacks the human ability to interpret social tools like complex emotions, nonverbal cues, and cultural context, thereby raising concerns about diagnostic accuracy and patient-provider relationships. Cognitive biases, such as automation bias and algorithm aversion, further exacerbates how individuals perceive and interact with AI-driven assessments. Ethically, AI's role as a gatekeeper to mental healthcare raises concerns about algorithmic bias, data privacy, and equitable access. While AI has the potential to expand mental health services, its effectiveness depends on addressing these challenges to ensure it does not inadvertently reinforce disparities or limit access to human providers. The role of mental health care recipients cannot be overstated in this endeavor; it is only through continuous dialogue and refinement that both profitable and objective healthcare is achieved. This literature review critically examines the cognitive mechanisms underlying AI-driven mental health screening and patient trust, as well as the ethical implications of incorporating AI in clinical decision-making. By exploring these dimensions, this study aims to contribute to ongoing discussions on the responsible integration of AI in mental health care.

Project Mentor: Vera Tobin, Department of Cognitive Science

## Topological Data Analysis: Techniques and Applications

**Ziang Li**, Mathematics

Topological Data Analysis (TDA) is an emerging field that leverages concepts from algebraic topology to uncover latent structures in complex, high-dimensional datasets. This study introduces two foundational TDA techniques: persistent homology, which quantifies multi-scale topological features, and the mapper algorithm, which produces simplified graphical representations of data geometry. To contextualize TDA's performance, we conduct a comparative analysis with the Self-Organizing Map (SOM), an unsupervised learning algorithm known for dimensionality reduction and clustering. This comparison reveals key differences in how each method represents data geometry, with TDA offering a more nuanced view of the topological and connective structure, while SOM excels at preserving local proximity and neighborhood relationships. We begin with a simulation of a synthetic dataset to demonstrate how TDA captures the underlying shape and connectivity of the data. Next, we apply these techniques to a real-world dataset, illustrating TDA's capacity to extract meaningful topological patterns that may remain hidden by traditional methods.

Faculty Mentor: Daniela Calvetti, Department of Mathematics, Applied Mathematics and Statistics

Capstone Instructor: Daniela Calvetti, Department of Mathematics, Applied Mathematics and Statistics

**Adversarial Learning Schema for Semantic Segmentation in Fractography Analysis of Laser Powder Bed Fusion (LPB-F) Parts**

**Shawn Liang,** Computer Science; **A**nthony Manuel Lino, Material Data Science for Stockpile Stewardship: Center of Excellence, Department of Materials Science and Engineering; John Lewandowski, Material Data Science for Stockpile Stewardship: Center of Excellence, Department of Materials Science and Engineering; Laura Bruckman, Material Data Science for Stockpile Stewardship: Center of Excellence, Department of Materials Science and Engineering, Department of Computer and Data Science; Pawan Tripathi, Material Data Science for Stockpile Stewardship: Center of Excellence, Department of Materials Science and Engineering

This work continues to improve the current defect analysis method for Laser Powder Bed Fusion parts with Semi-Supervised machine learning algorithm. The Aerospace industry looks for components produced via additive manufacturing methods since they offer great potential with more complex and efficient jet engine components. However, the progress is hindered by defects that can unpredictably reduce mechanical properties, making components unable to meet the industry's rigorous standards for fatigue. The current standard method of addressing this issue is through fractography of fatigue test samples, where experts qualitatively analyze the fracture surfaces. We aim to gain additional insights by quantitatively analyzing these images using an automated method. We propose a semi-supervised semantic segmentation using an adversarial network. The Unet architecture has shown success with small datasets, and is chosen as the architecture. The architecture is implemented to be adaptable to various input channels and classes, making it suitable for segmenting multiple classes using data from multiple imaging processes of the fracture surface. A discriminator network can be used to improve the segmentation network. As a part of the PFDI initiative in SDLE, we are developing this tool with a package to make it easily accessible and applicable to various problems. The package consists of two parts: a supervised segment where both the segmentation network and the discriminator network are trained on labeled data; an unsupervised segment is used to train the segmentation network while the discriminator remains static. Through adversarial learning, both segmented and unsegmented images are utilized into the training, allowing a more training efficient and potentially accurate model for image segmentation.

Faculty Project Mentor: Dr. Laura S. Bruckman, Department of Materials Science and Engineering, CWRU

## Collection of IR Spectrum of ortho-Phosphophenol in the Gaseous Phase

**Sam Lichenstein**, Chemistry

The purpose of this project is to confirm the findings of calculations done on the conformations of *ortho*-Phosphinophenol (OPP) in the gaseous phase. While the solid and in solution confirmations were able to be tested for using crystal X-ray, NMR and IR studies the experimenters were unable to test for confirmations in the gaseous phase. To test the calculated confirmations we ran an IR spectrum on OPP in the gaseous phase. The issue with this is that OPP is naturally solid and to get a IR of it in the gaseous phase specialty methods are necessary. Most of these methods require specialty setup and experience and thus require large capital investments. In this paper we have created a method using off the shelf products and a standard IR spectrometer to capture the IR spectrum of OPP in the gaseous phase. This was accomplished by Using a sealable 100mm cell, with the sample placed in it. This was then vacuumed down and then heated and placed in the spectrometer. The spectrometer was then run, collecting the IR spectrum of the analyte OPP. This resulted in a IR Spectrum of the Analyte to be used to confirm the computer calculations done in previous work.

Faculty Project Mentor: Laura Bruckman, Department of Materials Science

Capstone Instructor: John Protasiewicz, Department of Chemistry

## Investigating Serotonergic Fiber Distribution in Cervical Region of ALS Mice

**Jason Lin**, Neuroscience

Amyotrophic lateral sclerosis (ALS) is a progressive neurodegenerative disease characterized by degeneration of upper and lower motor neurons, leading to deficits in voluntary movements and ultimately respiratory failures. There is increasing evidence suggesting the involvement of the serotonergic system in the progression of ALS pathophysiology, given its role in motor control, proprioception, and autonomic nervous system regulation. Although previous research suggests that there is degeneration of serotonergic neurons in the upper motor neurons like the brain stem, little is known about 5-HT fiber distribution specifically in the cervical spinal cord, which is involved in upper limb control and respiratory functions. This study aims to quantify the change in serotonergic fiber distribution in SOD1-G93A ALS mice compared to wild-type (WT) control. Using immunohistochemistry with 5-HT and serotonin transporter markers (SERT), we visualize the difference in serotonergic systems in the cervical spinal cord section 9 and 16 weeks of age. High-resolution imaging using Keyence Bz-x 800 microscopy was done and intensity-based analysis was performed using MATLAB to assess the differences in 5HT and SERT in ALS and WT mice. Based on the role of cervical spinal cord in respiratory and upper limb function and serotoninergic system involvement in ALS progression, this experiment would inform future investigations into therapeutic targets for preserving motor function. By focusing on the cervical region, this study would also allow a clearer understanding of serotonergic involvement in ALS progression.

Principal Investigator and Mentor: Dr. Yu-Shang Lee, Associate Professor, Medicine, CCLCM-CWRU

## Highly Accelerated Lifetime Testing of Multilayer Ceramic Capacitors

**Ravi Lin**, Materials Science; Rishabh Kundu, Department of Materials Science and Engineering; Alp Sehirlioglu, Department of Materials Science and Engineering

There are hundreds to thousands of multilayer ceramic capacitors (MLCCs) in the electronic devices that we use every day. They have a variety of purposes like filtering signals, storing charge, and as parts of sensors. MLCCs make up a more than 20 billion dollar industry, which is expected to triple within the next 5 years. There is a need for MLCCs with thinner layers and better volumetric capacitance that are able to withstand higher temperatures and voltages, which increases the likelihood of early failure in these devices. However, component failure is highly unpredictable and MLCC lifetimes are not well known. Therefore, the lifetime and reliability of MLCCs must be studied in order to better predict their performance and elucidate on their failure mechanisms. This project tests the reliability of X5R type ceramic capacitors in both conventional and novel procedures for Highly Accelerated Lifetime Testing (HALT) using an aixHALT (manufactured by aixACCT GmbH, Germany) instrument. The effects of overvoltage on the lifetime of capacitors with different rated voltage limits will be determined. The goal of this project is to discover signals that indicate upcoming early failure and predict the lifetime of MLCCs. This testing procedure will be coupled with data analysis methods to determine the lifetime under real-use conditions. This project would test the legitimacy of HALT as a predictor of device lifetime while also creating a framework for similar experiments in the future.

Faculty Advisor: Alp Sehirlioglu, Department of Materials Science and Engineering, CWRU

## An MILP-Based Wide-Reach Classification Approach for Red and White Wine Quality Prediction

**Ricky Lin,** Computer Science; **Oliver Yuan**, Computer Science; Daneil Lin, Department of Computer and Data Sciences, Case School of Engineering

In many classification tasks, it is crucial that positive predictions are highly reliable. This is particularly important in unbalanced binary classification problems, where false positives—incorrectly identifying something as positive—vastly outnumber true positives. These situations often arise in applications like record matching, entity matching, and junk mail filtering, where precision is critical to avoid costly mistakes. To manage this, a precision constraint is applied, which ensures that positive classifications are accurate but limits the model's ability to find as many true positives as possible (the "reach").

Previously, Prof. Vincenzo Liberatore formulated this classification problem with a precision constraint as a Mixed-Integer Linear Programming (MILP) problem. In this formulation, the goal is to maximize the number of true positives (reach) while maintaining high precision. The MILP model finds optimal solutions by making binary decisions for each sample during the training process. While using fractional variables would simplify the problem, it tends to lead to overfitting when there are outliers or noise in the training data.

Despite its effectiveness in some cases, this model performs inconsistently across different datasets. One notable example is the stark difference in performance between two datasets with the same features: red wine and white wine. The model trains efficiently on the red wine data but struggles with the white wine data, even though the datasets are quite similar.

In this project, we aim to explore the reasons behind this inconsistency. We have formulated several hypotheses and will test them to better understand the model’s behavior and improve its performance across different datasets. By the end of this project, we hope to provide clear answers and potential improvements to the MILP-based classification model.

Faculty Project Mentor: Vincenzo Liberatore, Department of Computer and Data Sciences, Case School of Engineering

Capstone Instructor: Shuai Xu,Department of Computer and Data Sciences, Case School of Engineering

**Edge-Aware Signal Coupling Graph Neural Networks for Seizure Detection**

**Leonora Lipson**, Applied Mathematics; Catherine Jayapandian, PhD, Department of Computer and Data Sciences; Katrina Prantzalos, MS, Department of Population and Quantitative Health Sciences; Saeideh Salehizadeh MD, Department of Neurology; Suraj Thyagaraj PhD, Department of Neurology; Guadalupe Fernandez-BacaVaca, MD, Department of Neurology; Satya S. Sahoo, PhD, Department of Population and Quantitative Health Sciences

Intracranial EEG (iEEG) is routinely used for pre-surgical evaluation of refractory epilepsy patients; however, identification of ictal activity is a labor-intensive process involving expert review of EEG recordings. Graph neural networks (GNNs), representing electrodes as nodes and signal coupling as edges, are an intuitive approach for classification of ictal and interictal activity using iEEG data modeled as graphs. We evaluate three GNN architectures: graph convolutional networks (GCNs), graph isomorphism networks (GINs), and GINs with edge attributes (GINEs) for ictal and interictal classification of iEEG data. Although GCNs and GINs applied to iEEG have shown some success, they ignore pertinent signal coupling information. This is the first study applying GINEs (which preserve critical signal coupling information) to iEEG for ictal and interictal classification. Using iEEG from 20 epilepsy patients, GINE consistently outperformed other models, highlighting the potential of GNNs leveraging edge weights and motivating development of tailored methods for iEEG analysis.

Faculty Project Mentor: Professor Satya Sahoo, Department of Population and Quantitative Health Sciences, Case Western Reserve University School of Medicine

Capstone Instructor: Professor Erkki Somersalo, Department of Mathematics, Applied Mathematics and Statistics, Case Western Reserve University College of Arts and Sciences

## Impact of School-Based Intervention Programs on School Violence and Student Outcomes

**Abra Lisowski**, Sociology

When a student makes a threat of violence or harm to other students, it is often up to the school to intervene and determine appropriate measures to take to ensure everyone's safety while also handing out appropriate discipline. Since the 1990s, schools have often employed zero tolerance policies to handle disciplinary measures, however there is growing concern about whether those policies do more harm than good. The purpose of this research is to better understand and implement interventions that serve as alternatives to zero tolerance policies, specifically the Multi-Tiered System of Support (MTSS) framework and the Comprehensive School Threat Assessment Guideline (CSTAG). This research was conducted in the form of a narrative literature review, examining the integration and effectiveness of these policies in middle and high schools in the United States. The key findings indicate that alternative policies that focus on restorative practices that seek to meet the needs of the students who make threats of harm show promising results for student outcomes. These findings are significant for school districts looking to implement policy level changes in their disciplinary proceedings to better support students.

Faculty Project Mentor: Sharon Milligan, Department of Anthropology

Capstone Instructor: Sharon Milligan, Department of Anthropology

## 3D Printed Electrodialysis Setup for Analyzing Cation-Cation Selectivity in Commercial Ion Exchange Membranes

**Edward Liu**, Department of Chemical Engineering

Currently, solvent extraction stands as the dominant method for separating rare earth metals at high purities. Many of the solvents in this process – volatile, toxic, and non-reusable organics – require energy intensive properties for production, contributing significantly to $CO_2$ emissions. Recently, electrodialysis has developed as a sustainable alternative for these metal recoveries: offering a scalable, continuous and renewable energy replacement to solvent extraction. In general, the ion-exchange membranes used in electrodialysis have high selectivity between positive and negatively charged ions, but struggle to achieve selectivity between cations. This challenge is the main limitation preventing the application of electrodialysis to rare earth metal recovery.

This study aims to investigate how the cation-cation selectivity of commercial cation exchange membranes between $Na^+$ and $Ca^{2+}$ is impacted by applied potentials. Custom 4-cell and 2-cell chambers were printed using Grey V5 resin (Formlabs) in a Form 4 3D printer for a bench electrodialysis system and diffusion cell, respectively. The cation exchange membrane studied was CXM-200 membrane (Membrane International), with the AXM-100 (Membrane International) anion exchange membrane used to complete the electrodialysis system. Constant current conditions were applied ranging from 0 to 1.5 mA (Biologic Potentiostat) and the voltage drop across the cation exchange membrane was recorded over time.

As $Ca^{2+}$ partitions more strongly than $Na^+$ into CXM-200 due to its higher valence charge, increasing the potential drop across the membrane should decrease $Na^+/Ca^{2+}$ selectivity as electromigration begins to outweigh partitioning. Experimental data was collected and compared to the theoretical transport predicted by the Nernst-Planck equation, where the theoretical decrease in selectivity should be by a factor of two due to the ratio of valence charges.

Faculty Project Mentor: Dr. Christine Duval, Department of Chemical Engineering

## Disparities in Choline Nutrition in Preterm Infants

**Gloria Liu** (B.A. Biology & B.S. Finance Candidate), Mrinaj Janampalli, Deborah Gakpo, Dr. Cynthia F. Bearer; Department of Pediatrics, CWRU School of Medicine

Choline is an essential nutrient responsible for metabolic pathways involving acetylcholine, betaine, phosphatidylcholine, and sphingomyelin. For preterm infants, these metabolites are key to neurological development, and low choline levels could increase the risk of developing structural abnormalities. Maternal nutritional supplements often do not have choline, and the primary source of choline is from the diet. Therefore, choline intake may be affected by a range of social determinants of health such as socioeconomic status, ethnicity, environmental exposures, and access to prenatal care. As such, it is important to analyze relationships between levels of key nutrients and non-medical factors, namely the relationship between choline levels and ethnicity. In a prior study of 176 term and preterm infants, the median cord plasma choline concentration at birth was 41.4 μmol/L, with a 25th-75th percentile of 31.8-51.2 μmol/L. In this study, we sought to determine whether preterm babies are choline sufficient and if choline concentrations are dependent on ethnicity. Twenty-six first drawn blood samples from preterm infants of 24-28 weeks gestational age (GA) (11 African American (AA) and 15 White) were collected. The median of choline concentrations for the AA infants of 18.7 μmol/L was similar to that of the White infants (20.7 μmol/L). While there was no significant difference between the choline concentrations of the White infants compared to the AA infants, it is noteworthy that the choline concentrations of all AA infants were less than 41.4 μmol/L, a trend suggesting that AA preterm infants may be more at risk for choline deficiency and that ethnicity may influence choline levels. Additionally, most preterm infants had choline concentrations substantially lower than 41.4 μmol/L, indicating a need to further explore the significance of choline concentrations in preterm infants.

Faculty Project Mentor: Dr. Cynthia F. Bearer, Department of Pediatrics, Case Western Reserve University School of Medicine

## A Review of Anxiety Interventions for Individuals with Developmental Disabilities

**Benjamin Lobas**, Psychology

Developmental disability (DD) is a broad and complicated section of disorders boasting prevalence rates near 16%. Despite its prevalence throughout the world, sections of this population have largely been neglected in terms of care and research, particularly for those with more severe cases and comorbidities. Given the communication and introspective issues that come with many developmental disorders, individuals that have comorbid anxiety, with near 30% prevalence rate among US adolescents, may struggle to seek care or achieve remission. As such, this review seeks to conglomerate the active literature on the intersection of DD and anxiety to elucidate potential effective treatments. The PsycInfo database was used to locate relevant articles. Using keywords developmental disabilities, anxiety, comorbidity, intervention, intellectual disabilities, and prevalence, 11 articles were collected for the review. From the results, a prevalent methodology was the use of cognitive behavioral therapy and preparative approach to managing anxiety. CBT is effective as it allows therapists to meet the client at whatever level they are at and make adjustments as needed. However, many of the articles have participants with selective mutism or other communication disorders but then made little effort to accommodate. This trend brings up a larger issue in the study of DD in that few researchers take the time or effort to study these conditions in their more severe or profound cases. Furthermore, extra steps such as communication boards and other aids for all stages of developmental disorders should be made commonplace in treatment to expand accessibility.

Capstone Instructor: Amy Przeworski Department of Psychological Sciences

## Investigating the Fluorescence Properties of Indocyanine Green

**Simone Monteiro**, Chemical Biology and Biology; **Zoey Lockwood**, Department of Chemistry

Indocyanine green (ICG) is a near-infrared dye with biomedical applications, specifically in imaging and diagnosis. The fluorescence quantum yield (FQY) of ICG has shown to be influenced by various solvent properties, such as water content, viscosity, and polarity. However, the effects of these solvent properties on ICG fluorescence are relatively unknown. Understanding how variations in these conditions affect the FQY of ICG can provide insight into how biomedical imaging via ICG may change throughout the dynamic biological environment. In the water series, we found that as the concentration of water in methanol increased, the FQY of ICG exhibited a linear decrease. In previous studies, ICG has shown instability in aqueous solutions due to induced H-aggregation and degradation, which remains consistent with our results. For the viscosity series, we observed a direct relationship between viscosity and FQY. By increasing viscosity via increasing glycerol concentration in methanol, the electrons of ICG's conjugated system were better able to delocalize, leading to a strengthened FQY measurement. In the polarity series, we found that ICG exhibited decreased FQY measurements as polarity increased. When solvent polarity is decreased, ICG is more likely to present a planar conformation, which in turn, would increase FQY. However, increased solvent polarity induces solvation effects, leading to intramolecular rotation and decreased FQY. Our goal in this comprehensive study was to explore how ICG's fluorescence can be impacted by its environment as it is used in the human body and provide insight as to how we may be able to optimize its diagnostic and therapeutic applications in the biomedical field. One potential application of ICG may be in photothermal therapy by attaching it to gold nanoparticles and observing its effects through laser studies.

Project Mentor: Dr. Clemens Burda, Department of Chemistry

**Detecting Seizure Propagation Both in Cortical and Subcortical Structures in a 4-Aminopyridine-Induced Rat Model**

**Sid Lokam,** Neuroscience, CAS - College of Arts & Sciences

Status epilepticus (SE) is a critical neurological condition characterized by prolonged or recurrent seizures, leading to significant brain damage, with its origins typically attributed to the brain's gray matter. While much research has concentrated on the cortex, particularly the primary motor cortex (M1), seizure activity within white matter remains less clear. This study investigates 4-Aminopyridine (4-AP) induced seizure activity, demonstrating its presence in both gray and white matter, specifically the corpus callosum. Using an in vivo rat model, the experiment involved the stereotaxic implantation of four electrodes: two in the primary motor cortex (M1) on both the ipsilateral and contralateral sides, and two in the corpus callosum, also ipsilateral and contralateral. Seizures were induced in the cortical region through targeted delivery of 4-AP. Neural signals were recorded using LabChart and subsequently analyzed in MATLAB to determine trends in root mean square (RMS) and power spectral density (PSD). Data has shown that although the seizures were induced in the motor cortex, they were also observed in the corpus callosum. This suggests that there is a propagation of the epileptic activity from the gray to the white matter. In addition, a gradual build-up of signal amplitude in the corpus callosum before the seizures was detected, indicating potential pre-seizure activity in the white matter. On average, the seizures lasted about 2 minutes and occurred about 2-3 times per hour. These findings may expand our understanding of seizure networks beyond the gray matter, potentially leading to new diagnostic tools, early warning systems, or targeted stimulation therapies designed to intervene before a seizure fully develops.

Project Mentor: Dominique Durand, Department of Biomedical Engineering
Capstone Mentor: Ashley Nemes, Department of Neurosciences

**The Role of Periodontitis in Oral Squamous Cell Carcinoma: A Literature Review on Microbial Dysbiosis and Immune Modulation**

**Jeanine Longo,** Biology major, Department of Biology, Case Western Reserve University

Oral squamous cell carcinoma (OSCC) is a fatal disease where periodontitis has emerged as a significant risk factor. This review presents data showing that periodontitis promotes OSCC through oral microbiota dysbiosis, chronic inflammation, and immune modulation. The dominance of *Porphyromonas* species and activation of IL-17+ γδ T cells drive OSCC proliferation via the IL-17/STAT3 pathway, while M2 tumor-associated macrophages (TAMs) contribute to immunosuppression. Other biological pathways, such as the PI3K/AKT/mTOR and NF-κB pathways, along with others, are also crucial in understanding the various mechanisms through which periodontitis can contribute to cancer development. A case-control study found that 72.1% of OSCC patients had stage 4 periodontitis, highlighting a strong correlation. Additionally, tobacco use, alcohol consumption, age, and socioeconomic status may further increase OSCC risk. Epidemiological data suggest that periodontal treatment reduces cancer susceptibility, emphasizing periodontal health as a modifiable risk factor and a potential target for OSCC prevention

Project Mentor: Dr. Nancy Dilulio, Department of Biology, Case Western Reserve University

## The Role of Myeloid Cells in The Conditioning Lesion Response

**Collin Lorenzen**, Neuroscience

Accelerating nerve regeneration remains of exceeding significance with important medical consequences. Currently, one means of acceleration is the in vivo conditioning lesion response, whereby a preceding, conditioning injury accelerates the recovery of a subsequent lesion. There is evidence that myeloid cells, e.g. macrophages and/or neutrophils, are involved in the response to conditioning lesions. Using a transgenic mouse that expresses a thymidine kinase suicide gene on a CD11b myeloid promoter, this experiment explores the connection of macrophages and neutrophils to this mechanism. When exposed to treatments of ganciclovir, these genes activate a cell death mechanism in CD11b+ myeloid cells. This allows for an investigation and analysis of regenerating axons through the role macrophages and neutrophils play in the conditioning response mechanism. This model was first validated in the work of Barrette et al. 2008, who used the mouse model to demonstrate a failure of peripheral nerve regeneration under ganciclovir conditions. After rederivation, we found a likewise decrease in macrophages and neutrophils under control settings of sham and crush operations. Additionally, a reduction in remyelination clearance was witnessed in ganciclovir treated groups after injury. Cumulatively, these results demonstrate the effectiveness of this mouse model for determining the role of myeloid cells in peripheral nerve regeneration, and we are currently investigating the role of these cells in the conditioning lesion response.

Faculty Mentor: Richard Zigmond, Department of Neurosciences

Capstone Instructor: Ashley Nemes-Baran, Department of Neurosciences

**Effects of Anti-Inflammatory Drug Delivery from Mechanically-Adaptive Neural Probes on Neuroinflammation**

**Isabella S. Lugo Surís**, Department of Neuroscience, Case Western Reserve University Mali Ya Mungu Ocoko, Advanced Platform Technology (APT) Center, Louis Stokes Cleveland VA Medical Center, Hoda Amani Hamedani, Department of Biomedical Engineering, Case Western Reserve University, Jeffrey Capadona, Allison Hess-Dunning, Department of Materials Science and Engineering, Case Western Reserve University

Intracortical microelectrodes (IMEs) are devices that can be used to record neuronal activity or stimulate nearby neurons, with one application in BMIs for the recording of activity from small groups of neurons in specific brain regions. However, IMEs face challenges in long-term reliability, with neuroinflammation induced by IME implantation considered a main contributor to IME failure. Neuroinflammation, exacerbated by mechanical mismatch and insertion damage of the IME, leads to oxidative stress, neuronal death, and probe encapsulation by the glial scar. Our approach for mitigating the neuroinflammatory response targets alleviating mechanical mismatch with a mechanically-adaptive implant and insertion damage through local anti-inflammatory delivery.

In this study, we investigated a mechanically-adaptive polymer nanocomposite (NC) integrated with nanotubes loaded with dexamethasone (DEX) for sustained local release. We hypothesized that local DEX administration would reduce IME-induced neuroinflammation. The NC transitions from a stiff to compliant state in response to water absorption and physiological temperatures. Titania nanotube arrays (TNAs), ordered nanostructured tubes capable of holding and releasing pharmacological substances, were integrated onto the NC surface to enable sustained DEX delivery. Two groups with five mice each were implanted with TNA-NC probes: one with empty TNAs and the other with DEX-loaded TNAs, for 2 or 4 weeks. To characterize the biological response, we performed differential gene analysis using a custom 152 gene panel focused on neuronal function and neuroinflammation. Comparing both time points, we observed a decrease in common differentially expressed genes and more unique differentially expressed genes in the DEX-loaded group at 4 weeks. This study explores an alternative approach to reducing neuroinflammation with the aim of improving long-term IME reliability by combining a mechanically-adaptive polymer nanocomposite with DEX-loaded TNAs.

Project Mentor: Dr. Allison Hess-Dunning, Department of Biomedical Engineering & Advanced Platform Technology Center, Louis Stokes Cleveland VA Medical Center

Capstone Mentor: Dr. Ashley Nemes, Department of Neurosciences

**Iron binding Capabilities of Catechol-Containing Polyphenols and Phenolic Acids**

**Abigail C. Luthern,** Department of Chemistry, Case Western Reserve University; Terra Marie M. Jouaneh, Josiah J. Morison, Riley D. Kirk; Jodi L. Camberg and Matthew J. Bertin, Department of Chemistry, Case Western Reserve University.

Urinary tract infections are caused by *Escherichia coli*, and UTIs affect between 50 to 70% of women at some point in their lifetimes. Preliminary data suggest that certain plant polyphenols and phenolic acids are effective in reversing quiescence for recurrent urinary tract infection (UTI)-causing *Escherichia coli*. The purpose of this project was to determine whether the catechol moiety present in the more effective quiescent reversal compounds was due to the compound's ability to bind iron. Iron is a necessary nutrient for *E. coli* to survive and grow, so compounds that bind to iron in the bacteria's environment could be a way to reverse the bacteria's quiescent state. This is important as bacteria cannot be treated with antibiotics within the quiescent state, so reversal is required for thorough treatment and to prevent recurrent infection. The experiment was split into two parts: the first intended to confirm the catechol moiety as essential to iron-binding and the second to observe the relative abilities of the plant polyphenols to bind iron. The aforementioned first part of the experiment consisted of a UV comparison of phenylalanine, tyrosine, and levodopa when the compounds were in solution with iron. There was an obvious UV shift for the levodopa-iron complex, but none for the phenylalanine and tyrosine, confirming the catechol moiety was a contributing factor to the plant compound's ability to bind iron. The second portion of the experiment utilized a liquid chrome azurol S (CAS) assay to examine the relative siderophore activity in the plant compounds that were most successful in reversing quiescence in preliminary research. The CAS assay provided data to support a linear relationship between quiescence reversal activity and siderophore activity, suggesting iron-binding as a potential mechanism to reverse quiescence in UTI-causing *E. coli*.

Faculty Mentor and Capstone Instructor: Matthew J. Bertin, Chemistry, CWRU

**Frazzled and E-Cadherin Regulate Decapentaplegic Signaling by Modulating Cell Adhesion and Proteolytic Processing in *D. melanogaster***

**Collin Lyndaker**, Biology

Morphogenetic gradients determine body plans by informing cells about their positions along embryonic axes. The Decapentaplegic (DPP)/Bone Morphogenetic Protein (BMP) secreted protein forms a dorso-ventral gradient that separates epidermis from neuroectoderm. Our lab identified Frazzled (FRA), a transmembrane receptor involved in axon guidance and morphogenesis, and E-cadherin (ECAD), an epithelial cell adhesion protein, as novel regulators of DPP. DPP attracts cells towards its peak levels in the dorsal midline by increasing adhesivity and constriction of dorsal-most cells, a process mediated by the maintenance of high ECAD levels at adherens junctions by FRA. Interestingly, the resulting higher cell density packing modulates the shape of the DPP gradient, but the mechanisms by which FRA and ECAD increase DPP signaling are unknown. FRA and ECAD are processed by Presinilin (PSN), suggesting that FRA stabilizes ECAD in the membrane by diverting excessive cleavage of ECAD by PSN. We show that loss of PSN increases cell constriction, whereas preventing FRA cleavage by PSN decreases cell constriction. These results confirm that lowering FRA and ECAD cleavage enhances cell adhesivity and that FRA has a protective role over ECAD cleavage. We next analyzed FRA cleavage products distribution in wildtype and mutant embryos with altered FRA cleavage. We expressed a FRA-GFP fusion protein that labels the FRA extracellular domain (ECD) and used an anti-FRA antibody that recognizes the intracellular domain (ICD). We show distinct distributions of processed FRA: FRA-ICD is detected in adherens junctions and the cell nucleus, whereas FRA-ECD is exclusively apical. The full-length protein appears to be located basally, and at low levels in apical junctions. The apical accumulation of FRA-ECD suggests binding to other proteins that may enhance DPP signal reception and/or receptor activation, since loss of FRA reduces DPP signaling, while increase of apical extracellular FRA in PSN mutants enhances DPP signaling.

Faculty Mentor: Claudia Mieko Mizutani, Department of Biology

**The Role of Culture in Shaping the Psychological Effects of Parentification**

**Cassidy Lyninger,** Psychology, CAS - College of Arts & Sciences

The healthy development of a child relies on sensitive and suitable parenting. A lack of proper care can have long-lasting negative effects. Parentification refers to when an adolescent reverses roles with their parents, taking on the responsibilities associated with a care-giver. Much research has supported the generalization that parentification has enduring negative consequences. Parentification has shown to lead to increased levels of anxiety and depression, reduced self-esteem, and encourages risky behavior such as substance abuse. Recently, research has shown that negative effects are not the only results of parentification, especially for those raised in a collectivist culture. The purpose of this narrative review is to examine the relationship between culture and the psychological impact of parentification. Scholarly search engines such as GoogleScholar, PubMed, Scopus, and PsycINFO were used with keywords such as: parentification, role reversal, immigrant families, communal parenting, and culture. Collectively, findings indicate that the expected negative effects of parentification are more likely to occur in an individualistic culture. However, key support mechanisms embedded in collectivist cultures mitigate and protect adolescents from the negative effects of parentification. Those in a collectivist culture who experienced parentification describe stronger parent-child bonds, higher resilience, and a better ability to cope with stress. Implications of these findings support the importance of social support, cultural values, and social role flexibility in mitigating adverse psychological effects of parentification. Mental health professionals should take a balanced approach that is culturally sensitive when assessing and treating individuals who were subject to parentification.

Faculty Sponsor: Anastasia Dimitropoulos, Department of Psychological Sciences

**From Data to Playlist: Mathematics Behind Music Recommendations**

**Tina Ma**, Applied Mathematics and Music

With the rapid growth of digital media, music streaming platforms have become a primary way people access music. According to the International Federation of the Phonographic Industry, approximately 67% of global music listeners prefer some form of music streaming service. Platforms such as Spotify, Apple Music, and YouTube Music are widely popular for music consumption. While these platforms offer a great amount of music, they also want to generate new ways to enhance user experience and improve music explorations. One of the creative processes is to generate personalized recommendation playlists for users. This capstone project explores the mathematics behind the recommendation system, especially the implementation of collaborative filtering. This is a widely adopted method that predicts user preferences based on past interactions and the behaviors of similar users. The purpose is to understand the method by applying different approaches and evaluate the effectiveness of collaborative filtering in music recommendations. By using real-world music data from streaming platforms, we can achieve both user-based and item-based collaborative filtering approaches. The whole process involves data preprocessing, algorithm development, and performance evaluation. The algorithm employs matrix decomposition and approximations using Singular Value Decomposition (SVD) to assess data performance in Python. By analyzing system behavior and comparing filtering approaches, this project aims to find the strengths and limitations of collaborative filtering and identify a better approach for recommendation accuracy. The insights from this project are valuable to the broader field of machine learning in digital media. By learning recommendation algorithms, this research illustrates how digital platforms generate playlists and improve user experience while addressing practical challenges faced by developers. Future work may explore other recommendation models or incorporate other data types to further enhance recommendation performance.

Faculty Mentor: Sakshi Arya, Department of Mathematics, Applied Mathematics, and Statistics

**Injury-Dependent Intrinsic Neurite Growth Properties of Neurons Within the DRG**

**Anastasia Malyshkina**, Margaret Pinkevitch, Brian Balog, Richard Zigmond

Injury-dependent neurite growth has previously been characterized in nociceptive neurons expressing CGRP (peptidergic) and IB4 (nonpeptidergic) within the dorsal root ganglia (DRG). The previous experiments indicated that there was little to no neurite growth following a conditioning lesion. However, it is also known that both CGRP and IB4 expression are downregulated after injury. Therefore, looking at other markers that colocalize within these neurons, such as MrgD, is necessary to visualize whether or not these neurons within the DRG do experience neurite growth after injury. To further characterize the neurons within the DRG, other markers can be visualized and analyzed for neurite growth. CGRP+ neurons have been determined to likely not have any intrinsic neurite growth properties with both direct CGRP visualization as well as a TdTomato line. However, IB4+ neurons experience a more heterogeneous response. MrgD+ neurons, which colocalize with ~80% of IB4+ neurons experience neurite growth after injury. Proprioceptive neurons were also characterized through the TrkC marker—they also experience neurite growth after injury.

Faculty Project Mentor: Richard Zigmond, Department of Neurosciences, School of Medicine

Capstone Instructor: Ashley Nemes, Department of Neurosciences, School of Medicine

## Minimizing Cytotoxicity in Leukemia Treatment with Differentiation-Based Therapies

**Remuna Marti**, Neuroscience

Standard treatments for leukemias activate apoptosis (cytotoxicity) in both malignant and normal cells, causing significant short- and long-term toxicities to patients. Unfortunately, these treatments also select for apoptosis-resistant leukemia cells that drive relapse and death. Therefore, there is a need for new treatments that do not rely on the apoptosis pathway and preserve normal proliferating cells. Epigenetic therapies, such as decitabine and 5-azacytidine, function by depleting DNA methyltransferase 1 (DNMT1), promoting cancer cell differentiation and cell cycle exit. However, resistance to these hypomethylating agents can develop in leukemia cells, particularly in those with alterations in DNA methylation or pyrimidine metabolism, limiting their effectiveness. To investigate alternatives, our lab has identified compounds that induce leukemia cells to undergo lineage maturation, effectively halting their growth without requiring the apoptosis program and without causing toxicity to normal proliferating cells. Two small molecules are under evaluation: CCF101 and teriflunomide. CCF101 is a first-in-class inhibitor of the ISWI and CHD family of epigenetic enzymes, discovered in the laboratory. While it effectively terminated the growth of some leukemia cells, it was ineffective against those resistant to standard hypomethylating agents. In contrast, teriflunomide, an inhibitor of the pyrimidine metabolism enzyme dihydroorotate dehydrogenase (DHODH), successfully terminated the growth of leukemia cells resistant to hypomethylating agents. Further experiments are underway to investigate the molecular mechanisms underlying these effects. Characterizing these mechanisms could lead to the development of more effective and less toxic treatments for leukemia.

Project Mentor: Dr. Yogen Saunthararajah, Department of Hematology and Oncology
Capstone Mentor: Dr. David Friel, Department of Neurosciences

**The Unmet Needs of Caregivers of Individuals Living with Alzheimer's and Dementia-Related Disorders in a Care Facility**

**Paris Martin,** Nursing; Samantha DeSimio, Frances Payne Bolton School of Nursing, Cleveland State University; Siobhan Aaron, Frances Payne Bolton School of Nursing

**Purpose:**
Informal caregivers of individuals living with Alzheimer's Disease and Related Disorders (ADRD) who reside in a care facility were asked to participate in a study aiming to explore their lived experiences comprehensively. This study aimed to examine the experiences of informal caregivers and receive feedback on caregiver support services that could be beneficial as their loved one is losing their independence due to the nature of the illness.
**Methods:**
Snowball sampling was utilized to recruit participants for this study. Study eligibility included those older than 25 years old, present or former unpaid caregivers of those living with ADRD who resided in nursing homes within the last 5 years, and with the ability to speak, read, and comprehend English. Data collection took place during the semi-structured interviews on a HIPAA-compliant Zoom. This study utilized a descriptive, qualitative design. Additionally, survey measurements were administered to measure caregiver stress levels and depression.
**Results:**
Six caregiver interviews are included in this subanalysis. Interviews of caregivers revealed that frequently reported unmet needs of these individuals were - stress associated with increased physical demands, a lack of resources (educational, financial, social, and medical), an increase in anxiety, uncertainty of care, and the financial burdens of a loved one were the most common unmet needs of the caregivers. Moreover, caregivers expressed concern about their loved ones experiencing feelings of isolation as they underwent significant lifestyle changes and transitioned into a care facility.
**Implications:**
The transition period often left caregivers feeling alone and unsupported, highlighting a gap in available resources. Others shared that they struggled to find adequate resources to support their coping during the transition. Results suggest that caregiver strain can be eased through a supportive framework surrounding the care transition, encompassing emotional peer support groups, informational clarity, and transitional care resources.

Project Mentor: Siobhan Aaron, Frances Payne Bolton School of Nursing

**Bridging the Gap: School Transitions for Bilingual Students Following Traumatic Brain Injury**

**Jocelyn Martinez,** Cognitive Science and Communication Sciences

Traumatic brain injury (TBI) can significantly affect a student's academic journey, particularly in the critical process of transition back to school. Language development, executive functioning, and academic performance can be interrupted, with outcomes depending on a student's age, injury severity, and linguistic background. While previous research has focused on the educational impact of TBI on monolingual students, little is known about how bilingual students navigate during this transition. Bilingualism presents unique cognitive and linguistic demands, which can influence both the nature of the impairment and the pace of recovery. The aim of this project is to bridge that gap, contributing to the variety of existing research on the experience of bilingual students and their families. In this manner, it contributes to a larger knowledge base within the field of Speech-Language Pathology and informs future educators and clinicians on how to better support linguistically diverse students.

This study includes a qualitative and quantitative analysis of eight bilingual students with TBI and their monolingual counterparts (with one lacking a matched pair due to age of injury). Using data extracted from REDCap and Box, we examined academic and cognitive performance data, including: school absences, difficulties with assignments, and executive functioning struggles, as well as parent and student interview data. Thematic coding was used to determine patterns of school reintegration, academic struggles, and parental concerns. The findings suggest that while many of the bilingual students were able to maintain academic performance post-TBI, they often faced challenges that were less visible, such as: executive functioning difficulties and emotional struggles. Compared to their monolingual peers, bilingual students may require more personalized and culturally responsive accommodations that address both cognitive recovery and linguistic demands.

Faculty Mentor: Angela Ciccia, Department of Communication Sciences

## Metabolite Based Reprogramming of Human Immune Cells

**Anna E. Mathis**, Case Western Reserve University, Department of Biomedical Engineering; Srivatsan J. Swaminathan, Arizona State University, School of Life Sciences; Joel P. Joseph, Indian Institute of Science, Department of Bioengineering; Abhinav P. Acharya, Case Western Reserve University, Department of Biomedical Engineering

Methylmalonic Acid (MMA) is a known immuno-suppressant that has been found to induce CD8+ T cell exhaustion (Joanne D. Tejero, et. al.). We are investigating the influence of MMA on CD3+ T cell populations, and seek to establish the effect of long-term MMA release from MMA-based polymers. These polymers could act as therapeutics for inflammatory and autoimmune disease via injection or implant, ensuring a gradual release of MMA from the designed polymer to avoid repetitive treatments.

For this study, blood was obtained from healthy donors from which T cells and dendritic cells were isolated and separately plated. The cells were then exposed to the treatments of free MMA, 1,4 butanediol (free diol), and the MMA polymer synthesized using MMA and 1,4 butanediol. After a set incubation period, the cells were all treated with their respective activation agents. The cells were then stained for activation markers to determine the effect of the MMA polymer on immune cell activation.

From the results, we can conclude that MMA is effective in inhibiting the expression of the CD69 early activation marker due to the decrease in CD69 expression levels in helper T cells as the concentration of the free MMA treatment increases. Additionally, CD86, a proinflammatory marker, was significantly downregulated in dendritic cells treated with free MMA.

Principal Investigator: Abhinav P. Acharya, Department of Biomedical Engineering, Case Western Reserve University

## The Evolution of Human Sexual Dimorphism

**Maura McDonald**, Anthropology and Natural Sciences

Sexual dimorphism, which is the differences between the males and females of a species, is a widely studied phenomenon in anthropology. This paper explores the evolution of sexual dimorphism in humans, focusing primarily on secondary sexual characteristics such as body size, skeletal structure, and craniofacial features. By comparing human sexual dimorphism to that of non-human primates, particularly gorillas and chimpanzees, this study highlights patterns of male-male competition, reproductive strategies, and social structures that have resulted in these differences. Fossil evidence suggests that most early hominins exhibited higher levels of sexual dimorphism than modern humans, with various theories as to the reductions over time potentially being linked to shifts in mating systems, cooperative breeding, and the demands of childbirth. Theories explaining this reduction include the transition to increased monogamy and the evolutionary necessity of female body enlargement to account for larger-brained offspring. Understanding the evolution of sexual dimorphism provides insight into human social structures, reproductive behaviors, and evolutionary pressures that have shaped our species and influence many aspects of human life today.

Faculty Mentor: Dr. Lawrence Greksa, Department of Anthropology

## Design Of An In-Line Self-Powered Temperature Sensing Display

**Oliver Meisel**, Department of Mechanical and Aerospace Engineering; **Matthew Wenger**, Department of Mechanical and Aerospace Engineering; **Robert Yoon**, Department of Mechanical and Aerospace Engineering

Hot and unregulated water temperatures can create uncomfortable and potentially dangerous environments. Real-time access to accurate water temperature data enhances safety and ease of use in everyday applications like showering and handwashing. This project presents the design and fabrication of a self-powered, in-line temperature sensing retrofit for household water systems, primarily targeting showers and sinks. The device integrates into standard plumbing by attaching between existing pipes and outlets. A thermistor embedded in the flow path measures water temperature, with its resistance data processed by a microcontroller to calculate and display real-time temperature on a low-energy 7-segment digital display. Unlike existing solutions that rely on batteries, this design is powered by a miniature Pelton wheel turbine, which captures the kinetic energy of flowing water. A brushed DC motor connected to the turbine acts as a generator, supplying sufficient power to operate the electronics. The internal components are housed in a compact, waterproof 3D-printed PETG enclosure, designed in two sections: one in-line with the water flow to hold the turbine and thermistor, and another perpendicular section that contains the electronics and display for easy visibility. The design includes gaskets and epoxy coatings to protect against water intrusion and prevent structural degradation. The resulting system is low-cost, durable, easy to install, and maintenance-free, offering a practical, scalable solution to enhance water safety and user experience in both residential and commercial settings.

Project Mentor: Majid Rashidi, Department of Mechanical and Aerospace Engineering

Capstone Instructor: Majid Rashidi, Department of Mechanical and Aerospace Engineering

**Radical-Induces Lipid Oxidation Produces Leukotriene-like Agonists in Severe Asthma**

**Abigail Meneses,** Biology B.A.

Cysteinyl leukotriene (CysLT)-like biomolecules, pseudo leukotrienes (øLTs), is produced through radical-induced oxidation of arachidonate in the plasma membrane phospholipids. We developed an ESI-LC-MS/MS method for the detection of øLTs, øLTC, øLTD, and øLTE in human urine in this lab and applied it for the detection of øLTs in the urine of healthy donors and patients with moderate and severe asthma. Patients with severe asthma have 7-fold higher levels of urinary øLTC compared with healthy donors and approximately 4-fold higher levels of øLTD in the urine from people suffering from moderate asthma. We also demonstrated that øLTC levels are a 2-fold increase in the lungs of mice exposed to a known allergen, an extract from house dust mite. Our data show that øLTD and øLTD trigger inflammatory signaling in bronchial epithelial cells, a process that is suppressed by CysLT receptor antagonists. Given their elevated levels in individuals with severe asthma, this offers speculative support that øLTs may play a role in CysLT receptor-mediated inflammation, contributing to pathological effects traditionally attributed solely to genuine cysteinyl leukotrienes. These findings suggest a need to reassess the underlying mechanisms of using CysLT receptor agonists in chronic asthma treatment

Faculty Mentor: Mikhail Linetsky, Department of Chemistry

Capstone Instructor**:** Jean H. Burns, Department of Biology

**Unveiling Asprosin's Role in Pain Modulation: Insights into Inflammatory Pain Mechanisms and Therapeutic Potential**

**Jingzhi Meng,** Neuroscience, CAS - College of Arts & Sciences

Chronic pain remains a major clinical challenge, necessitating novel therapeutic approaches. This study investigates the role of asprosin, a fasting-induced hormone, in inflammatory pain modulation. Using  mice with genetic asprosin deficiency and Ad5-FBN1-treated mice with elevated asprosin levels, we conducted formalin-induced inflammatory pain assays. Our findings demonstrate that asprosin deficiency heightens pain sensitivity, whereas asprosin upregulation mitigates nociceptive behavior. To explore the underlying mechanisms, we knocked out the protein tyrosine phosphatase receptor delta (Ptprd) in basolateral amygdala (BLA) neurons, as Ptprd has been identified as a high-affinity receptor for asprosin in the central nervous system. The BLA was selected due to its well-documented role in integrating affective and sensory pain responses. However, our results revealed no significant impact on inflammatory pain regulation in BLA-specific Ptprd knockout mice, suggesting alternative neuronal pathways may be involved.

Faculty Mentor: Atul Chopra, Genetics and Genome Sciences, MED - School of Medicine

## A Low Cost, Reconfigurable Mould for Prototyping Composite Surfaces

**Ashwin Menon,** Mechanical Engineering

The rapid prototyping of curved surfaces is useful in many industries including motorsports, architecture, and manufacturing. However, the rapid prototyping of curved surfaces from polymers, ceramics, or laminated composites is constrained by the need to create one-off molds through subtractive methods. A mold that can be reconfigured as needed would reduce the time and material costs associated with making curved surfaces. Such technologies exist on the market today, however their cost and size make them out of reach for the everyday engineer. A novel low-cost, modular, reconfigurable mold has been designed, which will enable engineers and makers to prototype curved surfaces quickly while meeting their needs in terms of space and cost. The design consists of 16 pins in an array, covered by a rubber interpolating surface. This design reduces the required actuator and control signal quantity through the use of row-column addressing and a setting-platen. Initial testing demonstrates individual control of pins, system scalability, and the ability to increase pin density.

Faculty Mentor: Majid Rashidi, Mechanical and Aerospace Engineering, ENG - Case School of Engineering

## Mechanical Plastic Bottle Shredder

**Aidan Mercado,** Mechanical Engineering, ENG - Case School of Engineering; **Alexander Schreiter,** Mechanical Engineering, ENG - Case School of Engineering; **Luke Woolley,** Mechanical Engineering, ENG - Case School of Engineering; **Monsour Zaher,** Mechanical Engineering, ENG - Case School of Engineering

The growing demand for plastic recycling, coupled with the rise of 3D printing, has highlighted the need for small-scale, accessible recycling solutions. This project aims to design and fabricate a hand-operated mechanical plastic bottle shredder that enables users to shred used plastic bottles into fine pieces suitable for recycling. Despite not being electric-powered our design will still allow for users to shred plastic bottles without much effort. To achieve this, we selected a single-axle shredder mechanism driven by a crank arm. The device is engineered using a combination of machined metal, wood, and 3D-printed components, utilizing 2D profiles to ease the manufacturing process. The main considerations in our design include torque requirements, user effort, and particle size consistency, with a target shred size of 3-10 mm. Success in this project will be defined by the shredder's efficiency in breaking down plastic, ease of use, and mechanical durability. The final deliverable will be a fully functional prototype that demonstrates the feasibility of manual plastic shredding for personal and small-scale recycling applications.

Faculty Mentor: Majid Rashidi, Mechanical and Aerospace Engineering, ENG - Case School of Engineering

## Locked in and Losing out: Analyzing Noncompete Agreements' Impact on the Healthcare Industry

**Ammar Sulemanjee,** Economics B.A., **George Merrifield,** Accounting B.S.

Our study investigates how banning noncompete agreements (NCAs) in healthcare impacts physician wages. NCAs, which restrict physicians' ability to work for competing employers or start their own practices, are often criticized for suppressing wages and reducing competition. This issue is timely due to the Federal Trade Commission's proposed nationwide ban on NCAs in April 2024, followed by a federal judge's blocking of the ban in August 2024. This legal uncertainty shifts the responsibility for regulating NCAs to individual states. Noncompetes are a particularly significant topic in healthcare, as an estimated 45% of physicians are tied to NCAs by their employers (American Medical Association) Given the fragmented enforcement of NCA regulations across U.S. states, there is a lack of evidence on how varying state-level policies impact physician wages. By examining state-level variations in NCA bans, this study aims to determine the extent to which such bans influence physician wages. Our empirical approach involves a Callaway Sant'anna Difference in Difference model to observe the effects of NCAs across states implementing legislation at different times. Our analysis contributes to the existing literature by utilizing a difference-in-difference approach, a method that is not widely used when studying NCAs. We also use a two-way fixed effects model to improve robustness. Working from cross-sectional panel data from 2003-2023, we focus on five treatment states who implemented physician NCA bans within our data timeframe. We expect the banning of NCAs to cause a statistically significant increase in physician wages by fostering job market competition. This research has implications for legislation in the fragmented U.S. landscape regarding NCAs. By examining state-level regulations, the findings could provide valuable insights into the broader effects of NCA bans on physician wages and the healthcare industry, potentially leading to a more uniform regulatory approach.

Project Mentor: Professor Jenny Hawkins, Department of Economics

## Examining Brain Specificity of Candidate Biomarkers after Traumatic Brain Injury

**Tanishka Mhaskar,** Neuroscience; Dr. Andrew A. Pieper, Department of Neurosciences

Traumatic brain injury (TBI) is a highly prevalent, chronic, and debilitating condition that harms both the brain and peripheral organs. Monitoring the progression of chronic TBI is currently through clinical assessment, which is resource intensive and variable. There is an unmet need for objective and readily measured peripheral biomarkers that could help stage the progression and severity of the various aspects of chronic TBI. Brain-enriched gene expression after TBI has been well studied and provides candidates for serum-based biomarkers reflecting brain damage. Recognizing that chronic TBI also impacts the peripheral system, and any injury can induce aberrant gene expression in organ systems, we are examining whether any brain-enriched genes are also aberrantly expressed in peripheral organs after TBI. This will establish the brain specificity of aberrant expression after TBI, and provide candidate biomarkers for peripheral organ damage in chronic TBI, This study investigates the expression of brain-enriched genes in the liver, kidney, lungs, spleen, heart and whole blood of C57BL/6 mice following a TBI. The organs investigated were chosen due to their impact in immune system regulation, metabolism and various other secondary responses that are known to be highly active after TBI. Specifically, the expression of tau, Neurofilament Light, Glial Fibrillary Acidic Protein and SNAP25 were analyzed to assess their potential as diagnostic biomarkers. Gene expression was conducted by performing western blots to detect biomarker protein levels post tissue collection and extraction of protein from the tissue. By studying the tissue-specific molecular responses, we can establish correlations between peripheral gene expression changes and TBI. These findings may contribute to the development of non-invasive biomarkers for TBI diagnosis and monitoring, which would enhance clinical assessment and treatment. Understanding the systemic impact of TBI in the peripheral organs may also help highlight other potential therapeutics for acute and chronic TBI.

Project Mentor: Dr. Andrew Pieper, Department of Neurosciences

Capstone Mentor: Dr. Ashley Nemes, Department of Neurosciences

## Development of a Rotating 3D Observation Stand for Close-Proximity Space Operations

**Yasmin Michemich,** Mechanical and Aerospace Engineering

Close-proximity space operations require precise observation tools to analyze and simulate mission scenarios effectively. This project focuses on developing a rotating 3D observation stand to enhance the testing and analysis of such operations. The stand is designed to simulate dynamic space environments by integrating a multi-axis rotational system with precision control mechanisms. The research aimed to create a stable and adaptable observation platform that improves real-time visualization for space mission simulations. The design process involved material selection, structural stability analysis, and rotational dynamics optimization. The system incorporates stepper motors for controlled movement along predefined axes and a high-resolution imaging system to capture multi-angle object motion. Initial testing demonstrated successful controlled movement and stability, validating its effectiveness. Future improvements include automation of the control system and increased payload capacity for expanded functionality.

Faculty Project Mentor: Dr. Majid Rashidi, Department of Mechanical and Aerospace Engineering, Case Western Reserve University

## Gossip in Jane Austen and its Influences

**Elizabeth Miller**, Double major in International Studies and English Capstone

In this capstone, I analyze how the theme of gossip is used in romantic literature, specifically by tracing its movement through a novel that influenced Jane Austen (*A Gossip's Story* by Jane West, 1796), then Austen's own works, and then with a novel that was influenced by Austen (*Old Friends and New Fancies* by Sybil G. Brinton, 1914.) I also use secondary sources written by scholars on the topic of gossip in Austen, and incorporate them in my analysis of why gossip is used as a literary device. I focus on the use of gossip to discuss recognized social truths, and how its use changes through the different eras in which these novels were written—in the late 1700s, first quarter of the 1800s, and the early 1900s.

Faculty Mentor: Michael Clune, CWRU English Department

## The Effects of the Soviet Occupation of East Germany from 1945-1949 on German Voting Trends Today

**Elizabeth Miller,** International Studies, CAS - College of Arts & Sciences

Formally, the Soviet occupation of East Germany lasted from May 8, 1945, following the collapse of the Nazi regime, to October 7, 1949, ending with the founding of the German Democratic Republic (GDR) (Tikhomirov 47). Notwithstanding the formal period of occupation, the Soviet Union, and its communist government, still influenced the GDR—specifically the Ministry for State Security (MfS, Stasi)—between 1950-1990. For example, the Soviet KGB provided a model of mental torture methods to the GDR, who then taught these methods to the Stasi, the state security service (Solbrig 4). Additionally, in October and November 1949, the GDR also asked Moscow to supply it with informational materials devoted to Joseph Stalin, the leader of the Soviet Union at the time, which they used to instruct the younger generations in schools and youth groups (Tikhomirov 39). For over four decades, the GDR controlled East Germany, therefore influencing the lives of multiple generations of Germans through propaganda and fear tactics. Today, the eastern part of Germany consists of six states: Brandenburg,

Mecklenburg-Western Pomerania, Saxony, Sachsen-Anhalt, and Thuringia. The Alternative für Deutschland (AfD), a far-right political party, finds most of its support in four of these eastern states—Brandenburg, Saxony, Saxony-Anhalt, and Thuringia—but not much support in the west of the country. I argue that the AfD focuses its party's propaganda towards East Germans, knowing that their memory of being under Stasi and GDR control is still fresh. This memory, which was influenced by the authoritarian and socialist Stalinist Soviet Union, makes them susceptible to believing in AfD's policies which promise a different vision for the future of Germany than the one provided by the center and left parties.

Faculty Project Mentor: Damaris Punales-Alpizar, CAS - College of Arts & Sciences

## Role of Aversive Tones in *Aedes aegypti* Escape Responses

**Frances Miller**, B.S. Neuroscience

*Aedes aegypti* are the most effective disease vector for four of the diseases with the greatest cost to human health over centuries: yellow fever, dengue, chikungunya, and Zika fevers (Powell, 2018). Understanding *Aedes aegypti* is crucial to population-controlling technologies, and their behavior gives insights into threat detection and escape behaviors of many animal species. As blood feeders, *Aedes aegypti* must detect and avoid defensive actions of their blood hosts as well as predation risks by aerial predators. Wynne et al., 2022 found that a looming visual stimulus will initiate an escape response in female *Aedes aegypti* mosquitoes, and Lapshin & Vorontsov, 2018 demonstrated that the audible range 140-200 Hz is repulsive to *Aedes diantaeus* mosquitoes. Our work investigates whether this finding holds true in another member of the genus, *Aedes aegypti.* We have previously observed auditory-evoked wing and head behaviors in response to dynamically changing sound stimuli within several frequency ranges: 100-250 Hz (aversive), 250-350 Hz (neutral, no known ecological significance), and 350-550 Hz (conspecific wingbeat frequencies of females). It is not clear from these findings whether this escape behavior is elicited in response to the frequency of the sound stimulus *per se*, the change in stimulus frequency, or some combination of the two. To determine if the observed wing and head behaviors result from the frequencies themselves, I played pure tones of 180 Hz (aversive), 300 Hz (neutral), 450 Hz (female wingbeat), and 700 Hz (male wingbeat) to a tethered mosquito. I repeated these auditory conditions with a simultaneous looming visual stimulus, and also trialled the looming visual stimulus alone. We show that *Aedes aegypti* respond to pure tone stimuli in the aversive range by modulating their wingbeat amplitude and frequency. We present an analysis of all tested tones, outlining the influence of stimulus frequency, direction, and animal sex.

Faculty Project Mentors : Dr. Gabriella Wolff, Department of Biology, Dr. Michael Rauscher, Department of Biology

## Characterization of the Relationship Between the Vagus Nerves and Sympathetic Trunks in Human Cadavers

**Grace Misiunas,** Psychology

The sympathetic trunks are autonomic nerves on each side of the spine that stretch from the upper cervical region to the coccyx and contain ganglia with preganglionic sympathetic neuronal cell bodies, which drive the body's "fight-or-flight" response. On the contrary, the vagus nerve, the tenth and longest cranial nerve, extends from the brainstem to the abdomen and is known for its role in supplying somatic and parasympathetic fibers to structures in the neck, thorax, and abdomen. Vagus nerve stimulation (VNS) is an FDA-approved treatment for epilepsy and depression, but also shows promising potential for treatment and regulation of many other diseases and injuries. Characterizing the relationship between the vagus nerves and sympathetic trunks may prove useful for furthering use of VNS and limiting its side effects. In this study, left and right vagus nerves and their branches to the sympathetic trunks (V-ST branches), including the superior cervical ganglion, were dissected and enumerated from 46 cadavers and then compared between left and right sides, anatomical landmarks, and across race and sex. Considerable variation was observed for the number of V-ST branches total and on the left and right sides, but communication between the vagus nerve and the sympathetic trunk was observed for all cadavers, most notably in the region superior to the angle of the mandible, indicating either that the vagus nerve may carry sympathetic fibers, the sympathetic trunk may carry parasympathetic fibers, or that both nerves may carry both sympathetic and parasympathetic fibers. Additionally, the mean number of V-ST branches was larger for black cadavers than white cadavers and for males than females.

Principal Investigator: Dr. Andrew Crofton, Department of Anatomy

Project Mentor: Dr. Darin Croft, Department of Biology

## Reconstructing Vagal Anatomy

**Anika Mittal**, Biomedical Engineering, Case Western Reserve University

The vagus nerve transmits sensory and motor information between the brain and major organs and is vital for neural function. Vagus nerve stimulation (VNS) is used to treat various conditions; however, improper device placement can stimulate unintended fibers, leading to side effects such as muscle spasms. To address this, the objective of the REVA project is to develop a comprehensive atlas of the human vagus nerve to guide precise device positioning. This study evaluates the imaging clarity provided by two dyes, DiO and DiI, on segments of the median nerve using 3-dimensional microscopy with ultraviolet surface excitation (3D-MUSE). Each segment underwent different staining protocols: three with DiI for varying durations (2, 4, and 8 hours) and one with DiO for 4 hours. Results indicated that the DiO-stained sample provided the clearest visualization of fascicles, epithelium, and perineurium structures. This suggests DiO's superior efficacy under controlled staining conditions for enhancing neural structure visibility. Findings from this work advance our understanding of nerve anatomy, supporting future VNS applications.

Faculty Project Mentors: Dr. Andrew Shoffstall, Case Western Reserve University, Dr. James Seckler, Biomedical Engineering

## Investigating the Long-Term Patient Outcome Following Neonatal Bypass Surgery

**Marisa Mohapatra**, B.A Psychology, College of Arts and Sciences, Case Western Reserve University

Congenital heart defects are the most frequent birth anomaly, with an occurrence rate close to 1% of all live deliveries. Babies who undergo cardiopulmonary bypass for heart repair can receive large volumes of red blood cells. Transfusion of banked blood may enhance rather than correct deficits in tissue oxygenation, which may lead to organ dysfunction and worse postoperative outcomes. This is because banked blood is depleted of S‑nitrosohemoglobin (SNO‑Hb), the main regulator of microvascular blood flow. We previously linked declines in SNO‑Hb caused by intraoperative transfusion to reductions in tissue oxygenation, organ dysfunction, and worse outcomes in young cardiac surgery patients.1 The goal here was to see if acute changes led to any long-term deficits.

This retrospective cohort record review was approved by the University Hospitals-Cleveland Medical Center Institutional Review Board. Each patient's overall health was individually analyzed using past visit records in UH Epic. A Pediatric Overall Health Scale was used to assess the status of each patient's organ systems, generating an overall score (1 = normal, 2 = mild abnormality, 3 = severe abnormality) with a total score range of 8-24 (8-12 = good, 13-17 = poor, 18-24 = extremely poor).

The study is currently undergoing an analysis of overall health scores alongside their SNO-Hb values during the original blood transfusions during neonatal bypass to determine any correlations. These findings will provide insight into the long-term impact of early blood transfusion on patient health and help determine whether treating declines in SNO-Hb could be beneficial for improving outcomes in neonatal bypass surgery.

Project Mentors: James Reynolds, PhD, Department of Anesthesiology, Case Western School of Medicine, and Caroline Al Haddadin, MD, University Hospitals

**Fat Gone, GAGs On: dermal adipocyte lipids promote proteoglycan buildup in skin fibrosis**

**Miles Montegut**, Biology; Qiannan Ma, Biology; Suneeti Madhavan, Biology

Skin fibrosis is characterized by excessive scarring, with overproduction of extracellular matrix (ECM) components, including proteoglycans, in addition to lipid depletion, known as lipolysis, in dermal adipocytes. Adipocyte lipid handling is crucial for skin function, contributing to thermoregulation, hormone production, and ECM homeostasis. We previously demonstrated that Wnt-induced skin fibrosis in mice leads to adipose triglyceride lipase (ATGL)-dependent lipolysis and elevated proteoglycan expression, which can be reversed upon removal of Wnt. During this reversal, de novo lipogenesis (DNL) via fatty acid synthase (FASN) occurs to refill adipocyte lipids. However, it remains unclear whether lipolysis is required for increases in proteoglycan expression at the onset of fibrosis, or whether DNL is necessary for rescue of proteoglycan expression during fibrotic reversal. Here, we use two genetic mouse models to test the role of lipid handling in proteoglycan expression during fibrotic onset and reversal. In the first model, ATGL-dependent lipolysis is blocked during Wnt-induced fibrotic onset to assess whether lipid release is necessary for fibrotic upregulation of proteoglycan expression. In the second, FASN is inhibited during reversal of Wnt-induced fibrosis to determine if replenishing fat stores is required to restore proteoglycan expression. We stained dorsal skin sections with Alcian blue at pH 2.5 and 1.0 to visualize the expression of widely distributed and highly acidic proteoglycans, respectively. We found that ATGL-null mice did not show increased proteoglycan expression following fibrotic induction, suggesting lipolysis is essential for fibrotic changes in proteoglycans. Additionally, we found that the elevated proteoglycan expression was not rescued in FASN-null mice after removal of the fibrotic stimulus, supporting that DNL is necessary for reversing fibrotic increases in proteoglycans. Ultimately, we demonstrate the crucial role of adipocyte lipid handling in proteoglycan expression during the onset and reversal of skin fibrosis, opening new avenues for identifying therapeutic targets.

Faculty Project Mentor: Dr. Radhika Atit, Department of Biology, Department of Genetics, and Department of Dermatology

## “If he's not comfortable, I can't be”: Using Qualitative Analyses to Explore the Needs of Caregivers of Autistic Youth

**Marc-Joelitza Montgomery,** Department of Psychological Sciences, Case Western Reserve University

Autism is a neurodevelopmental condition characterized by a wide range of symptoms and abilities, which vary from person to person. Caregivers of autistic individuals (see Kapp et al., 2013 for identity-first preferred terminology) often face unique challenges when caring for autistic youth. Navigating the school and healthcare systems, in addition to parenting responsibilities in general, are some of the many realms where it can be challenging for caregivers. Existing research has largely focused on the experiences of White, middle-class caregivers. However, due to structural racism and other social barriers, caregivers from underrepresented backgrounds may encounter additional caregiving challenges. The presence of caregiving challenges suggests that caregivers have unmet needs that need to be addressed. Previous research has explored caregiving challenges and assumed caregiver needs without directly asking caregivers to describe them. In this project, we examine the needs of caregivers from underrepresented backgrounds who care for autistic youth. We interviewed 22 participants (12 African American; 7 White; 1 Hispanic; and 2 mixed race/ethnicity) about their caregiving needs and used an inductive thematic analysis to explore emergent themes from two interview questions. Many caregivers expressed needs related to community support and acceptance, mental health, better access to services, and time for self-care. Understanding these needs is critical for aligning caregivers with the services and supports necessary to improve their quality of life and enhance their caregiving capacity.

Project Mentor: Dr. Rita Obeid, Department of Psychological Sciences

Capstone Instructor: Dr. Rita Obeid, Department of Psychological Sciences

## Modeling The Dzyaloshinskii-Moriya Interaction In Magnetic Thin Films

**Caidan Moore**, Physics, CAS - College of Arts & Sciences

The automation of first order reversal curve (FORC) measurements has revolutionized the study of magnetic hysteresis in thin film materials. Despite this advancement, decoupling quantum effects in magnetic hysteresis experiments remains a significant challenge. This project seeks to bridge this gap by extracting the antisymmetric Dzyaloshinskii-Moriya Interaction (DMI) through the use of computational modeling and machine learning. Motivated by recent successes in the field, we simulate a classical Heisenberg model of a two-dimensional square lattice in a FORC experiment and determine the stable energy configuration at each field step. The resulting data is used to train a random forest algorithm, which infers the DMI coefficient from the hysteresis plot. By leveraging computational techniques, this approach aims to provide a groundwork for identifying antisymmetric effects in magnetic thin films through magnetic measurements. This work is supported by Sandia National Laboratories and the RadEdge group, which has enabled the integration of computational methods into the study of magnetic materials.

Project Mentor: Todd Monson, Sandia National Laboratories

**Exploring Brain Injury-Associated Purinergic Signaling in a Cockroach**

**Anna Mott**, Neuroscience Major; Emily Vasko, Biochemistry Major; Mary Tang, Biochemistry Major; Maize Connolly, Biochemistry; Rachel Thiesen, Biochemistry; Dr. Ryan Arvidson PhD, Department of Biochemistry

The emerald jewel wasp, *Ampulex compressa,* injects venom into the cockroach (*Periplaneta americana*) brain making it docile enough to host the wasps' larvae for their development, but able to support the cockroach's metabolic needs. This venom includes the enzyme adenosine deaminase which affects purinergic adenosine signaling, specifically in certain parts of the cockroach ganglia where the venom is injected to induce its behavioral and motor effects.

We are looking to see adenosine's effects on a cockroach brain, monitoring for inflammation-like signaling following brain-injury. We are injecting adenosine and adenosine receptor antagonists into explants of cockroach ganglia that have been cultured in 96-well plates to simulate a brain injury that doesn't immediately destroy the brain, in such a way that we can examine its effects. We are also investigating whether inhibiting adenosine receptors through antagonism by adenosine deaminase, a major component of the wasp venom, could have neuroprotective effects.

We perform cockroach brain dissections, attempting to keep the tissue as intact as possible for transfer of the neurons to an antibiotic solution to support the longevity of the cell cultures. We fix them with a variety of enzymes and treatments, and then the neurons can then be transferred and cultured in the 96-well plates to adhere before the fluorescent dye for calcium imaging can be added. We use a fluorimeter to measure calcium signaling in cultured cells. We hope to confirm our hypothesis that the adenosine receptors present in the explant functionally respond like Gαq GPCRs through live-cell calcium imaging.

In parallel, we are measuring the apoptotic response seen in brain injury through luminescent apoptosis detection reagent and expect that by blocking the adenosine receptor and adding the venom adenosine deaminase, we could minimize apoptosis in the modeled brain injury.

Project Mentor: Dr. Ryan Arvidson, Department of Biochemistry, School of Medicine

Capstone Instructor: Dr. David Friel, Department of Neuroscience, School of Medicine

## Characterizing a Novel Mutation in Larval Tracheal Growth

**Alexander Muller,** Biology major, Department of Biology, and Dr. Robert Ward, Department of Biology, CWRU

Allometric growth is an important phenomenon in human development that explains why certain parts of our body grow to different sizes. This phenomenon is not well understood in humans, so we can investigate allometric growth using *Drosophila melanogaster*. During larval stages, tracheal cells stop dividing, and the trachea grows by adding mass and extending along the anterior-posterior body axis. We know from previous work that tracheal-specific cell growth is under genetic control and have identified several mutations that alter tracheal growth. This project characterizes one of these novel mutations *(l(3)12265)* located on the third chromosome of *Drosophila melanogaster* that results in an overgrown, highly convoluted trachea phenotype. Antibody staining revealed that the relative levels of *Uninflatable* were higher in *l(3)12265* flies. *Uninflatable* is a positive regulator of tracheal growth and acts stoichiometrically to promote growth. This finding suggests that the gene affected in *l(3)12265* acts in the same pathway. RT-PCR testing will be conducted to further elucidate if increased expression of *Uninflatable* is responsible for creating the phenotype.

Genetic mapping of the mutation suggested that *CG1907* may be responsible for the *l(3)12265* phenotype. *CG1907* encodes a solute transporter and has human orthologs implicated in a tumor overgrowth disease. RNA interference was used to knock down *CG1907* both throughout the body and specifically in the trachea through genetic crosses with *Daughterless* and *Breathless* Gal4 drivers, respectively. Ubiquitous expression of *CG1907* interference caused the mean trachea length to be statistically larger than wildtype trachea. We plan to examine *Uninflatable* protein levels in larvae expressing *CG1907 RNAi* to see if it recapitulates the *l(3)12265* phenotype. If so, we will generate new mutations of *CG1907* using imprecise P-element excision of a P-element inserted near the start of the gene. We will use these alleles to examine how the loss of *CG1907* impacts tracheal growth.

Project Mentor: Dr. Robert Ward, Department of Biology, CWRU

**Advanced Metabolomics for the Dereplication and Characterization of Metabolites from Cyanobacterial Collections**

**Gabriella Mullet**, Chemistry, Runjie Xia, Department of Chemistry, Dr. Matthew J. Bertin, Department of Chemistry, Dr. Eduardo Caro-Diaz, School of Pharmacy, University of Puerto Rico, Marie L. Matos-Hernandez, School of Pharmacy, University of Puerto Rico

Cyanobacteria are photosynthetic prokaryotes found in many environments worldwide and have had a major impact on Earth's geochemical cycles. However, certain cyanobacterial organisms produce toxins that can harm humans and marine life through harmful algal blooms (HABs). By understanding these toxins and their structures, we not only gain insight into their potential risks but also open up opportunities for new medical and therapeutic applications, such as anti-inflammatory or anti-infective agents. In this project, we examined over 40 cyanobacterial samples collected from Puerto Rico's coasts, aiming to discover novel compounds using an untargeted metabolomic strategy. We relied on MPACT (Metabolomics Peak Analysis Computational Tool) to highlight the most metabolically unique samples in our large dataset. With its advanced statistical features and user-friendly data visualization, MPACT helped us pinpoint several unique extracts, choosing to focus on sample WIS50 because of the abundance of the sample and notably distinct metabolic profile. After fractionating WIS50 on a C18 SPE cartridge with various water-to-methanol ratios, we used dichloromethane for a final elution step to capture all possible metabolites. After preliminary proton NMR suggested a fraction with the highest purity, we used HPLC to isolate its main components. Further HSQC NMR analysis hinted at a lipid with unsaturated bonds. Furthermore, we uploaded HSQC data into SMART NMR, an AI-based platform that compares user data to extensive natural product libraries, which pointed us toward a novel cyanobacterial lipid. Mass spectrometry confirmed a unique molecular formula of $C_{30}H_{42}N_4O_9$. These findings highlight how untargeted metabolomic tools can accelerate the discovery of novel cyanobacterial compounds, paving the way for deeper insights into their ecology and potential benefits in medicine.

Faculty Project Mentor: Dr. Matthew Bertin, Department of Chemistry

Capstone Mentor: Dr. Drew Meyer, Department of Chemistry

**The effects of early life stress on the development of the meningeal lymphatic vasculature**

**Jessica Munro,** Neuroscience; Dr. Antoine Louveau, Department of Neurosciences, Cleveland Clinic Lerner Research Institute; Dr. Gabriel Tavares, Department of Neurosciences, Cleveland Clinic Lerner Research Institute

Early life stress (ELS) has been shown to negatively impact neurodevelopment. Children who experience ELS display symptoms of anxiety, depression, schizophrenia, and autism spectrum disorder (ASD). Epidemiological studies have indicated that the brain undergoes structural changes which interfere with proper emotional and social development. The meningeal lymphatic vasculature (mLV) is a network of vessels that line the main sinuses of the dura mater. They provide a drainage system for cerebrospinal fluid and immune cells into the deep cervical lymph nodes. Various rodent models have been used to mimic ELS, including a combination of maternal separation, limited bedding material, and mesh flooring or models involving primarily maternal separation. When[GT1] [GT2] the mLV develops, perinisinusal sprouts arise around P16 (post-natal day). Their growth peaks around P20, then reduces, and they begin to display their adult morphology by P25. Our lab has uncovered that the pruning of mLV occurs through phagocytosis by macrophages. Failure to prune the sprouts is linked to behavioral deficits in mouse models of ASD. Interestingly, around the same timeframe, the central nervous system undergoes intense remodeling, including synaptic pruning by microglia. Several studies have reported that ELS can interfere with this plasticity process during development. Therefore, our hypothesis is ELS disrupts mLV development. In this study, mice underwent early weaning (EW) to simulate ELS. The mice were separated from their dam at P15 (EW) or P21 (RW). Subsequently, the mice were euthanized at P18, P20, and P25 to assess the developmental timeline of the mLV. Whole-mount dura maters were stained for Lyve-1, a lymphatic marker, and the mLV morphology was assessed by a set of various parameters. Our findings suggest that EW alters the developmental timeline of the mLV and may modulate brain function indirectly by modifying the mLV development. Further studies will investigate the mechanisms responsible for these changes, and the functional consequences for the brain.

Project Mentor: Dr. Antoine Louveau, Department of Neurosciences, Cleveland Clinic Lerner Research Institute

Capstone Instructor: Dr. Ashley Nemes, Department of Neurosciences

## Orientation Sensing in MRI using Hall Effect Sensors

**Adam Thompson,** Electrical Engineering; **Colin Myers,** Electrical Engineering**; Justice Smith,** Electrical Engineering;

For patients with certain heart conditions, such as complex congenital heart disease and intracardiac shunts, catheterization is a common and effective approach for treatment. Specialists have begun using MRI to aid in catheterization. MRI catheterization provides a multitude of benefits; Limiting radiation exposure, better imaging, and more accurate measurements of certain blood flow tests are all ways in which MRI catheterization proved its efficacy over X-Ray. To further improve the efficacy and reliability of these catheters, intravenous navigation using an MRI compatible robotic catheter is currently being developed by researchers in Dr. Çavuşoğlu's lab. To aid this development, we aim to develop an orientation sensing device that can be embedded into the tip of the catheter. This will allow the controls algorithm of the catheter to have real-time feedback on the catheter's orientation and movement within the body, leading to more accurate and reliable procedures.

Our design utilizes three hall effect sensors positioned at 90 degree angles on a flexible PCB. As the sensors rotate in the magnetic field of the MRI, the voltage across the devices will change relative to the magnetic flux. Due to the hostile, noisy environment, we have implemented an amplification and filtering circuit outside of the MRI zone. The sensor data is then processed to determine the calculated orientation of the hall effect sensor enclosure. This design is intended to be used as a proof of concept that can later be miniaturized and utilized by the automated robotic catheter lab.

Faculty Advisor: M. Cenk Çavuşoğlu, Ph.D, Department of Electrical, Computer, and Systems Engineering

Capstone Instructor: Gregory Lee, Department of Electrical, Computer, and Systems Engineering

## Fbxo4 - hnRNPK Ubiquitylation Mechanism and Regulation of BRD4

**Pranav Nampoothiripad**, Biology

RNA-binding proteins (RBPs) regulate key post-transcriptional processes and are often dysregulated in cancers, promoting metastasis, immune evasion, and drug resistance. The tumor suppressor SCF-Fbxo4 ubiquitin ligase regulates the oncogenic RBP hnRNPK through non-degradative ubiquitination, inhibiting its ability to promote the synthesis of the oncoprotein c-myc. Loss of hnRNPK ubiquitylation contributes to a metastatic phenotype in which c-myc inhibition is rescued only partially. This suggests the contribution of other hnRNPK downstream targets. Bioinformatic analysis identified the oncoprotein BRD4 as a potential target of hnRNPK. This study investigates the Fbxo4-hnRNPK axis's role in BRD4 regulation and its therapeutic relevance in esophageal squamous cell carcinoma (ESCC). Due to its role in tumor progression, therapeutic vulnerability, and promising preclinical results, BRD4 is a strong candidate for further study. Using multiple cancer cell line models we manipulated SCF-Fbxo4/hnRNPK proteins via shRNA/siRNA depletion and plasmid/retroviral overexpression. Western blotting and immunoprecipitation analyses revealed that hnRNPK modulates BRD4 levels in Fbxo4-dependent manner. Quantitative PCR and cycloheximide chase ruled out transcriptional and degradation-based mechanisms. ESCC cell survival was compromised by inhibition of BRD4 under conditions of disrupted Fbxo4-hnRNPK signaling and low BRD4 expression. Moreover, co-immunoprecipitation showed that ubiquitylation-resistant hnRNPK mutants had reduced self-association, implicating ubiquitylation in hnRNPK complex formation and function. These findings identify the Fbxo4-hnRNPK axis as a critical regulator of BRD4 and highlight its potential as a therapeutic target in cancers driven by dysregulated RBPs.

Faculty Mentor: J. Alan Diehl, Lab Supervisor: Bartosz Mucha, Department of Biochemistry, Case Western Reserve University

## Non-Canonical Role of Septate Junction Proteins in Border Cell Migration of Drosophila

**Amita Nanda**, Biology B.S. and Medical Anthropology B.A. at Case Western Reserve University

Border cell migration (BCM) during oogenesis in Drosophila melanogaster is a model for studying collective cell migration, crucial for tissue morphogenesis, wound healing, and cancer metastasis. During mid-oogenesis, polar cells secrete signaling molecules that recruit nearby somatic follicle cells to surround them, forming a migratory cluster that delaminates and moves between nurse cells to the anterior side of the oocyte. This cluster exhibits anterior-posterior, apical-basal, and rotational polarity, essential for directed movement. Our research focuses on the role of septate junction (SJ) proteins in BCM. SJs are occluding junctions analogous to vertebrate tight junctions. It has been found that they have not yet formed in the follicular epithelium at the time of BCM, suggesting a non-junctional regulatory role in morphogenesis.

Previous studies have shown that SJ protein knockdown can result in incomplete migration, failure of cluster delamination, or dissociation of the cluster. Using the GAL4-UAS system, we employed the slbo-Gal4 line with RNAi to target SJ proteins Kune-kune (Kune), Macroglobulin complement-related (Mcr), and Coracle (Cora). Antibody staining revealed that knockdown of these proteins resulted in incomplete migration, delayed delamination, and cluster dissociation during movement. These defects may be due to impaired cell-cell adhesion, disrupted polarity signaling, or altered cytoskeletal dynamics.

To further investigate these defects, we conducted fixed staining of wildtype and SJ RNAi knockdown egg chambers. Analysis of filopodia dynamics revealed that mutants exhibited more, shorter, and less directed filopodia compared to controls. Preliminary results show downregulation of aPKC, Rab11, and Sqh1p in mutants, which may contribute to the defective migratory phenotypes. Future directions include additional staining of polarity markers (Baz) and cytoskeletal proteins (β-tubulin, phalloidin, Sqh) to further examine BCM defects, live imaging to analyze filopodia dynamics, and a genetic screen for SJ RNAi knockdown to identify additional genes affected.

Project Mentor: Robert Ward, Department of Biology, Case Western Reserve University

**Racialized Minds: How Early Social and Cultural Biases Influence Cognitive Development**

**Breana Ngamaleu-Kemta**, Cognitive Science, CAS - College of Arts & Sciences

Children develop an understanding of others' beliefs, emotions, and intentions through social interactions and exposure to various media. However, racial biases in media representations may influence this development, particularly among minority preschool children. This literature review examines existing research on early exposure to racial biases in media and its effects on cognitive and social development. By collecting and analyzing studies on racial representation, implicit bias, and ToM acquisition, this paper explores whether racially inclusive and positive media enhance ToM development compared to stereotypical or absent representation. The findings suggest that positive representation correlates with increased ToM accuracy, while negative representation correlates with increased implicit bias within young children.

Keywords: Theory of Mind, Race, Children, Development

Project Mentor: Todd Oakley, Cognitive Science, CAS - College of Arts & Sciences

## The Price of No Tax: The Impact of State Income Tax Removal on Crime in Tennessee

**Dustin Nguyen,** Finance and Economics**; Nam Nguyen,** Accounting and Economics

Tax policy significantly influences economic behavior such as spending, saving and income distribution, yet its relationship with crime remains unclear. To balance economic growth and public safety, policymakers must understand how tax policy affects crime rates. This study examines the impact of eliminating state income tax on crime, using Tennessee's 2021 repeal as a natural experiment. We analyze how changes in disposable income, income inequality, and state funding for public services influence crime rates. We identify causal effects using Difference-in-Differences (DiD) and Synthetic Control methodologies, comparing Tennessee to states that maintained or never had an income tax. Tennessee serves as the treatment group, while control groups include states with income taxes and those that never imposed one. This study builds on existing research by focusing on a recent tax repeal, incorporating long-term data from 2010-2023, and controlling for Covid-19's temporary effects on crime trends. Our hypothesis suggests that eliminating the income tax could lower economically driven crimes such as property crime and robbery by raising disposable income yet potentially increase violent crimes such as aggravated assault if reduced state revenues cut law enforcement and social program funding. Existing research links tax policy to crime through its effects on income distribution and public spending. However, prior studies largely examine broader tax structures rather than the consequences of completely eliminating state income tax. By analyzing this specific policy shift, our study provides new insights into how tax changes directly affect crime and the trade-offs policymakers face when designing fiscal policy. We use data from the FBI Crime Data Explorer and the U.S. Census Bureau, covering crime rates, socioeconomic indicators, and policy changes from 2010 to 2023. This research offers valuable insights into the social consequences of tax reforms and helps policymakers understand how fiscal decisions can impact public safety.

Project Mentor: Professor Jenny Hawkins, Department of Economics

## "Buy American, Hire American": Did the 2017 Visa Restrictions Affect Wages in H-1B Dependent Industries?

**Kiet Nguyen**, Economics, Data Science; **Lien Tran**, Economics, Finance

In April 2017, the Trump administration's "Buy American, Hire American" executive order created a natural experiment in labor economics by dramatically altering H-1B visa accessibility. Denial rates surged from 6% in 2016 to 18% by 2018, generating a significant labor supply shock in specialized sectors. This study examines whether this policy-induced restriction on skilled foreign workers affects wage dynamics differently across industries based on their H-1B dependency.

Using a Difference-in-Differences framework analyzing data from 2012-2020, we compare quarterly wage changes in industries with high H-1B dependency ratios (treatment group) against those with low dependency (control group). Our dataset integrates USCIS H-1B petition records, Labor Condition Applications, and BLS wage data. The primary dependent variable is industry-level quarterly wages, while the key independent variables are H-1B denial rates and industry-specific dependency ratios. We include comprehensive controls: productivity metrics, offshoring rates, employment growth, inflation, and sector-specific unemployment rates.

This research advances the immigration economics literature by directly measuring how visa restrictions propagate through labor markets with industry dependency as the critical mediating factor. Through extensive data preparation that matched 95% of previously unclassified employers with standardized industry codes, we create precise H-1B dependency measurements across economic sectors—enabling a level of analysis previous studies have not achieved.

We hypothesize that high-dependency industries experience lower wage growth following visa restrictions, as productivity constraints outweigh potential wage pressure from labor scarcity. Our findings will provide evidence-based guidance for optimizing visa allocation systems that balance domestic worker protection with innovation-driven economic growth—a critical consideration for U.S. competitiveness in knowledge-intensive industries.

Project Mentor: Professor Mark Schweitzer, Department of Economics and Professor Jenny Hawkins, Department of Economics

## System on Module (SoM) Design for Embedded Systems

**Tobias Nguyen**, Department of Electrical Engineering and Computer Science

The project focuses on designing and developing a System on Module (SoM) that integrates essential embedded system components to address the industry's increasing need for efficient and cost-effective solutions. This SoM design will incorporate an ARM architecture processor, memory systems (DRAM, EMMC, Flash), communication interfaces (I2C, SPI, UART), and advanced features like HDMI and Display Serial Interface (DSI). The project's primary goal is to provide a practical, low-cost alternative to existing SoM solutions, with additional emphasis on display functionalities critical for sectors such as Electric Vehicle (EV) development.

Drawing on academic knowledge and hands-on experience from previous internships, the project will employ industry-standard design tools like Altium for PCB layout and component selection. The design process will integrate theoretical and practical aspects of hardware and embedded system development, such as power management, signal integrity, and environmental considerations. The project will follow a structured design approach, focusing on the selection of key components that balance performance, cost, and industry relevance.

This project will culminate in a comprehensive SoM PCB design, including detailed schematics, a bill of materials (BoM), and a design rule check (DRC) to ensure the layout meets manufacturing standards. While no physical prototype will be produced due to time and cost constraints, the design will be validated through simulations and theoretical analysis. The results are expected to contribute to the understanding of embedded system design and offer a practical solution for the growing need for custom, low-cost SoM solutions.

Faculty Project Mentor: Professor Christos Papachristou, Department of Electrical Engineering and Computer Science, Case Western Reserve University

Capstone Instructor: Dr. Gregory Lee, Department of Electrical Engineering and Computer Science, Case Western Reserve University

## Intracellular Endosomal and Cytosolic Targeting Lipid Nanoparticles

**Ashley Novak**, Biomedical Engineering

Lipid nanoparticles (LNPs) are a widely used platform for the non-viral delivery of gene therapies, vaccines, and immunotherapies. Certain LNP-based treatments co-deliver nucleic acid adjuvants that activate Toll-like receptors (TLRs) on the endosomal membrane. However, a key challenge arises when therapeutic components require distinct intracellular destinations—some necessitating cytosolic delivery, while others function within the endosome. This study investigates how lipid composition influences cargo localization and therapeutic outcomes using a Dual-LNP system designed to deliver both siRNA, which requires cytosolic delivery, and CpG, which targets the endosome. Three distinct LNP formulations were developed to preferentially target different intracellular compartments. In the first phase of this study, ELISA assays quantified TNF-α cytokine production as a marker of endosomal TLR activation. In the second phase, flow cytometry was used to assess GFP knockdown efficiency by measuring GFP fluorescence in RAW264.7 macrophages. These findings provide insight into the relationship between lipid composition and cytosolic delivery efficiency. The results of this research will contribute to optimizing LNP designs for more precise intracellular delivery, ensuring therapeutic cargo reaches its intended destination for maximal efficacy.

Faculty Project Mentor: Colin Drummond, Department of Biomedical Engineering

## Evaluation of a Combined Engine Turbosupercharger Mechanism

**Xavier Nye,** Mechanical and Aerospace Engineering Major and CWRU School of Engineering

Turbochargers are an increasingly common mechanism for extracting additional power and efficiency from engine designs by increasing the engine inlet pressure using energy extracted from the exhaust gasses. For compressor designs which can produce higher pressure ratios to increase an engine's power output, more power is required to be produced by the turbine. This results in the effect commonly known as "turbo lag", where at low engine RPMs there is not enough power capable of being extracted from the exhaust flow to sustain high compressor pressure ratios. Therefore, the performance of the vehicle may suffer during high acceleration out of corners or after gear changes, even if the engine has a large maximum power output. This project will evaluate the performance of a new concept for a mechanism that combines both a turbocharger and a supercharger into a single mechanical package. The design allows the system to transition from supercharger to turbocharger operation, mitigating the effect of turbo lag while also allowing for a high maximum pressure ratio. A mathematical model of the system is implemented to calculate the performance and determine the viability of the concept.

Project Advisor: Richard Bachmann, Case School of Engineering, Department of Mechanical and Aerospace Engineering

**Stereo Electronic Stethoscope: Detection of Cardiac Murmurs**

**Brady Oakes,** Department of Biomedical Engineering; **Ria Sharma**, Department of Biomedical Engineering; **Kai Sheng Tham**, Department of Biomedical Engineering; **Kelly Vann,** Department of Biomedical Engineering

Cardiac murmurs are relatively common conditions that affect about 10% of patients [1]. While many are benign, others can be indicators of life-threatening conditions. Conditions are currently detected by traditional stethoscope auscultation, but this has several limitations. First, variability and subjectivity occur between physicians performing the assessment, with no standardized ways to identify the condition pathology [2]. Secondly, there are limitations to the human auditory system, particularly with high-frequency or low-magnitude sounds [3]. Finally, the proficiency of detection is highly dependent on the training the physician received [4]. To address this, we developed a stereo-electronic stethoscope to collect quantitative heart sound data for initial cardiac patient screening and assist doctors/cardiologists in the detection of murmurs, preventing low sensitivity of current auscultation methods. Our prototype uses two bell/diaphragm heads connected to two sets of microphones to record sounds captured by the heads. The two microphones send the raw signal to the left and right earpieces to play the two heart sounds from the different cardiac locations in each ear. The raw signal also travels through an electronic filtering system that then moves to an Arduino to be exported. The Arduino is capable of data transfer via a USB flash drive. The USB will allow for long-term storage of patient data by secure transfer to a computer. Using MATLAB, the output signal will be filtered and transformed into a phonocardiogram (PCG) for visualization of the heart sounds. These innovations will aid physicians and cardiologists in detecting cardiac murmurs and improve auscultation practices by having two data collection sites and a visualization tool.

Project mentors: Dr. Colin K. Drummond, Department of Biomedical Engineering, CWRU Dr. Matthew Williams, Department of Biomedical Engineering, CWRU

## Attentional Bias to Threat in Children Who Stutter

**Rafaela Oliveira,** Neuroscience

Stuttering is a complex communication disorder that significantly affects children's social, emotional, and academic experiences. Although stuttering is linked to an increased risk of social anxiety, the role of known anxiety risk factors, such as attentional bias to threat, remains unclear. This pilot study examined differences in attentional bias to threat between 10 children who stutter (CWS) and 10 children who do not stutter (CWNS), aged 3;2 to 12;10 years, using a child-friendly Emotional Stroop task. In this task, children named the color of facial stimuli (red, green, blue) displaying angry, neutral, or happy expressions while their speech reaction time was recorded. Contrary to hypotheses, preliminary results revealed no significant differences in attentional bias to threat between CWS and CWNS, as measured by speech reaction time differences across facial expressions. However, among preschool-age CWS, attentional bias to threat was significantly and positively associated with stuttering severity. These findings suggest that while attentional bias to threat may not differentiate CWS from CWNS, it may be linked to stuttering severity in younger children. Further research is needed to clarify its role in the development of social anxiety in children who stutter.

Faculty Project Mentor: Katerina Ntourou (CWRU Communication Sciences)

**A Systematic Review of Protective Factors impacting the Experience of Adolescent Dating Violence**

**Michelle Orioha**, Nutritional Biochemistry and Metabolism, Psychology, Case Western Reserve University. Katie Russell, School of Social Work, University of Central Flordia. Laura Voith, Jack, Joseph, and Morton Mandel School of Applied Social Sciences, Case Western Reserve University

Adolescent dating violence (ADV) occurs between youth dating partners and includes physical, sexual, or emotional violence, harassment, stalking, or coercion. 33% of US adolescents experience ADV, which is associated with deleterious outcomes such as psychiatric disorders, substandard academic performance, and adult revictimization. Given the profound impact of ADV on youth, further exploration of protective factors to be implemented in prevention/intervention is warranted. Methods: This systematic review of the extant literature examines factors that protect against ADV, with attention to considerations related to youth race, gender, and sexual orientation. 507 articles from ten databases were screened in Rayyan for inclusion. Studies include ADV as an outcome, >1 protective factor/theme, and a sample majority (>75%) age of 10-19 years. Studies were excluded if published before 2003, not peer-reviewed, prospective, or in English. Data was extracted from included studies using Excel. Results: This review includes 22 studies. All but one used quantitative methods. Most were conducted in the US, with sample sizes ranging from 10-18,451 and ages from 11-20. The most studied protective factors were social support and parental monitoring. Parent communication, school bonding, and school belonging were also protective in multiple studies. Other significant factors include self-esteem, resilience, parental caring, empathy, and future orientation. Ten studies explored the influence of minority experience on protective factors and ADV. Six focused on Latino youth, one on Black youth, one on gender minority youth, and three on several racial/ethnic minorities. Studies suggest that minority youth experience ADV at higher rates than White, cisgender youth. Parental monitoring functions differently among Latino families and heritage/culture garners protective benefits. Family support was not protective for gender minority youth. Discussion: These results identify malleable individual and interpersonal factors that can protect against ADV. Researchers and clinicians should investigate how youth identity intersects with protective factors and ADV to best support minoritized youth. Project Mentor: Katie Russell, School of Social Work, University of Central Flordia.

Faculty Mentor: Laura Voith, Jack, Joseph, and Morton Mandel School of Applied Social Sciences, Case Western Reserve University.

**Connecting orphan gene clusters to specialized metabolites in cyanobacteria using bio- and cheminformatics**

**Emily Ortega,** Chemistry, CAS - College of Arts & Sciences

Connecting orphan gene clusters to specialized metabolites in cyanobacteria using bio- and cheminformatics Emily Ortega, Chemistry Cyanobacteria are gram negative bacteria present within all bodies of water and play an important role in the oxygenation of the ocean and atmosphere and nitrogen fixation, providing a nitrogen source for heterotrophs. In large concentrations these organisms can pose a threat to human health and ecosystems due to the production of toxic secondary metabolites known as cyanotoxins. Despite the toxicity, these organisms produce other secondary metabolites, some which may have potential pharmacological applications. The biosynthetic pathways of these metabolites are not widely studied, limiting the development of any further research. This project aimed to characterize a peptide associated with a biosynthetic gene cluster produced by Iningainema tapete, a newly discovered cyanobacterial species. Implementation of both biological and chemical techniques to identify and structurally characterized a peptide associated with the gene cluster of interest. The biosynthetic gene clusters provided insight into the possible type of peptides encoded. The Iningainema extract was fractioned and structurally characterized using HSQC NMR and mass spectrometry, leading to the identification of the peptide as nodularin. The identification of this peptide shows how successful the integration of both chemical and biological techniques are as an approach for molecular characterization, while also expanding our knowledge on these organisms, to further understand their ecological roles and potential applications.

Project Mentor: Dr. Matthew J. Bertin, Department of Chemistry

## Optical Brain Machine Interface Device for Mouse Spatial Navigation

**K. Ozdermili**1,2 , M. Maldonado1,3, T. L. Connor1 , M. Lacin1 , M. Rashidi2 , *M. Yildrim1 1 Cleveland Clinic Lerner Research Institute Department of Neuroscience, Cleveland, OH; 2 Case Western Reserve Department of Mechanical and Aerospace Engineering; 3 Case Western Reserve University Department of Computer and Data Science

Navigation is a core cognitive function that integrates sensory input, memory, and motor planning— all processes disrupted in neurological disorders like Alzheimer's disease. Notably, spatial navigation deficits often appear before memory loss, making them among the earliest behavioral signs. Over 6.9 million Americans aged 65+ are currently living with Alzheimer's, a number expected to double by 2050. The economic impact is immense, with Alzheimer's and related dementias projected to cost the U.S. $360 billion in 2024 alone, rising to over $1 trillion in the coming decades. These statistics highlight the urgent need to understand how neural circuits support navigation and how these systems break down in disease. Brain-machine interfaces (BMIs) provide powerful tools to link brain activity to behavior, but conventional BMIs depend on invasive implants, limiting their use. Optical techniques like calcium imaging and optogenetics offer minimally invasive alternatives, yet few platforms integrate both in real time. To address this, we developed a one-photon optogenetics system with integrated calcium imaging for use in mice navigating a virtual reality (VR) environment. Our setup uses custom-designed dichroic mirrors and emission filters to enable blue-light optogenetic stimulation (488 nm) while recording jGRECO1a calcium signals (565 nm). Optical components were designed in SolidWorks and aligned with micrometer precision to produce a sub70 μm laser spot. We used VGAT-ChR2 mice to stimulate inhibitory neurons and introduced jGRECO1a via retroorbital injection for wide-field imaging. A custom ViRMEn-based VR system enabled synchronized real-time stimulation during behavioral tasks. Testing showed that 10 mW of whole-brain stimulation reduced movement, while targeted stimulation of the frontal—but not visual—cortex halted locomotion, confirming spatial specificity. This scalable, minimally invasive system opens new avenues for studying the neural basis of navigation and its disruption in neurodegenerative disease, with potential to inform future therapeutics.

Project Mentor: Murat Yildirim, Department of Neurosciences
Capstone Instructor: Majid Rashidi, Department of Mechanical and Aerospace Engineering

**Rolling the Dice: Does Sports Betting Legalization Increase Property Crime, Assault, and Robbery?**

**Trevor Wood**, Economics; **Arsalan Padder**, Economics

The legalization of sports betting in the United States raises concerns about its potential impact on crime. As of 2025, 38 states and Washington, D.C., have legalized sports betting. Supporters argue that legalization eliminates illegal bookmaking and generates tax revenue, while opponents claim it increases crime, particularly violent and financial crime. Despite extensive research on the relationship between gambling and crime in casino settings, empirical analysis of sports betting remains scarce. This study aims to fill that gap by investigating whether states with legalized sports betting experience changes in robbery, property crime, and assault. To estimate the causal effect of legalization, we leverage a Difference-in-Differences (DiD) approach using state-level panel data from 2010-2023. Our first model identifies pre-legalization periods as the control and post-legalization periods as the treatment among individual states. Our second model identifies states that have legalized sports betting as the treatment and states that have not as the control. We compile crime data from the FBI's Uniform Crime Reports (UCR) and the National Incident-Based Reporting System (NIBRS), alongside state-specific information on sports betting legality. Control variables include alcohol consumption, income per capita, unemployment rate, police budget, and police per one hundred thousand residents. Our hypothesis suggests that sports betting legalization increases financial, violent, and property crime due to the financial strain imposed by gambling. Our findings carry substantial policy implications, underscoring the importance of anti-fraud protections, responsible gambling regulations, and law enforcement strategies to mitigate the risks associated with legalized sports betting. As more states consider legalization, understanding these effects is crucial for policymakers aiming to balance economic benefits with public safety. Our research provides a more comprehensive understanding of the societal impacts of sports betting legalization.

Project Mentor: Professor Jenny Hawkins, Department of Economics

**Rheology of Dense Suspensions with Repulsive Inter-particle Forces under Shear Reversal**

**Ryan Pappalardo**, Department of Chemistry, CWRU; and Alessandro d'Amico, Department of Chemical Engineering, CWRU; and Shweta Sharma, Department of Macromolecular Science and Engineering, CWRU; and Michel Orsi, Department of Chemical Engineering, CCNY; and Abhinendra Singh, Department of Macromolecular Science and Engineering, CWRU

Dense suspensions are dispersions of small particles in a Newtonian solvent that are ubiquitous in nature and industry. The presence of various surface interactions and particle properties such as size, roughness, interfacial chemistry, and shape manifests itself as various non-Newtonian rheological features such as yielding, shear thinning, shear thickening, and jamming. In this work, we use a simulation tool LF-DEM that combines lubrication flow (LF) with discrete element method (DEM) to simulate inertialess buoyant particles dispersed in a Newtonian solvent. We include DLVO potential, including repulsive forces with hydrodynamic and contact friction. We find that in the lubricated state, the reversal of the shear direction briefly breaks all frictional contacts, resulting in a significant drop in bulk viscosity. However, at higher stresses, i.e., frictional state, we find that some contacts persist through shear reversal. The portion of contacts which persist increases with stress and volume fraction. We use network analysis to further understand the connection between contact microstructure and bulk rheology. The quantification via network analysis of these contacts and their associated structures can allow for the construction of constitutive models which account for transient behavior, in addition to the steady state response.

Project Mentor: Professor Abhinendra Singh, Department of Macromolecular Science and Engineering, CWRU

**Impaired CO2-mediated cerebral blood flow regulation in the absence of Hb βCys93 in a murine model**

**Joshua Park**, Biochemistry BS, College of Arts and Sciences; Rongli Zhang, MD, PhD, School of Medicine; Jonathan Stamler, MD, School of Medicine

The body maintains adequate oxygen supply to tissues by regulating microvascular blood flow, a mechanism known as blood flow autoregulation. Hemoglobin (Hb) is traditionally known for its role in oxygen transport, but recent findings highlight its additional function in modulating blood flow. This regulation is achieved through the oxygen-dependent release of S-nitrosothiol (SNO), a vasodilatory molecule linked to hemoglobin's allosteric properties. Studies on β-globin Cys93Ala (βC93A) mutant mice, which lack S-nitrosohemoglobin (SNO-Hb) bioactivity, demonstrate substantial deficiencies in microvascular circulation and tissue oxygenation, similar to the microvascular dysfunction observed in certain disease states. Despite its potential significance, the specific influence of SNO-Hb on cerebral blood flow (CBF) remains unexplored. In normal physiology, CO2 functions as a potent cerebral vasodilator through various largely unsolidified mechanisms. Here, we demonstrate that βC93A mice with impaired SNO bioactivity are deficient in acute CO2-induced microvascular perfusion and tissue oxygenation increase in the cerebral cortex (n = 20) monitored through Laser Doppler Flowmetry and pO2 sensors. Our findings were validated through 2-photon microscopy results, which demonstrated impaired CO2-induced increases in microvascular perfusion. Thus, these results demonstrate that βCys93-derived SNO bioactivity is essential for normal cerebrovascular regulation, and possibly hints at other roles in CBF regulation for SNO-Hb.

Project Mentor: Rongli Zhang, MD, PhD, School of Medicine PI: Jonathan Stamler, MD, School of Medicine

**Implementation of the "Virtual Clinic" to Improve Age Friendly Care Delivery**

**Noah Park**, Biology; Grace Armstrong[2], Sarah Ball[1], Mary McCormack[1], Jackson Fielder [2], Ilona Seaman[2], Nicholas Schiltz[2] Anne Pohnert[1], Mary Dolansky[2]

1. MinuteClinic in select CVS Health Pharmacy Locations, Woonsocket, RI, 02895,
2. Case Western Reserve University, Frances Payne Bolton School of Nursing, Cleveland, OH, 44106.

Ensuring that older adults receive comprehensive and evidence-based care remains a challenge in retail healthcare. Age-Friendly Health Systems (AFHS) is a framework aimed at providing quality care for older adults, promoting the 4Ms: What Matters, Medication, Mentation, and Mobility. The 4Ms aligns care with older adults' personal priorities through identifying and integrating What Matters most to them, ensuring that care decisions, medications, mental health strategies, and physical health strategies are all guided by the patient's own goals and preferences. MinuteClinic, a retail-based healthcare system in select CVS Health Pharmacy locations adopted AFHS in 2020 to improve older adult care by integrating the 4Ms into routine visits. However, individual provider adherence was inconsistent, highlighting the need for additional training interventions. To address this, the Virtual Clinic, an interactive educational tool (a "serious game"), was developed to enhance provider competency in 4Ms implementation through scenario-based modules and competency assessments.

This study evaluated provider performance across three implementation waves. For each wave, participants were matched to controls in a 1:3 ratio based on eligible visit volume and 4Ms delivery metrics one month before each virtual clinic wave. Metrics recorded included the percentage of visits where providers delivered each M, percentage of visits with all 4Ms, and percentage of visits with no Ms. Statistical significance was identified using p-values.

Providers who participated in the Virtual Clinic demonstrated significant improvements in individually delivering What Matters, Medication, and Mobility, but not Mentation. While there was no significant difference between participants and controls in visits delivering all 4Ms, participants had a significant reduction in visits with no Ms. Although the Virtual Clinic did not significantly increase the percentage of visits where all 4Ms were delivered, it effectively improved the integration of individual Ms into provider practice, particularly in What Matters, Medication, and Mobility.

Faculty Mentor: Mary Dolansky, Frances Payne Bolton School of Nursing

## Assessing Noise Filter Behavior in MicroRNA

**Daniel Passmore**, Physics

MicroRNA are small, non-coding RNA found in eukaryotes. They act in post-transcriptional regulation, binding to mRNA, leading to its destruction and acting as a noise filter. It is unclear how the microRNA system evolved because creating mRNA only for it to be destroyed by microRNA uses extraneous resources, despite this system being important to the development of many eukaryotes. To understand how this system evolved, stochastic differential equations were used to model protein transcription, microRNA regulation, and translation. These equations were tested using the Gillespie Algorithm and were used to determine which system parameters lead to advantageous protein regulation. Wright-Fisher simulations were used to model how individuals with different fitness levels are selected in a population. Paired with the protein transcription system, this approach shows how different parameters for microRNA affect an organism's fitness and evolution.

Faculty Mentor: Michael Hinczewski Department, Department of Physics

**Characterizing Sleep Quality and the Sleep Environment in School-Aged Children on the Autism Spectrum**

**Manav Patel**, Physics B.S., Department of Physics, CWRU; **Megha Patil**, Psychology B.A., Department of Psychology, CWRU

Introduction/Background: Up to 78% of children with autism spectrum disorder (ASD) experience sleep difficulties, including difficulty falling and staying asleep, and early morning awakenings. Sleep quality in children with ASD is influenced by a complex interplay of biological, developmental, psychological, environmental, and cultural factors. Therefore, the purpose of this study is to characterize sleep quality and the sleep environment in children with ASD.

Methods: A qualitative descriptive approach was used to collect data with a purposive sample of children with ASD age 6-12 years with moderate or greater sleep disturbance. Children with a sleep apnea diagnosis or an untreated medical condition that could interfere with sleep were excluded. Parents completed a 1-hour, individual Zoom interview. A semi-structured guide was used to collect information on the child's physical sleep environment. Interviews were audio-recorded, transcribed verbatim, and analyzed using thematic analysis via Dedoose version 9.0.17. Parents completed surveys online about child sleep quality (Modified Children's Sleep Habits Questionnaire, MCSHQ) and the child's broader sleep environment (Children's and Adolescent Sleep Environment Scale, CASES).

Results: Twelve parents of children with ASD (58.3% Female, mean age= 9.5$\pm$2.06 years) completed the interviews. Mean values: MCSHQ Total = 42.58$\pm$10.21; CASES Total = 16.08$\pm$10.87. Parents identified several themes related to the child's physical sleep environment including inconsistent sleep location, preferred item or a collection of items, familiar bedroom, sensory-friendly bedding and pajamas, nightlights, and minimizing noise.

Conclusions: Parents identified key aspects of the child's sleep environment, highlighting the need for targeted interventions to improve child sleep. The modifiable nature of these factors indicates that interventions focusing on the sleep environment may be beneficial.

Project Mentor: Megan Wenzell, PhD, RN, Frances Payne Bolton School of Nursing, CWRU

## A Woman's Right to Work: The Effect of Mandatory State-Paid Family Leave Law on Female Labor Force Participation

**Pehel Patel**, Economics, Finance, Cognitive Science, CWRU; **Sonia Shenoy**, Economics, Marketing, CWRU

Women are often known to shoulder familial responsibilities such as caregiving, looking after young children, and supporting a family's home needs. For some, these priorities can cause prolonged career disruptions and contribute to persisting gender gaps in labor force participation. This study investigates the impact of mandatory state-paid family leave (PFL) laws on female labor force participation (FLFP) by examining the effect of the implementation of New York's PFL law in 2018 against that of New Jersey's earlier adoption in 2009. We use an individual-level panel dataset extracted from IPUMS CPS–Core and the Annual Social and Economic Supplement (ASEC) to run a reverse difference-in-differences model (DiDR) that explores the magnitude and variation of PFL effects on different 'types' of working women; survey respondents form New York and New Jersey form the treatment and control groups, respectively. Our dataset captures outcome indicators such as labor force participation status, weeks worked, and full-time or part-time employment status, from 2013-2023 (5 years before and after the treatment of New York law). We also include controls such as household composition, income, children, age, industry, etc. Based on theoretical and empirical models, we hypothesize that New York's PFL law will lead to a jump in FLFP post-treatment, causing it to become parallel with New Jersey's trends. Paid leave is expected to reduce the opportunity costs of taking personal leave for admissible reasons by providing women with income security. Our research furthers the discussion about the gender gap in labor economics by employing a newer empirical approach on how family leave provisions impact FLFP. This paper, in tandem with relevant literature, can inform state-level policies intending to promote equality in the workplace and long-term economic growth.

Project Mentor: Professor Mark Schweitzer, Department of Economics, CWRU

Capstone Instructor: Professor Jenny Hawkins, Department of Economics, CWRU

## Automated Glioblastoma Segmentation MRI Imaging Using a 3D U-Net Deep Learning Model

**Shreya Patel**, Neuroscience

Glioblastoma (GBM) is an aggressive and fatal brain tumor, and accurate detection of response and size change is pivotal for evaluating effective therapies. Manual outlining (segmentation) of tumors from MRI imaging in current clinical practice is exhaustive and prone to human error. A 3D U-Net model is a convolutional neural network with an encoder-decoder structure and skip connections, allowing it to preserve fine spatial information, making it a promising tool for medical segmentation.

In this study, we tested whether a pre-trained 3D U-Net deep learning network could be used to segment GBM automatically. This was tested on imaging from the BraTS Challenge training dataset, a high-quality pre-labeled MRI image collection with expert-annotated ground truth for comparison. Images were first preprocessed with skull stripping, where non-brain tissues are removed, and resolution standardization for uniformity between scans. Two regions of the tumor were segmented on each MRI scan: the enhancing tumor core (ET) and the non-enhancing tumor core (NCR).

A deep learning-based segmentation model has the potential to save time and effort in GBM segmentation while enhancing the accuracy and consistency of tumor size measurements. This could improve clinicians' ability to assess imaging response and track tumor progression more effectively. Future expansion, such as implementing image augmentation and hyperparameter fine-tuning, could further improve model generalizability and stability for clinical application.

Project Mentor: Dr. Andrew Dhawan, Department of Cardiovascular and Metabolic Sciences, Cleveland Clinic Lerner Research Institute

Capstone Instructor: Dr. Jon Niemi, Department of Neurosciences

## Hearing Changes Post-TBI

**Jia Phillips**, Neuroscience; Dr. Angela Ciccia, Department of Psychological Sciences

Auditory dysfunction after traumatic brain injury (TBI) in children is a critical area of research that is relatively unexplored. Previous studies establish a link between hearing sensitivity changes and auditory processing deficits post-TBI; however, research specifically in pediatric populations is deficient, leaving gaps in understanding that ultimately impact evidence-based intervention. Addressing these gaps is critical for facilitating rehabilitation. This project aims to study the parent-reported changes in hearing sensitivity and auditory processing of children who have experienced TBIs. To do this, families from the School Transition after Traumatic Brain Injury (STATBI) study, a longitudinal study on children's return to school after brain injury, will be surveyed. Specifically, this project will assess the associations between auditory dysfunction (e.g., hearing sensitivity and auditory processing) and the child's age at injury, brain injury severity, and sociodemographic factors and how these affect socialization and academic performance. It is hypothesized that children who have experienced TBI will exhibit auditory dysfunction, with severity influenced by age at injury, brain injury severity, and sociodemographic factors, subsequently affecting socialization and academic performance. Survey questions will gather both parent- and child-reported difficulties. These results may aid in developing better interventions, including modifying classroom accommodations and informing best practices for pediatric auditory assessments. By determining specific auditory issues children face after TBI, this study will contribute to the broader understanding of sensory impairments after injury. It will also acknowledge the struggle for accessibility and highlight the need for better support services in clinical and educational settings.

Project Mentor: Dr. Angela Ciccia, Department of Psychological Sciences

Capstone Instructor: Dr. Jessica Fox, Department of Biology

**Characterization of Novel Pathogenic Drp1 Mutations in Neurological Disease and Mitochondrial Dysfunction**

**Anisha Phukan**, B.S. Biochemistry, CWRU; Pooja Madan Mohan, M.S. Biochemistry, CWRU

Dynamin-related protein 1 (Drp1), encoded by *DNM1L*, is a self-assembling, mechanochemical GTPase that plays a critical role in mitochondrial fission. Drp1 consists of four primary domains: the GTPase (G) domain, middle domain (MD), variable domain (VD), and GTPase effector domain (GED). Mutations in *DNM1L* are linked to neurological disorders, such as encephalopathy (EMPF1) and optic atrophy. Pathogenic mutations in the MD impair higher-order assembly and GTPase activity, while mutations in the G domain often result in milder phenotypes, such as isolated optic atrophy.

This study analyzed six disease-causing Drp1 isoform 3 mutants: E2A, C446F, I512T, Y654C, R673G, and Q684Ter, which correspond to de novo variants found in the longer Drp1 isoform 1. This includes C452F, located in the middle domain and linked to dilated cardiomyopathy, and mutations in the GED, such as Y691C and Q721Ter, associated with encephalopathy and other neurological symptoms. These mutations were introduced in human Drp1 isoform 3, heterologously expressed in bacteria and purified by affinity and ion-exchange chromatography. The purified proteins were then analyzed by size-exclusion chromatography-coupled multi-angle light scattering (SEC-MALS) and GTPase activity assays. SEC-MALS revealed altered self-assembly characteristics for all mutants, with C446F exhibiting both higher and lower-order oligomerization tendencies. GTPase assays revealed that the C446F, Y654C, and R673G mutants had significantly reduced activity compared to wild type (19.6%, 39%, 22.6% of wild-type activity). Structural analysis revealed that the C446F mutation perturbs a critical hinge region facilitating Drp1 conformational dynamics, whereas the Y654C mutation impairs the critical self-assembly interface 1. Additional findings include R673G disrupting an essential salt bridge involved in Drp1 auto-inhibition, whereas the E2A/Q684Ter mutations affect overall protein stability. These results provide critical insights into the molecular mechanisms of Drp1-related pathologies, with implications for therapeutic intervention.

Faculty Mentor: Dr. Rajesh Ramachandran, Department of Physiology & Biophysics, Case Western Reserve University School of Medicine

**Molecular Basis and Solvation Behavior of Choline Halide-Based Deep Eutectic Solvents**

**Kayla Poling**, Ross Clark Prado, Desiree Mae Prado, Phoebe Hood, Anna Cristina Samia, Clemens Burda,* Department of Chemistry, Case Western Reserve University

Deep eutectic solvents (DESs) are considered tunable solvents since specific properties can be achieved based on the choice of components and their relative concentrations in the mixture. In this work, we investigate the influence of the variation of halide ion of ammonium salt used in the thermodynamic and volumetric properties of choline halide-based DESs. Our findings have shown that the density of choline halide-based DESs decreases nonlinearly with increasing water content, following a trend based on the ionic radius of the halides, with choline iodide showing the highest density. Temperature-dependent density data reveal that the thermal expansion coefficient decreases slightly with increasing water content, indicating more stable volume behavior at higher water fractions. The excess molar volume of the DES mixtures exhibits complex behaviors depending on the choline halide used, with both negative and positive excess molar volume observed across different water mole fractions. These variations are linked to the hydrogen bonding interactions between the DES components and water molecules. In addition, conductivity of choline halide-based DESs increases with water content until a percolation threshold is reached, after which it starts to decline, while viscosity decreases only marginally, suggesting that excess water enhances ion mobility but does not generate additional charge carriers.

Faculty Mentor: Dr. Clemens Burda, Department of Chemistry, CWRU

## Neural Correlates of Manipulative Dexterity Tasks During Supplemental Oxygen Exposure: A Comparison of Electrical Signal Transmission

**Jackson Pollard**, Neuroscience & Cognitive Science
Lab Personnel: Niveta Ramakrishnan, Elizabeth Damato, Jeremiah Ogbadu, Hannah Boehringer, Michael Decker

Introduction: Increased inspired oxygen concentrations must be delivered to high-performance aviators to mitigate risks of hypobaric hypoxia, cerebral hypoperfusion-induced hypoxemia, and decompression injury. However, the effect of increased inspired oxygen on brain networks is poorly understood. This study aims to characterize and compare cortical EEG activity in standard inspired oxygen and 100% inspired oxygen scenarios.
Methods: This study was approved by the CWRU IRB. A 64-lead EEG headcap was used to collect cortical electrical activity in a subset of three participants selected from a pool of 8 studies. The EEG signal was analyzed to determine the origin of major electrical activity in the cerebral cortex. To generate and record changes in cortical electrical activity, study participants completed a grooved pegboard psychomotor task while exposed to 21% and 100% fractions of inspired oxygen.
Results: Coordinates of localized positive charges were referenced with the Curry 7 EEG brain atlas to determine regions of interest for electrical activity in the first two seconds of each pegboard task. Average time between charge appearances in regions of interest for the 21% and 100% inspired oxygen scenarios were compared to determine the effect of inspired oxygen concentration on the speed of electrical signal transmission. This experiment is ongoing, but currently identified regions of interest include Brodmann area 11 (including frontal and rectal gyri), temporal gyri, the precuneus/cuneus complex, and the precentral gyrus.
Discussion: Based on preliminary results, electrical signal transmission from the temporal gyri to the frontal gyri, frontal gyri to the precuneus/cuneus complex, and the precuneus/cuneus complex to the precentral gyrus all occur in less time while breathing 100% inspired oxygen compared to 21%. As more results are processed, these findings are expected to be supported.

Faculty Mentors: Elizabeth Damato & Michael Decker, Dept. of Physiology & Biophysics, CWRU School of Medicine
Capstone Instructor: Jon Niemi, Dept. of Neurosciences, CWRU School of Medicine

## Genetics of Acral Melanoma

**Tamar Poreh**, Biology

Acral lentiginous melanoma (ALM) is the rarest and most aggressive subtype of cutaneous malignant melanoma that arises on non-hair-bearing-skin, including the palms, soles, and nail beds, accounting for 2-3% of melanoma cases. Unlike other melanomas which possess high mutational burden, its disease progression is largely independent of ultraviolet exposure. Key genetic components involved in the development of acral melanoma include mutations in tumor suppressor genes such as NF1, copy number variations affecting oncogenes like TERT and CDK4, and focal amplifications in the MAPK and PI3K/AKT pathways. ALM disproportionately affects non-white populations, yet research addressing racial disparities in diagnosis and treatment remains limited. It is essential to understand the genetic and molecular basis of acral melanoma to improve early detection and develop targeted therapies to decrease high mortality rates. This review will provide a comprehensive overview of current research on the genetic landscape of acral melanoma. This includes a discussion of key genetic alterations, the pathway in which they work, epigenetics, and current therapeutic treatments.

Faculty Mentor/ Capstone Instructor: Dr. Nancy Dilulio, Department of Biology

## Detection of Heart Arrhythmia in ECG Signals Using Machine Learning

**Reyhane Pourbemany**, Biology; Dr. Hossein Ravanbakhsh, Department of Biomedical Engineering, The University of Akron

Electrocardiogram (ECG) recordings are essential for diagnosing cardiac abnormalities like arrhythmias, critical in managing cardiovascular diseases. However, manual ECG analysis is error-prone and challenging in remote areas, underscoring the need for automated systems.

This project investigates the detection and classification of cardiac arrhythmias using electrocardiogram (ECG) signals with machine learning techniques, aiming to enhance early diagnosis in healthcare. The study leverages the MIT-BIH Arrhythmia Database, a publicly available dataset with ECG recordings from 48 patients, yielding 108,251 beats. These beats were mapped into five AAMI (Association for the Advancement of Medical Instrumentation) classes: Normal (N: 90,578), Supraventricular ectopic (S: 2,779), Ventricular ectopic (V: 7,235), Fusion (F: 802), and Unclassified (Q: 6,857), aligning with clinical standards. The ECG signals were preprocessed by segmenting into 180-sample heartbeats, normalizing, and extracting features (mean, standard deviation, max, min) for traditional models, while CNN and MLP utilized raw data.

Four machine learning models—Convolutional Neural Networks (CNN), Multi-Layer Perceptrons (MLP), Support Vector Machines (SVM), and Random Forests (RF)—were evaluated. The dataset was split into 80% training, 10% validation, and 10% testing sets. Results highlight CNN's superior performance with a precision of 0.987, recall of 0.988, and F1-score of 0.987, excelling at capturing spatial patterns. MLP followed with a precision of 0.973, recall of 0.970, and F1-score of 0.971. SVM achieved a precision of 0.813, recall of 0.856, and F1-score of 0.801, while RF scored a precision of 0.812, recall of 0.789, and F1-score of 0.800. These findings underscore deep learning's advantage over traditional methods for ECG analysis.

This project offers a practical introduction to machine learning in biomedical signal processing, demonstrating CNN's potential for arrhythmia detection. Limitations include reliance on a single dataset and potential overfitting, suggesting future exploration of diverse datasets, ensemble methods, or real-time applications to improve robustness and clinical utility.

Project Mentor: Dr. Hossein Ravanbakhsh, Department of Biomedical Engineering, The University of Akron

Capstone Mentor: Dr. Stephen Haynesworth, Department of Biology

## Cx43 dependent Src Activation Facilitates Invadopodium Formation and ECM Degradation

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Glioblastoma (GBM) is an incurable grade 4 astrocytoma characterized by its extreme cellular heterogeneity and plasticity with a dismal overall survival of 16 to 20 months. The metastatic and infiltrative capabilities of GBM allow for extensive infiltration, leading to the failure of current treatment strategies. Actin-rich membrane protrusion called invadopodia drives this invasive process by facilitating the degradation of extracellular matrix (ECM) and tumor cell motility. Connexin 43(Cx43) is a gap junction protein forming channels between neighboring cells to exchange small molecules, allowing for intercellular communication. Cx43 has a context-dependent role in cancer, having both pro and anti-tumoral roles. In GBM, Cx43 has been implicated in invasion and proliferation due to its cytoskeletal-modulating roles. Preliminary studies have shown that Src, a non-receptor tyrosine kinase, interacts with Cx43. Data indicates the co-localization of Cx43 and Src at the invadopodia tips. Using glioma stem cell (GSC) lines, we sought to understand the underlying mechanism. Cx43 overexpression led to increased invadopodia formation whereas truncation of the C-terminal tail of Cx43 decreased the length and number of invadopodia. With these findings, Cx43 may function as a scaffolding protein to facilitate Src activation to enhance invadopodia formation and ECM degradation. Targeting this Cx43-Src-dependent mechanism may offer a therapeutic strategy to inhibit the hallmark invasion and infiltration of GBM.

Project Mentor: Justin Lathia, Department of Molecular Medicine, Cleveland Clinic Lerner College of Medicine at Case Western Reserve University

## Art, Cognition, and Nature: Exploring Natural Cycles

**Camille Prescott**, Cognitive Science

Past research in cognitive science looking at humans' connection to nature finds that increased nature connectedness has positive influences on mental and physical health. Art as a medium has been used to help people make meaning and engage with nature, and the present study measures whether creating and destroying as well as viewing nature-themed art can help people feel more connected to the natural cycles of the Earth. Pilot data from an activity at MoCa helps outline the proposed study.

Project Mentor: Fey Parrill, Department of Cognitive Science

## Exploring the Success of Drug Screening Techniques on Sarcoma Spheroids Using Microfluidic Devices

**Braeden Price**, Biology; Jaehun Lee, Center for Immunotherapy & Precision Immuno-Oncology, Cleveland Clinic Lerner Research Institute

Ewing sarcoma (EwS) is a highly aggressive cancer, which is characterized by sheets of small, round cells with a high nuclear-to-cytoplasmic ratio. The cells show a strong plasma-membrane staining for the protein endosialin. While there have been advancements in treatment over time, EwS remains the second most common malignancy of solid bone and soft tissue in children and adolescents due to its high metastatic proclivity and typical resistance to conventional chemotherapy and radiation. Despite these approaches, the survival rate remains poor, reaching 50% after 5 years and 30% after 10 years. Because of this, there is a vital demand for new targeting therapies that would have the ability to improve efficacy compared to chemo- and radiotherapy. This project aims to determine effective drug therapies that inhibit the proliferation of three-dimensional Ewing sarcoma spheroids in a microfluidic environment. Potential therapeutic opportunities to target sarcoma cells were determined by merging the spheroids with various drug therapies including Torin 2- an inhibitor of mTOR activity, PD 0332991- a CDK inhibitor, RGFP966- a selective inhibitor of HDAC3, Linsitinib- an inhibitor of IGF-1R and InsR kinases, and BMN 673- a PARP inhibitor. Spheroid growth was monitored via microscopy, and drug efficacy was assessed by comparing treated and untreated spheroids to determine IC50 values. The results of the drug screening are expected to align with conventional plate-based measurements, validating the microfluidic approach as a potential platform for drug testing in EwS. Additionally, we anticipate that specific inhibitors, such as Torin 2, PD 0332991, RGFP966, Linsitinib, and BMN 673, will demonstrate varying degrees of efficacy in reducing spheroid growth. These findings could provide insight into targeted therapeutic strategies for EwS, contributing to the development of more effective treatments that surpass the limitations of conventional chemotherapy and radiation.

Project Mentor: Dr. Chao Ma, Center for Immunotherapy & Precision Immuno-Oncology, Cleveland Clinic Lerner Research Institute

Capstone Instructor: Dr. Ronald Oldfield, Department of Biology

## Evaluation of Gluconeogenesis in the American Cockroach Central Nervous System (Periplaneta americana)

**Chanel Pudrycki**, Biochemistry

This project aims to evaluate the production of glucose, a simple sugar, in the central nervous system of the American cockroach (Periplaneta americana). RNA-sequencing transcriptomics that provide precedence for gluconeogenesis and glycogenolysis genes in the central nervous system. These data hint at the metabolic plasticity in pest cockroach species that might explain their adaptability to live in extreme environments, posing a concern for human health. We hypothesized that the metabolic plasticity of the CNS of pest cockroaches, via trehaloneogenesis, allows them to be pest organisms. Methodology for this project includes Glucose-Glo by Promega, quantitative PCR (qPCR), and Uric Acid Assays by Cayman Chemicals. Gene expression analysis revealed expression of crucial enzyme trehalose phosphate synthase I (TPS I), parallels sugar production in the ganglia over time. Additionally, adipokinetic hormone (AKH), the insect starvation signal, was shown to modulate TPS I expression and glucose production over time, indicating a response to external stimuli. This hormonal stimulation most likely works through signaling cascades like the PI3K/Akt/mTOR signaling axis, as mTOR activation and inhibition also modified observed neuronal glucose production over time. This sugar production has been characterized as trehaloneogenesis, as TPS I expression in the thoracic ganglia was greater than that of glucose-6-phosphatase (G6Pase). Inhibition of glycogen phosphorylase suggests that the primary neuronal method of sugar production is through glycogenolysis, and the CNS transcriptome indicates that there is more complex glycogenic regulation related to trehaloneogenic capabilities that must be further researched. Finally, observed uric acid production over time supports the hypothesis that the CNS of the American cockroach removes excess nitrogen from carbon sources, adding to its ability to function as an independent entity.

Faculty Project Mentor: Dr. Ryan Arvidson, Biochemistry, CWRU School of Medicine

**Exploring the Role of Asprosin in Anxiety Regulation: The Influence of the Hippocampus**

**Andrew Qian**, Department of Biology, CWRU; Bijoya Basu, School of Medicine, CWRU; Dr. Atul Chopra, School of Medicine, CWRU and Harrington Discovery Institute

This project examines the relationship between asprosin, a fasting-induced hormone, PTPRD, its receptor, and anxiety, focusing on how these factors are modulated by the hippocampus. Asprosin plays a key role in regulating energy metabolism by stimulating the release of glucose during periods of fasting. Recent studies suggest that asprosin may also influence emotional behavior, particularly anxiety, with elevated levels of the protein correlating with increased anxiety in animal models. The receptor PTPRD, which interacts with asprosin, is known to be involved in regulating anxiety through its role in cellular signaling. The hippocampus, a critical brain region involved in emotional regulation and stress responses, is thought to play a significant role in modulating anxiety, making it an ideal focus for this study. This research aims to investigate whether inducing anxiety in mice leads to changes in the expression of PTPRD within the hippocampus. We hypothesize that anxiety induction will alter the expression levels of these proteins, which may, in turn, affect behavioral responses related to anxiety. This project seeks to build on previous findings from our lab, which have shown that increasing asprosin levels in mice leads to heightened anxiety, while decreasing asprosin levels results in reduced anxiety. By examining the modulation of these proteins in the hippocampus, this study could provide important insights into the molecular mechanisms underpinning anxiety and the role of the hippocampus in emotional regulation. To test this hypothesis, histological staining techniques will be used to measure the expression levels of PTPRD in hippocampal tissue from anxiety-induced mice. Behavioral assays will be conducted to assess anxiety levels in the same animals, allowing for the correlation of protein expression with anxiety-related behaviors. This study will contribute to a deeper understanding of the molecular and neural mechanisms underlying anxiety, potentially leading to the identification of new targets for therapeutic intervention in anxiety disorders.

Faculty Project Mentor: Dr. Atul Chopra, School of Medicine, CWRU and Harrington Discovery Institute

Capstone Instructor: Elliot Gardner, Department of Biology

## Using Proximity Labeling to Interrogate Nitric-Oxide Dependent Protein-Protein Interactions

**Mashaal Qureshi**, Neuroscience

This research examines the role of nitric oxide (NO) in modulating protein-protein interactions involved in stress granule (SG) formation, targeting central nucleating protein G3BP1—Ras-GAP SH3 domain-binding protein 1). While stress granules are known to form in response to various environmental stressors, like heat shock and oxidative stress, the impact of NO and S-nitrosothiols (SNOs) on SG dynamics are still unknown. We aim to determine whether NO stress-induced exposure alters the G3BP1 protein interaction network to evaluate NO-mediated regulation of stress responses. To address this, a proximity labeling strategy using TurboID-Flag tagging of G3BP1. TurboID allows rapid and efficient biotinylation of proteins proximal to G3BP1 in live cells without the addition of hydrogen peroxide which risks oxidizing cysteine residues and interfering with protein function. TurboID-Flag-G3BP1 constructs were generated using bacterial cloning and expressing them in mammalian cells after which stretaviding-HRP detecting confirmed successful proximity labeling of G3BP1-associated proteins under control conditions. By characterizing NO-dependent interactions at stress granules, our results show that nitric oxide exposure modulates the G3BP1 interactome, specifically observing altered patterns of protein-protein interactions in response to NO/SNO treatment. This indicates that NO not only plays a role in redox signaling but may also act as a key regulator of SG formation through post-translational modification and interaction dynamics of G3BP1 protein. By characterizing NO-dependent interactions at stress granules, we offer insight into how nitrosative stress modulates cellular stress responses.

Project Mentor: Divya Seth, Department of Molecular Medicine
Principal Investigator: Jonathan Stamler, Department of Molecular Medicine
Capstone Mentor: Dr. Jon Niemi, Department of Neuroscience

## Risk factors for anxiety and depression in Deaf and Hard of Hearing children and adolescents

**Vanessa Rainier**, Psychology and Cognitive Science

Relative to their hearing peers, children and adolescents who are Deaf or Hard of Hearing (DHH) disproportionately exhibit symptoms of anxiety and depression, including internalizing thoughts and behavior. While many members of the Deaf community view deafness as a strength, DHH children face a variety of unique challenges related to their hearing loss that may act as risk factors for symptoms of anxiety and depression. In order to better understand the risk for anxiety and depression among DHH children, the purpose of this project is to examine previous literature on the association between potential characteristics of hearing loss and anxiety and depression. Articles were collected from the APA PsycINFO, EBSCO, and Web of Science databases using the keywords, "Deaf or Hard of Hearing," "anxiety or depression," and "children or adolescents." From these articles, ten were chosen to be reviewed in this project. Through the selected articles, this project highlights several potential risk factors, including poorer speech intelligibility, family communication, peer conflict, self perceptions, and intersectional marginalized identities, each of which was associated with greater prevalence of anxiety and depression among DHH children and adolescents. By considering risk factors that are especially relevant to the Deaf community, this review opens the door to encouraging more comprehensive early interventions and mental health care as well as further research into these risk factors and others that may predispose a child to developing anxiety and/or depression.
Keywords: anxiety, depression, Deaf and Hard of Hearing

Capstone instructor: Amy Przeworski, Department of Psychological Sciences

## Tracing Bilingual Development: A Longitudinal Case Study of Code-Switching in Tamil-English and Marathi-English Households

**Abi Rajasekaran**, Cognitive Science

This study looks at how children learn two languages in Tamil-English and Marathi-English bilingual homes. It focuses on how they mix languages, how their parents talk to them, and how their vocabulary develops. The study follows two children: a 9-month-old Tamil-English child and a 4-year, 3-month-old Marathi-English child. The younger child only speaks Tamil and doesn't mix English into their speech. However, the older child uses English nouns when speaking Marathi. When looking at the words they use most, the younger child mostly sticks to Tamil, while the older child borrows a lot of English words, especially for naming objects and school-related things. The way they form sentences also changes as they grow. The younger child mainly repeats simple Tamil phrases, while the older child mixes Marathi and English, even using English function words like "is" or "the." The study also looks at how parents speak to their kids. Tamil-speaking parents mostly talk in Tamil, which helps their child learn only Tamil at first. Marathi-speaking parents use Marathi most of the time but sometimes include English, which might help their child start code-switching early. Overall, the study shows that bilingual kids don't start mixing languages just because they get older—it depends on their environment, like school and how their parents talk to them. It also highlights that kids tend to mix languages more when talking about specific topics, like school or objects, especially in Marathi-English households.

Project Mentor: Todd Oakley, Department of Cognitive Science

**Investigating the Metabolic Role of Hyaluronic Acid in Retinal Pigment Epithelium Cells**

**Monisha Raju**, Systems Biology; Jessica Altemus & Dr. Bela Anand-Apte Cole Eye Institute, Department of Ophthalmic Research, Cleveland Clinic Foundation

Age-related macular degeneration (AMD) is a leading cause of vision loss, with no cure for its advanced stages. Current treatments, including VEGF inhibitors and photodynamic therapy, slow disease progression but fail to reverse damage. AMD pathology is characterized by metabolic dysfunction in the retinal pigment epithelium (RPE), which supports photoreceptors and maintains glucose homeostasis. Understanding the molecular mechanisms underlying RPE metabolic dysregulation is crucial for developing targeted therapies. Recent findings indicate that hyaluronic acid (HA), a key extracellular matrix component, is elevated in the plasma and RPE of patients with AMD and in models of Sorsby's Fundus Dystrophy (SFD), a monogenic form of macular degeneration. HA synthesis derives from glycolytic intermediates, suggesting that an interplay with glucose metabolism could contribute to RPE dysfunction.

This study investigates the role of HA in RPE metabolism through three experimental approaches. First, ELISA results confirm that HA production increases proportionally to glucose availability. Second, the metabolic impact of exogenous HA treatment is being assessed by analyzing intracellular and extracellular metabolites via gas chromatography-mass spectrometry (GC-MS). We anticipate that HA treatment will enhance glycolysis and TCA cycle activity, with metabolic effects potentially varying based on HA molecular weight. Specifically, high-molecular-weight (HMW) HA may promote metabolic stability, whereas low-molecular-weight (LMW) HA could induce metabolic stress responses. Third, siRNA-mediated knockdown of HA synthases (HAS1-3) will determine how HA depletion affects metabolic pathways, with the expectation that reducing HA synthesis will shift metabolism toward glycolysis.

By elucidating HA's role in RPE metabolism, this research aims to uncover novel links between extracellular matrix remodeling and metabolic dysfunction in AMD and SFD. These insights may inform the development of future therapies targeting HA to restore metabolic balance in retinal diseases.

Project Mentor: Dr. Bela Anand-Apte Cole Eye Institute, Department of Ophthalmic Research, Cleveland Clinic Foundation

Capstone Instructor: Dr. Robin Synder, Department of Biology

**Influence of Female Pheromone Concentration on Male Courtship and Mating Behavior in the Oriental Fruit Moth, Grapholita molesta**

**Arya Ramalingam,** Chemical Biology; Dr. Mark Willis, Department of Biology; Shivansh Dave, Department of Biology

A robust behavior results from millions of years of evolution, allowing species to adapt to environmental challenges. In sexually reproducing species, mate location is crucial for reproductive success. Among moths, chemical communication via sex-attractant pheromones is a common method for finding mates. Male moths typically track the female's pheromone by flying upwind along the odor stream. Unlike many species, Oriental Fruit Moth (OFM) males continue searching on foot in a zigzag pattern after landing. When within 2 cm of a female, the male releases his own courtship pheromone from specialized scales, known as hairpencils, at the tip of the abdomen. The female then accepts or rejects the male based on his pheromone signal and associated courtship behavior. This experiment aims to characterize the walking track of male OFM and tests whether varying concentrations of female pheromones influence male courtship behaviors. OFM males were exposed to a range of female pheromone concentrations that spanned the levels naturally emitted by OFM females. These pheromone concentrations (0.1 ug, 1.0 ug & 10.0 ug) were tested in a laboratory wind tunnel at 75 cm/s wind speed. We analyzed male walking tracks up the pheromone plume under the hypothesis that they vary in a concentration dependent manner. We observed three behavioral differences associated with pheromone concentration: (1) variation in the number of males reaching the pheromone source, (2) changes in the frequency of looping behavior while walking, and (3) incomplete execution of the stereotypical hairpencil display (HP), where males performed HP and wing fanning without properly orienting toward the female, potentially reducing mating success. These findings suggest an optimal pheromone concentration for courtship and that males behaviors change predictably when pheromone levels are suboptimal.

Faculty Project Mentor: Mark Willis, Department of Biology

## Targeting the CLOCK/TFPI2 signalling loop in glioblastoma

**Manaschandra Ramineni**, Biology

Past research has indicated that CLOCK and TFPI2 are mutually exclusive in GBM patients and interact symbiotically, suggesting that the inhibition of CLOCK or TFPI2 can benefit GBM patients. We identified that TFPI2 is an important secreted protein in the control of CLOCK expression. Using various biological methods, it was found that CLOCK transcriptionally induces the expression of TFPI2, while TFPI2 promotes CLOCK expression through HIF1-α-NF-kB signaling, forming a positive feedback loop in the GSC microenvironment. Inhibiting either TFPI2 or CLOCK reduced GSC stemness and promoted GSC apoptosis. Inhibition of their downstream glycolysis pathway and JNK-STAT3 cured some GBM in mouse models. Revealing TFPI2 and CLOCK work as partners in GSC self-renewal abilities. There lies promise in therapeutic interventions for GBM patients with high levels of TFPI2 and CLOCK expression.

Principal Investigator: Peiwen Chen, Cancer Biology, Cleveland Clinic
Capstone Instructor: Yolanda Fortenberry, Biology

**Investigating the Impact of a Polymer of Metabolite X on Macrophage Activity Through TLR4 Signaling**

**Ranvir Rana**, Biomedical Engineering; Dr. Sanmoy Pathak, Department of Biomedical Engineering

Inflammation is a protective immune response that helps the body fight infections and heal injuries. However, uncontrolled inflammation contributes to autoimmune disease pathology. Macrophages play a central role in generating an inflammatory response by processing foreign pathogens and releasing pro-inflammatory cytokines, such as TNF-α and IL-6. One key pathway regulating macrophage activation is the Toll-like receptor 4 (TLR4) signaling cascade, which is triggered by bacterial lipopolysaccharide (LPS) and signals through MyD88 to activate NF-κB, a transcription factor for pro-inflammatory gene expression. Given the importance of macrophages in inflammatory responses, we investigated whether our novel polymer, synthesized from metabolite X belonging to the propionate metabolism pathway, could downregulate macrophage activation and suppress inflammation. To assess the polymer's effects, peritoneal macrophages were treated with LPS in the presence or absence of the polymer for 24 hours in-vitro. Flow cytometry analysis demonstrated a significant reduction in proinflammatory macrophage responses by quantifying expression of CD80, CD86, and CD206 on CD11b+ macrophages upon polymer treatment, suggesting a decreased macrophage activation. Additionally, cytokine ELISA revealed that polymer treatment significantly reduced TNF-α and IL-6 secretion, indicating suppression of inflammation. To further investigate the mechanism through which the polymer downregulates macrophage activation, we examined its effects on the TLR4 signaling pathway. Since LPS treatment activates TLR4 through MyD88-dependent signaling, leading to NF-κB activation and subsequent pro-inflammatory gene expression, we sought to determine whether the polymer modulates key components of this pathway. Observing the expression of MyD88, NF-κB, and other antibodies found along this signaling pathway through a flow analysis would allow us to determine the step at which the polymer interferes and downregulates their activation. If the polymer does not interfere with this pathway, it suggests that an alternative signaling mechanism is responsible. Understanding this is crucial for identifying the polymer's immunomodulatory mechanism and its potential therapeutic applications.

Principal Investigator: Abhinav Acharya, Department of Biomedical Engineering

Faculty Project Mentor: Dr. Sanmoy Pathak, Department of Biomedical Engineering

**Sarcopenia and physical frailty result in worse outcomes in hospitalized patients with hepatocellular carcinoma than other solid organ cancers or hospitalized patients without cancer**

**Arnav Rao,** Biology; Dr. Srinivasan Dasarathy & Dr. Nicole Welch, Department of Inflammation and Immunity, Cleveland Clinic Lerner Research Institute.

Sarcopenia (defined by a muscle loss phenotype; MLP) and muscle contractile dysfunction (physical frailty; PF) contribute to adverse outcomes in patients with cancers including hepatocellular carcinoma (HCC). However, it is not known whether the adverse impact is different between HCC and other solid organ cancers (SOC). We tested our hypothesis that sarcopenia/PF contributes to worse outcomes in hospitalized patients with HCC than non-HCC SOC or patients without cancers. The National Inpatient Sample (2010-2014) was used to identify hospitalized patients with HCC. Comparisons were made with equivalent numbers of a random sample (2.5%) of non-pancreas other SOC, and a random sample (0.25%) of the entire general medical population (GMP) without cancers. Outcomes of interest included length of stay (LOS), hospital charges, discharge disposition (home or non-home setting), and inpatient mortality. Multivariate logistic and log-transformed linear regression analyses were performed with a 95% confidence interval. There were 33,772 patients with HCC, 43,773 with SOC, and 55,270 in the GMP. The percentage of patients with both PF and MLP was highest in the HCC group (6.8%) compared to SOC (4.4%) and GMP (3.3%). Logistic and linear regression analysis showed that HCC patients had a higher risk for in-hospital mortality when compared to all other SOC patients with the same condition of PF/MLP ($p<0.001$). HCC patients with PF alone and PF and MLP had worse outcomes when compared to all GMP and SOC patients, regardless of their PF/MLP condition ($p<0.001$). HCC patients with PF and MLP have higher costs of hospitalization, mortality rates, and longer hospital stays, with a reduced likelihood of discharge to home, compared to patients with other SOC and the GMP.

Project Mentor: Dr. Nicole Welch, Department of Inflammation and Immunity, Cleveland Clinic Lerner Research Institute.

Principal Investigator: Srinivasan Dasarathy, Department of Inflammation and Immunity

Capstone Instructor: Dr. Valerie Haywood, Department of Biology.

**Self-directed psychedelic therapy outside institutional frameworks: an ethnographic study**

**Shivani Rao**, Department of Anthropology

Psychedelics are serotonergic hallucinogens, engaging the 5-HT2A receptor to modulate neural circuits involved in sensory perception, cognition, and emotional processing. This category includes lysergic acid diethylamide (LSD), psilocybin, and N,N-dimethyltryptamine (DMT), each classified as Schedule I controlled substances due to perceived potential for abuse and lack of federal medical approval. However, emerging research suggests that psychedelics exhibit significant therapeutic potential for psychiatric conditions, including major depressive disorder (Carhart-Harris et al., 2021), post-traumatic stress disorder (Mitchell et al., 2023), and substance use disorders (Bogenschutz et al., 2015). While clinical investigations emphasize controlled administration in medical settings, this study examines ethnographic perspectives on self-directed psychedelic use outside institutional frameworks. The following investigation employed 22 semi-structured interviews with psychedelic users in Cleveland; recruitment was facilitated by an alternative medical practicioner and respondent-driven sampling. Participants reported using psychedelics in guided ceremonies, private meditation practices, and self-experimentation protocols, often informed by online communities and alternative medical practicioners. Findings indicate that users develop personalized frameworks—modifying set, setting, and dosage—to optimize therapeutic outcomes and mitigate risks. Informants describe experiences of emotional catharsis, enhanced self-awareness, and long-term psychological relief. However, they identified challenges, including navigating stigma, access barriers, and the unpredictability of psychedelic effects without professional guidance. By centering non-institutional psychedelic use, the preliminary data from this study contributes to discussions on harm reduction, accessibility, and the evolving role of psychedelics in mental healthcare beyond clinical frameworks.

Faculty Project Mentor: Dr. Lee Hoffer, Department of Anthropology

Capstone Instructor: Dr. Lee Hoffer, Department of Anthropology

**Cetirizine as a novel strategy to prevent age-associated hematopoietic decline**

**Ritisha Rashmil**, Systems Biology B.S.; Bailey R. Klein, Lyannah A. Contreras, Filip Goshevski, Sofia Wilhelm, Mia Kim, Amar B. Desai

Hematopoietic stem cells (HSCs) are primitive multipotent cells that reside in the bone marrow. They are responsible for the development, maintenance, and regeneration of blood-forming tissue throughout a person's lifetime. As age increases, the chance of developing age-related diseases is also more prevalent. In particular, cancer diagnoses generally increase with age, and hematological cancers make up a significant portion of these diagnoses.

These malignancies of the hematopoietic niche are often related to the aging of HSCs. This is characterized by a reduced ability to self-renew, a myeloid-biased differentiation pattern, and accumulation of unrepaired DNA damage caused by a lack of telomerase. This last characteristic has the potential to lead to oncogenesis, cancer, or clonal hematopoiesis of indeterminate potential (CHIP), the presence of somatic mutations in HSCs associated with an increased risk of cancer. Since decline in HSC function is believed to contribute to late-onset of hematological malignancies, understanding the aging process is crucial for effective treatments.

Our lab is currently examining new pathways or HSC regulation: in particular, the role of mast cells within the hematopoietic niche. We have previously demonstrated that mast cell-deficient mice (SASH) have significantly increased hematopoietic output in the bone marrow. We found that administration of the H1R inverse agonist, cetirizine, emulated this increased hematopoiesis in C57 wild-type mice.

This study's objective is to analyze the impact of cetirizine on HSC populations, and on hematopoietic decline in aged C57 wild-type mice. We hypothesize that cetirizine increases the functional capacity of HSCs and can be used to reduce age-related hematopoietic decline. The study is ongoing, but the results will help uncover more of the hematopoietic ageing process and contribute to safer and more effective treatments for hematopoietic malignancies.

Faculty Project Mentor: Amar B. Desai, Department of Pathology, CWRU School of Medicine

Capstone Instructor: Karen Abbott, Department of Biology, CWRU

## Differential Alternative Splicing of Genes due to PRMT1 and PRMT5 Inhibition

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Protein arginine methyltransferases (PRMTs) are enzymes that catalyze the methylation of the amino acid arginine. The main roles of PRMTs are to regulate gene transcription and RNA splicing. There are multiple classes of PRMTs. Type 1 PRMTs catalyze asymmetric dimethylation, while type 2 PRMTs catalyze symmetric dimethylation. Many cancers exhibit abnormal methylation of proteins by PRMTs, specifically PRMT1 for type 1 and PRMT5 for type 2. However, the similarities and differences in how these two different types of PRMTs regulate alternative splicing and gene expression remains poorly understood. To address this, we combined in silico RNA sequencing analysis with in vitro tumor cell experiments to demonstrate that both PRMT1 and PRMT5 inhibition alter the expression level and the splicing of RNA for a diverse array of genes. Specifically, PRMT5 inhibition promotes more intron retention, whereas PRMT1 inhibition promotes more exon skipping. When combining PRMT1 and PRMT5 inhibitors we found the combined effect was highly variable, ranging from antagonistic to synergistic.

We also examined how the effect of PRMT inhibition is influenced by the duration of exposure. As PRMT inhibitors often have a cytotoxic effect, cells that survive a longer exposure duration may have altered genetic expression that is favorable to survival compared to cells that did not survive. We hypothesized that genetic expression of cells from Day 5 duration exposure will be distinct from Day 3 duration exposure, reflecting both PRMT-induced expression differences and selection for resistance. Regardless of the outcome, understanding these effects of PRMT inhibitors at the genetic level is useful in refining PRMT inhibition approaches to cancer treatment.

Faculty Project Mentor: Dr. Daniel McGrail, Center for Immunotherapy & Precision Immuno-Oncology, Lerner Research Institute, Cleveland Clinic

**Investigating The Electronic Relaxation Mechanism in Thiophene Derivatives**

**Capri Reyes,** Reshma Mathew, Erqian Mao, and Carlos Crespo-Hernández*

Department of Chemistry, Case Western Reserve University, 10900 Euclid Ave, Cleveland, OH, United States

Thiophene derivatives, as key components in organic semiconductors, photodynamic therapy, and petroleum-derived pollutants, exhibit complex excited-state dynamics that influence their efficiency in optoelectronic applications and their environmental fate. This investigation studies the electronic relaxation mechanism of 2-3-dimethyl-benzo[b]thiophene. Using time-dependent density functional theory, ground-state geometry optimizations, vertical excitation energies (VEE), and spin-orbit coupling (SOC) were calculated in vacuum, acetonitrile, and cyclohexane. Steady-state absorption and fluorescence emission spectra were measured in acetonitrile and cyclohexane to compare with the results from the calculated VEE. These results agree well with the absorption spectra in both solvents and evidence that excitation with ultraviolet excitation of 2-3-dimethyl-benzo[*b*]thiophene at 290 nm directly populates the lowest-energy ππ* singlet state ($^1$ππ*). A fraction of the population reaching the $^1$ππ*state can decay by fluorescence with quantum yields of 0.11±0.08% and 0.29±0.06% in acetonitrile and cyclohexane, respectively. The relatively low fluorescence yields evidence that most of the population reaching the$^1$ππ* state decays non-radiatively, to either populate the ground state or a triplet state. Previous results for thianaphthene, 2-methylbenzothiophene, and 3-methylbenzothiophene have shown that triplet state population is the primary relaxation pathway.[1] Additionally, showing that S-C bond elongation plays an important role in the intersystem crossing (ISC) pathway to populate the triplet state.[1] Therefore, linear interpolation of internal coordinates (LIIC) calculations were performed to investigate the VEEs as a function of a ring-opening reaction coordinate by systematically stretching the S-C2 and S-C7 bonds of 2-3-dimethyl-benzo[b]thiophene. These calculations, together with the SOC and energy gaps between the singlet and triplet states, were used to understand the fluorescence emission and the non-radiative relaxation pathways (internal conversion to the ground state and ISC to the triplet state). Collectively, the calculations and the steady-state absorption and emission data suggest that ISC to the triplet state is the main relaxation pathway in 2-3-dimethyl-benzo[b]thiophene. The results obtained for 2-3-dimethyl-benzo[b]thiophene will be compared with those recently reported for thianaphthene, 2-methylbenzothiophene, and 3-methylbenzothiophene in both solvents.

Project Mentor: Carlos Crespo, Department of Chemistry

## Testing a New Method for Galaxy Cluster Mass Using Weak Lensing

**Joseph Rodriguez,** Physics Major

I test a new method of inferring mass profiles of galaxy clusters from weak gravitational lensing observations devised by Tobias Mistele and Amel Durakovic. The method assumes spherical symmetry and a fairly small convergence. These assumptions allow the method to be much more versatile, allowing it to be used on a wider range of galaxy clusters than other methods. To test the method, I use real data and compare inferred mass profiles of galaxy clusters to existing literature using other methods such as the NFW profile. I also use artificially created data to apply to the method to see if I get results I would expect. Expected results would be the method agreeing with existing literature and being applicable to a wider range of galaxy clusters than other methods.

Faculty Project Mentor: Stacy McGaugh, Department of Astronomy

Capstone Instructor: Idit Zehavi, Department of Physics

## “It’s something that I know that I so desperately need”: Examining Differences in Self-Stigma Toward Seeking Mental Health Support Among African-American and White Caregivers of Individuals on the Autism Spectrum

**Valery Romero**, Cognitive Science

Caregivers of individuals on the autism spectrum often experience significant stress, which impacts their well-being, increasing their need for mental health support services (Friesen et al., 2022). Self-stigma toward seeking mental health services can be one barrier to accessing these services (Mohamadi et al., 2019), particularly for African-American caregivers, who face additional challenges compared to their White counterparts. Stigma-related attitudes toward mental health care vary by race and culture, yet little is known about how caregivers of autistic individuals experience these attitudes. This study examines preliminary data on the differences in self-stigma toward seeking mental health support between African-American and White caregivers. It also explores how self-stigma and well-being are related within each group. A total of 92 caregivers (44 African-American and 48 White) were recruited through a caregiver support network. A mixed-methods analysis was conducted, including surveys using the Self-Stigma of Seeking Help (SSOSH) scale to measure self-stigma and the General Health Questionnaire (GHQ-12) to assess well-being, as well as follow-up interviews to explore participants’ experiences in more depth. No significant group differences in self-stigma were found between African-American ($M=20.32$, $SD=5.35$) and White caregivers ($M=18.39$, $SD=6.35$, $t=1.51$, $p=.14$). Correlational analyses revealed a significant relationship between self-stigma and well-being among African-American caregivers ($r=-0.42$, $p=.007$), whereas no correlation was observed among White caregivers ($r=-0.27$, $p=.08$). Additionally, differences in well-being emerged, with African-American caregivers reporting higher perceived well-being ($M=36.07$, $SD=5.81$) compared to White caregivers ($M=32.33$, $SD=7.03$, $t=2.73$, $p=.008$). A limitation of this study is the small sample size. Future research should further explore these differences across racial groups and emphasize the need for culturally responsive interventions to address stigma-related barriers to mental health care.

Project Mentor: Rita Obeid, Department of Psychological sciences

## Construction & Testing of Skipper CCD Test Stand

**Edward Rowley,** BS Physics

One of the prevailing theories of dark matter is that of weakly interacting massive particles (WIMPs), which despite being theorized to comprise 85% of matter in the universe, would interact both infrequently and with a low enough intensity with regular matter so as to make detection extremely difficult. While germanium-based detectors have become state of the art for such experiments, Skipper CCDs have recently been explored as a more cost-effective alternative. Similar to the devices found in some digital cameras, they consist of an array of small silicon capacitors, each capable of storing photon events generated by collisions with the detector as packets of electric charge. Using a well-timed series of clock pulses, charge packets can be transferred to a readout unit, whereupon charge is continually 'skipped' across the measurement gate, allowing for repeated measurement of the same charge packet and thus minimizing background noise to sub $e^-$ levels in the average over many readouts. Fermilab's OSCURA project has already built such an experimental apparatus and has opened group orders for both the CCD and LTA controller boards. The aim of this senior project is to acquire a Skipper CCD and LTA board from Fermilab, to construct a vacuum chamber housing with a dipstick cryostat for the CCD, and to assemble the electronic components along with a lab computer in order to create a new experimental setup for the university's advanced undergraduate laboratory.

Faculty Project Mentor: Benjamin Monreal, Department of Physics

Capstone Instructor: Idit Zehavi, Department of Physics

**Anatomical study of the branch patterns of the sciatic nerve in cadavers with and without unilateral knee arthroplasty.**

**Sydney Rubin,** Biology

Joint arthroplasty surgeries often result in significant changes to the biomechanics and neuromuscular function of the affected limb. We hypothesize that total joint arthroplasties of the knee joint triggers nerve sprouting to enhance sensory and motor function around the implanted joint and thereby changes the branching pattern of the sciatic nerve. The rationale for this hypothesis is that joint arthroplasty alters the mechanical load distribution and reduces proprioceptive feedback from the joint due to changes in sensory receptor function and the presence of foreign materials. Nerve sprouting, a known phenomenon after nerve injury, could counteract these effects by providing additional sensory input and restoring motor control, thereby facilitating adaptation to the new biomechanical environment and supporting rehabilitation. This adaptive response may also be a natural consequence of surgical interventions affecting local neural anatomy. To test this hypothesis, I intend to dissect sciatic nerves bilaterally in at least 2 cadavers (n=2 with joint arthroplasties, n=2 without joint arthroplasties) and characterize sciatic nerve branch patterns. Cadavers with a total knee arthroplasty in 1 limb will be enrolled in the study to observe differences in the sciatic nerve branch patterns between the 2 legs of those cadavers and between the legs of cadavers without a total knee arthroplasty. The results of this study will provide insights into the body's neural adaptations to joint arthroplasties and may inform improvements in surgical and rehabilitative practices.

Faculty Mentor: Dr. Andrew Crofton, Department of Anatomy

## Anxiety, Social Hypervigilance, and Perceived Parental Emotional Availability in Second-Generation Survivors of the Tutsi Genocide

**Tracy Rutagengwa,** Cognitive Science, Department, CWRU

This study examines how second-generation Rwandan survivors of the Tutsi Genocide experience anxiety and social hypervigilance, focusing on the scales and attitudes they report concerning these emotional states. Social hypervigilance, defined by heightened awareness and sensitivity to social threats, and anxiety, characterized by persistent worry or unease, are key areas of interest. The study also explores how parental emotional availability—defined as sensitivity (understanding the child's emotional needs), responsiveness (appropriate emotional reactions), and supportiveness (providing emotional care)—influences how second-generation survivors conceptualize their trauma and anxiety. It specifically investigates whether the ways parents were emotionally available or open about their past shape their children's emotional responses, coping mechanisms, and attitudes toward anxiety and social hypervigilance. The significance of this research lies in its exploration of intergenerational trauma and how familial dynamics affect emotional regulation and conceptualization of inherited trauma. Using a survey-based design, the study will employ Likert scale questions and open-ended questions to analyze the participants' attitudes, thoughts, and self-reported behaviors. Thematic analysis will identify patterns related to inherited trauma, emotional expression, and family dynamics. Expected results suggest second-generation survivors may report frequent patterns of anxiety and social hypervigilance with correlation to the level of perceived parental emotional availability. Moreover, the study expects to witness similar narratives and conceptualizations of the experiences of second-generation survivors of the Tutsi Genocide.

Faculty Project Mentor: Dr. Todd Oakley, Cognitive Science, CWRU

## Point-of-Care Device for ABO Blood Typing via Capillary Action

**Melis Sahin**, Biomedical Engineering; Praneeta Sambaraju, Rochester Institute of Technology; Kaitlyn Lockhart, Rochester Institute of Technology; Amanda Zigomalas, Rochester Institute of Technology; Steven W. Day, Rochester Institute of Technology

Proper blood transfusion in emergency medical situations is critical to ensuring patient survival. The high mortality rate associated with improper blood type matching makes the ABO-Rh system crucial in emergency care. Most of the conventional approaches to ABO blood type testing require expensive materials, large blood volumes, and extensive training [1]. Additionally, these methods are time-consuming and cannot be performed rapidly on-site or in developing countries. Our research looks to create a paper-based solution that is cost-effective, portable, requires minimal resources and training, and delivers results that are "ASSURED" as defined by the World Health Organization – Affordable, Sensitive, Specific, User-friendly, Rapid, Equipment-free, Deliverable. This investigation uses two distinct filter membrane housing models, as seen in Figure 1a, to develop a point-of-care diagnostic blood type test, reliant on the agglutination of red blood cells (RBCs) in the presence of anti-A, anti-B, and/or anti-Rh antibodies. Both variants contain a well from which four channels travel outward either in parallel or perpendicular directions. The blood introduced into the well flows via capillary action through the filter membrane channels, each coated with one of the previously mentioned antibodies. As the blood flows through the membrane, the antigens on the patient’s RBCs will potentially react with the corresponding dried antibodies. A positive agglutination results in either the visual separation of fluid or complete stoppage of flow allowing the user to identify the blood type of the sample.

Faculty Project Mentor: Steven Day, Rochester Institute of Technology

**Drug Target Overexpression Modulates Small Molecule Inhibitor Toxicity: Insights from DLD1 EBP and SC4Mol Overexpressing Cells**

**Salsabeel Salem**, Chemical Biology, Case Western Reserve University

Identifying small molecule inhibitors that selectively target enzymes with pathophysiological relevance is highly desirable yet challenging. Ideal inhibitors necessitate high specificity and potency, minimizing off-target binding effects while maximizing therapeutic potential. Thus, overexpressing target enzymes of potential small molecule inhibitors can mitigate the toxicity of selective inhibitors and allow for the development of a screening platform that utilizes engineered cells with the overexpression of enzymes of interest. Our platform utilizes high-throughput screening to evaluate the viability of cells that overexpress key enzymes in cholesterol biosynthesis, namely emopamil binding protein (EBP) and sterol-C4-methyl-oxidase (SC4MOL), compared to controls using a small-molecule library. A hit is defined as a compound inducing a significant fold-change in viability in overexpressive cells compared to controls. Preliminary data from the colorectal cancer cell line, DLD1, overexpressing EBP and SC4MOL demonstrate significant shifts in toxicity under lipid-restrictive conditions in response to known potent inhibitors, underscoring the efficacy of our approach. By emphasizing the rationale and workflow of our screening system, we propose an efficient method for identifying potential small molecule inhibitors of cholesterol biosynthesis enzymes.

Project Mentor: Elijah Hayes, Department of Pharmacology, Case Western Reserve University

Principal Investigator: Drew Adams, Department of Genetics and Genome Sciences, Case Western Reserve University

Capstone Mentor: Drew Meyer, Department of Chemistry

## Land of the Free—For Some: A Literature Review on Trump-Era Immigration and its Racist Nativist Roots

**Stephanie Salgado**, Sociology, Department of Sociology, Case Western Reserve University

In the United States, the Latinx community constitutes the largest minority group, yet they persistently face systemic racialization, inequality, and marginalization. This review critically examines the 2025 Trump administration's executive orders on immigration through the lens of racist nativism. It argues that these policies are not only a continuation of historical exclusionary practices that disproportionately target Latinx communities but also reinforce racialized hierarchies of domination and subordination. This literature review situates the administration's aggressive actions within broader systems of racialized subjugation and legal patterns of racist nativism– one inherently tied to US imperialism. This paper examines the far-reaching consequences of these policies, which ruthlessly deprive Latinos of fundamental rights and deny them the freedom to live in the United States without being entrenched in a system that denies them humanity and dignity. The field of social work is uniquely positioned to challenge these injustices, advocating for the Latinx community, and supporting their resistance in the fight for justice and equality.

Project Mentor: Dr. Sharon Milligan, Mandel School of Applied Social Sciences

## Electronics System for an Instrumented Prosthetic Liner

**Alden Salmons,** Electrical Engineering

Pressure concentrations in lower limb prosthetic sockets can lead to complications including but not limited to discomfort, pain, skin breakdown, and pressure ulcers. These pressure concentrations, frequently the result of improper fit, require device removal and loss of use during treatment and recovery. Real-time monitoring of these high-pressure regions can be accomplished by adding sensors to the prosthesis to aid in the fitment of the device. These sensors can monitor pressure and other metrics (e.g., temperature and humidity) to provide the clinician with valuable information on how to adjust the fit and minimize complications for the patient. One approach is to manufacture low-profile flexible sensors within the prosthetic liner to monitor the regions of high stress. This project supports that effort with a device that connects the sensors for data collection.

The prototype device employs six sensors of two types, strain gauges and force sensing resistors, to sense forces both along and normal to the liner, respectively. The design can accommodate commercial sensors or more novel aerosol jet printed gauges developed in a parallel research effort. Conductive threads connect the sensors to a secondary printed circuit board (PCB) by LilyPad-style connections. A primary PCB, housed externally to the liner, excites, amplifies, and samples the sensors. A microcontroller on the board enables battery-powered operation and wireless data transmission. This prototype validates the functionalities of a prosthetic liner-based sensing system with a low-cost solution.

Project Mentor: Janet L. Gbur, Department of Materials Science and Engineering

Capstone Instructor: Greg Lee, Department of Electrical, Computer, and Systems Engineering

**Health across the "Skills" Spectrum: Occupational Attainment, U.S. Citizenship Status, and the Immigrant Health Advantage**

**Nicole Samala,** Sociology; Rebecca Anna Schut, Department of Sociology

Although an "immigrant health advantage" (IHA) in the U.S. has been well established in the sociological literature, key questions surrounding immigrant health in the 21st century remain. Namely, increasing immigrant educational and occupational heterogeneity – as well as variation in citizenship status – necessitate further research into immigrant health across the "skills" spectrum, and an understanding of whether citizenship moderates the relationship between nativity and health. Using the 2000-2018 National Health Interview Survey, we assess whether immigrant health varies across the "skills" spectrum, measured as Bureau of Labor Statistics "job zones." We also evaluate whether U.S. citizenship moderates the relationship between nativity and health. Outcomes include self-rated health (SRH), mental health (sadness; hopelessness; Kessler (K6) distress scale scores), and healthcare access (health insurance status, whether one has a usual source of medical care). Immigrants in low skill jobs hold SRH advantages over the low skill U.S. born; this advantage diminishes, but is not eliminated, as skill level increases. Low and mid skill immigrants have lower (better) K6 scores and less hopelessness than the U.S. born. High skill immigrants report more hopelessness; higher (worse) but statistically insignificant K6 scores; and greater sadness. All skill levels of immigrants are less likely to have insurance/a usual source of care. By citizenship, low and mid skill non-U.S. citizen immigrants have the greatest advantages in SRH and most mental health outcomes. High skill non-citizens report higher levels of sadness. Yet non-citizens consistently have poorer healthcare access, even at the highest skill levels. Together, findings present a complex picture of the role that skill and U.S. citizenship play in shaping immigrant health, adding important nuance to the existing IHA literature.

Project Mentor: Rebecca Anna Schut, Department of Sociology

## Post Processing Station for Aluminum BC Impellers Morrison Products

**Dhruva Sanchai Krishnan Chinnasamy**, Mechanical Engineering

This project aims to develop an ergonomic workstation to improve the post-weld cell assembly process for backward-curved aluminum impellers at the Cleveland Facility. The post processing station is where an operator cleans weld residue and installs respective hubs and stiffeners onto the wheel with designated hardware. The transfer of this process from the Rochester, IN plant was necessitated by inefficiencies stemming from operator fatigue, unbalanced workstations, and poor tool organization. The redesigned workstation features a modular 80/20 aluminium extrusion construction, height-adjustable bench that enhances ergonomics and minimizes operator strain. Vertical storage solutions and a streamlined layout reduce clutter and optimize space utilization. The use of specialty torque guns is incorporated to reduce cycle time and improve quality standards. Tool and hardware placement within the workstation are some key concentrations of this project. Prototyping prioritized 85% completion, leaving 15% for real-time adjustments based on operator feedback. Future steps include completing the hydraulic system, integrating the impeller handling jig, and conducting time studies to quantify improvements in efficiency and operator comfort.

Project Mentor:  Nick Robinson (Plant Manager) Advisor: Majid Rashidi

## Evaluating the Role of the 3'-Untranslated Region of the NF1 Gene in mRNA Stability

**Vedhan Sarvesh,** Biology

Neurofibromatosis Type 1 (NF1) is a common autosomal dominant disorder characterized by neurofibromas, cognitive impairments, and skeletal abnormalities. NF1 patients inherit a mutant NF1 allele, leading to haploinsufficiency—a condition where only 50% of normal neurofibromin, a tumor suppressor protein, is produced. This deficiency contributes to various non-tumor-related symptoms, which remain poorly addressed by current treatments. The 3'-untranslated region (3'-UTR) of NF1 mRNA, unusually long and rich in regulatory elements, plays a key role in mRNA stability and degradation. Many RNA-binding proteins and microRNAs interact with the 3'-UTR, generally destabilizing NF1 mRNA, reducing neurofibromin expression, and leading to NF1 protein degradation. This study aims to characterize regulatory elements within the NF1 3'-UTR that influence mRNA stability. Current efforts focus on cloning NF1 3'-UTR sequences into reporter constructs and optimizing a cell model to investigate their regulatory effects. By identifying specific destabilizing elements, we seek to clarify how post-transcriptional mechanisms contribute to NF1 mRNA turnover. Understanding these interactions will provide insights into NF1 gene regulation and its role in disease pathology. Additionally, this work will serve as a foundation for future studies exploring whether targeted interventions could enhance NF1 mRNA stability and neurofibromin expression. Given the limited treatment options for NF1-associated cognitive and developmental symptoms, uncovering mechanisms that regulate neurofibromin levels may open new avenues for therapeutic development.

Faculty Mentor: Dr. Hua Lou, Department of Genetics and Genome Sciences

## Ultraviolet Photodegradation of DNA and RNA Nucleotides at 266 nm

**Arjun Saulnier,** Chemistry; Tazrin Islam Tonny, Department of Chemistry; Dr. Carlos Crespo-Hernández, Department of Chemistry

Ultraviolet (UV) radiation from the sun is absorbed by DNA and RNA nucleotides, which can result in photodegradation reactions and the formation of mutation products. These can lead to oxidatively-generated damage and carcinogenesis in living organisms. However, the efficiency of these crucial reactions is not quantitatively understood. Specifically, the photodegradation quantum yield (QY) of this interaction—the number of nucleotides degraded per absorbed photon of light—is currently unknown. To rectify this gap in knowledge, we measured the QY of the five canonical DNA and RNA nucleotides (cytidine-, thymidine-, uridine-, guanosine-, and adenosine 5' monophosphate; CMP, TMP, UMP, GMP, and AMP, respectively) in a phosphate buffer solution of pH 7.4 using a low-intensity laser at 266 nm. To quantify the radiation flux absorbed by each sample, the chemical actinometers 1,3-dimethyluracil and $KI/KIO_3$ were used because their QYs are accurately known. The changing concentrations of the sample solutions were monitored via UV-visible spectrophotometry periodically as they were irradiated. It was found that the QYs of the DNA and RNA nucleotides increases in the following order: AMP < GMP < TMP < CMP < UMP. Future work will investigate how the QYs of these nucleotides vary as a function of the excitation wavelength to understand the mechanisms of UV-induced photodegradation.

Faculty Mentor: Dr. Carlos Crespo-Hernández, Department of Chemistry

## Spin Wave Dynamics of Magnetic Nanodisk In Trilayer System

**Oliver Schatzle,** Physics

Spin waves (SWs) in nanostructured magnetic systems offer a promising platform for quantum sensing—particularly through coupling with nitrogen-vacancy (NV) center spins—as well as for information processing, due to their ability to transfer angular momentum with low energy dissipation. In this work, we theoretically investigate the SW modes in a trilayer system composed of two permalloy disks with vortex magnetic textures, separated by a non-magnetic spacer of variable thickness. The disks are coupled via interlayer exchange and dipolar interactions. Our objective is to understand how the coupling strength—tuned by the spacer height—affects the characteristics of the coupled SW modes, with particular emphasis on the roles of chirality, polarity, and propagation direction. We also explore future directions, including the interplay between coupled SW modes and spin qubits, in the context of developing new quantum sensing modalities based on spin waves. Micromagnetic simulations are employed to compute the energy and phase spectra of SW modes in these trilayer structures, systematically varying spacer thickness, vortex polarities, and coupling strengths. Representative results will be presented, highlighting how these factors influence the coupling mechanisms and offering strategies for effective control of SW interactions. In addition, we will discuss ongoing efforts to dynamically couple SW modes via mutual angular momentum pumping between the two magnetic layers, and how this dynamic mechanism differs fundamentally from static coupling.

Faculty Mentor: Shulei Zhang, Physics, CAS - College of Arts & Sciences

## Material Flammability in Future Spaceflight

**Jocelyn Schechter,** Senior, Mechanical & Aerospace Engineering

Material flammability research is an extremely important contributor to increasing the safety of spaceflight. An engineering unit called FM', Flammability of Material on the Moon, has been developed that will allow researchers to perform testing on the Lunar surface to study the effects of partial gravity on material flammability. This unit is scheduled to be delivered to the Moon in July of 2026.

The objective of this project is to further understand how oxygen and pressure affect the spread and ignition of flames. The project consists of two efforts. The first effort will involve a series of fire experiments using the FM' prototype. This effort will help determine the characteristics of flammability in certain materials when parameters such as oxygen and pressure are changed. These characteristics include the minimum energy it takes for the material to ignite as well as the rate a flame spreads. The materials to be tested include plastic (e.g., PMMA rods) and cellulose-based fabric (e.g., a custom cotton and are the same materials that will be tested in the FM? mission). The second effort is to design, plan, and conduct burning experiments aboard a parabolic flight in support of the Lunar experiments in FM'. The purpose of this flight is to test the engineering unit in simulated partial gravity conditions. Parabolic flights have limited time between tests which means there is limited time to switch the sample material and to condition the chamber between the tests. The initial effort has focused on analyzing the switching time and deciding what variables need to be changed in order for these tests to take place. Overall, this research aims to enhance space mission safety by understanding how oxygen and pressures affect material flammability in both normal and partial gravity, leading to a safer future for space exploration.

Project Mentor: Dr. Ya-Ting Liao, Assistant Professor, Department of Mechanical and Aerospace Engineering, Case School of Engineering

## Examining the Effects of Estrogen on TGFβ signaling in CD4+ T Cells

**Caroline Schlessman,** Biochemistry; Alyssia Broncano, Department of Pathology; Sarah McNeer, Department of Pathology; Dr. Wendy Goodman, Department of Pathology

Autoimmune disease exhibits a clear sex bias, with female patients being significantly more likely to develop autoimmunity than males. Fluctuations in estrogen hormone have been shown to correlate with the onset of autoimmune disease, suggesting a connection between female sex hormone signaling and immune cell dysfunction. 17β-estradiol (estrogen) has established roles in regulating cytokine signals, which we hypothesize to underly T cell dysfunction in female autoimmune patients. Previous studies have shown that estrogen inhibits TGFβ signaling in breast cancer cell lines by binding to Smad proteins and promoting their degradation. TGFβ signaling typically has immunosuppressive effects in T cells, and its inhibition may lead to excess inflammation by altering the function of CD4+ T cells. Although estrogen has been shown to inhibit TGFβ signaling in breast cancer cell lines, it is unclear whether a similar response is seen in CD4+ T cells. Through the use of proximal signaling assays, we investigated the effects of estrogen on TGFβ signaling in murine CD4+ T cells. Our results indicate that estrogen inhibits TGFβ signaling by decreasing phosphorylation of Smad3, thereby inhibiting signal transduction downstream of TGFβ receptors. These findings suggest that estrogen regulates T cell responsiveness to TGFβ, providing a possible rationale for the sex bias seen in autoimmune disease.

Project Mentor: Dr. Wendy Goodman, Department of Pathology

Capstone Mentor: Dr. Vivien Yee, Department of Biochemistry

## Examining the Relationship Between Time Engaged in Sports Participation and Body Image Amongst Adolescents

**Zev Schreiber,** Psychology

According to the World Health Organization (WHO), children and adolescents are recommended to participate in moderate intensive activity for at least 60 minutes per day. Research has shown that factors including age and sex (male or female) significantly impact whether or not an individual continued to engage in sporting activities. A lack of physical activity has been linked with both the development of negative physical health outcomes and higher levels of body dissatisfaction. The purpose of conducting this literature reviews is to examine the correlation between time spent engaged in sporting activities and the development of positive or negative body image amongst adolescents. The articles were gathered by use of search engines such as Web Of Science, PsychInfo, and SociINDEX, with use of search terms such as adolescents, body image, and sporting activity. As a whole, the research suggested that several factors played into decreasing rates of sports participation amongst adolescent youth, such as gender differences, societal expectations, and influences by other athletes in their respective sports. As for the impact of sport on body image, research suggested that the majority of adolescents who reported greater amount of time spent on physical activities reported greater body satisfaction levels. The limitations on the literature examined consisted of a heavy reliance on questionnaires and other self-report measures, as well as a wide range of populations explored. Ultimately, the literature found that more time spent in athletic activities was positively correlated with positive body image amongst adolescents.

Faculty Mentor: Anastasia Dimitropoulos, Psychological Sciences

## Territoriality – Depletion of Histone H4 causes a Pyknosis-like Reorganization of the Nucleus

**Hannah Scott,** Biology; Tanaya Vyas, Biochemistry; Rithi Ranga, Biomedical Engineering; Dr. Tartakoff, Department of Pathology.

It is unclear why the nucleolus is a distinct territory within the nucleus, as it lacks a surrounding membrane. To address this central puzzle, we studied Saccharomyces cerevisiae yeast cells to learn whether the normal organization of chromatin is responsible for nucleolar integrity. Histones are essential for packaging DNA into nucleosomes, which form chromatin. Turning off the histone H4 promoter disrupts nucleosome formation and therefore challenges the structure of chromatin. In our cells, galactose caused expression of histone H4, while glucose repressed it. In typical experiments, cells were therefore transferred to glucose medium for up to sixteen hours to observe changes in the distribution of bulk DNA, histones, and the nucleolar proteins Utp5 and Mak11. To trace these components, a second histone (Htb2) was tagged with mRFP (red fluorescent protein), DNA was stained with DAPI (blue fluorescence), and nucleolar proteins were tagged with GFP (green fluorescent protein). In glucose, cells arrest in the G2 phase of the cell cycle, a period of rapid growth and protein synthesis. These cells include one nucleus and typically arrest with a large bud. Within 16 hr of depletion, DNA begins to segregate into the bud in about twenty percent of the cells (Grunstein et al., 1988). After sixteen hours, control cells and cells depleted of H4 were imaged, and the localization of each fluorescent component was recorded for each cell. At time zero, Htb2 and DNA overlapped, while nucleolar proteins formed an arc at the edge of the nucleus. After histone H4 depletion, the red Htb2 signal had two lobes of roughly equal size. Bulk DNA coincided with one domain, Mak11 coincided with the other, and Utp5 was between the two red domains. We are now monitoring the distribution of additional nucleolar proteins to better characterize the pyknosis-like endpoint caused by H4 depletion.

Project Mentor: Alan Tartakoff, Department of Pathology Capstone Mentor: Fritz Petersen, Department of Biology

## Evolutionary Significance of Mental Health Disorders

**Jonathan Sears**, Psychology and Anthropology

Mental health disorders have long been studied through biomedical and psychological frameworks, yet an evolutionary perspective offers valuable insights into their origins, persistence, and adaptive functions. This paper explores the evolutionary significance of mental health disorders, integrating research from evolutionary medicine and psychiatry. Drawing on the work of Nesse (2006, 2023), Durisko et al. (2016), and others, this study examines anxiety, depression, obsessive-compulsive disorder, schizophrenia, ADHD, autism, eating disorders, and Alzheimer's disease through an adaptive lens. It considers whether these conditions represent evolutionary trade-offs, mismatches to modern environments, or once-beneficial traits that have become maladaptive. The paper also highlights emerging perspectives on compulsivity (Stein et al., 2016; Tonna, 2024), PTSD as a survival adaptation (Rudzki, 2022; Cantor, 2009), and the evolutionary implications of neurodevelopmental disorders (Swanepoel et al., 2017; Ploeger & Galis, 2011). By applying an evolutionary framework to psychiatry, this research aims to refine diagnostic approaches and inform treatment strategies, bridging the gap between evolutionary theory and clinical practice.

Faculty Project Mentor: Lawrence Greksa, Anthropology

**Impact of Dietary Trimethylamine N-oxide (TMAO) on Hydrogen Sulfide ($H_2S$) Production in Rat Models and Its Implications for Cardiovascular Health**

**Ishana Senthil** (BS Biology), Dr. Christopher Hine (Cleveland Clinic LRI), Dr. David Lefer (Cedars-Sinai)

Cardiovascular disease is the leading cause of death worldwide, emphasizing the need to understand how dietary components influence metabolic processes to develop effective preventative strategies. Dietary sources of carnitine and choline — found particularly in red meats, egg yolks, and dairy products — are metabolized to form trimethylamine N-oxide (TMAO) which has been associated with an increased risk of cardiovascular disease. In contrast, hydrogen sulfide ($H_2S$), produced in tissues by enzymes cystathionine-β-synthase (CBS), cystathionine-γ-lyase (CGL), and 3-mercaptopyruvate sulfurtransferase (3-MST), has been linked to cardiovascular protection due to its role as an important gaseous signaling molecule in many biological pathways. We predicted that TMAO-fed rats would have a decreased ability to produce $H_2S$ in serum and tissues. To test this hypothesis, serum and tissue samples from control (n=4) and TMAO-fed (n=4) rats were analyzed using lead acetate assays to quantify $H_2S$ production capacity levels in the liver, kidney, heart, and plasma. Preliminary results suggested a qualitative trend in that TMAO-fed rats exhibited reduced $H_2S$ production compared to controls in the tissues but not serum, indicating a potential suppressive effect of TMAO on $H_2S$ synthesis. However, statistical analysis via t-tests revealed no significant differences between TMAO-fed and control rats. Further investigation is required to examine the protein expression levels of CBS, CGL, and 3-MST in the liver, kidney, and heart tissues and increase the sample sizes to fully understand the underlying metabolic interactions between TMAO and $H_2S$ biosynthesis.

Faculty Project Mentor: Dr. Christopher Hine, Cardiovascular and Metabolic Sciences, Cleveland Clinic Lerner Research Institute

Capstone Instructor: Dr. Kathleen Hershberger, Biology Department, CWRU

**Aging Signature and Hypercoagulable Status in Glioblastoma: Implications for Tumor Progression and Treatment**

**Yein Seo**, Neuroscience; Dr. Jeongwu Lee, Cleveland Clinic Lerner Research Institute; Dr. Hye-Min Jeon, Cleveland Clinic Lerner Research Institute

Cancer is a major age-related disease, with patient age serving as a critical prognostic factor influencing recurrence and mortality rates. This is particularly evident in glioblastoma (GBM), a highly aggressive and incurable brain tumor whose incidence rises significantly with age. GBM presents significant treatment challenges due to its complex and unpredictable nature, driven by a combination of genetic, epigenetic, and developmental factors that contribute to the tumor's resistance to conventional therapies. One major complication for GBM patients is the elevated risk of venous thromboembolism (VTE), a life-threatening condition driven by a cancer-related hypercoagulable state, which remains one of the leading causes of death among cancer patients. This study examined the relationship between aging and cancer by developing an aging gene signature and subtype in low-grade gliomas, and analyzing the expression levels of this aging signature across LGG and GBM datasets. Additionally, it aimed to explore the genetic and molecular mechanisms behind the hypercoagulable state in GBM by investigating gene expression profiles related to procoagulant activity using bioinformatic tools such as Tumor Immune Single Cell Hub 2 (TISCH2), an effective tool for single-cell transcriptome analysis of the tumor microenvironment. The goal of this research is to develop a predictive model that enhances our understanding of aging and VTE risk in GBM patients, while informing therapeutic strategies aimed at reducing aging-related and thromboembolic complications. The findings have the potential to not only guide targeted interventions for mitigating these challenges in GBM patients, but also provide broader insights into cancer as a whole, contributing to better management of these complications.

Faculty Mentor: Dr. Jon Niemi, Department of Neurosciences

**Comparison of 2 year and 10 year postoperative MOAKS scores to Functionality Assessments; A Nested MOON Cohort**

**Ansh Shah,** Department of Biology; Dr. Xiaojuan Li, Department of Musculoskeletal Imaging at Lerner Research Institute.

Knee osteoarthritis is a leading cause of chronic pain and disability, especially in aging populations, with studies showing this condition exists in 22.9% of the population aged above 40. In younger cohorts, osteoarthritis can occur after acute injury, commonly known as post-traumatic osteoarthritis (PTOA). PTOA in the knee accounts for about 12% of all knee osteoarthritis cases and occurs secondary to an acute injury to the knee joint, often related to athletics. Historically, PTOA development after anterior cruciate ligament (ACL) injury has been documented. PTOA can cause pain and functional instability in patients, potentially causing an economic toll on the patient and decreasing their quality of life. Radiographically, PTOA can present itself in the form of articular cartilage degradation, bone marrow edema like lesions (BMELs), osteophytes, effusion, synovitis, and more. A common semi-quantitative method developed to grade osteoarthritis in the knee while incorporating these radiographic elements of degradation is called MRI Osteoarthritis Knee Score (MOAKS). For our project, we used a cohort of patients that underwent ACLR from the Multicenter Orthopedic Outcomes Network (MOON). These patients underwent bilateral knee magnetic resonance imaging (MRI) at 2 years and 10 years, postoperatively. At these scanning visits, these patients also completed functionality tests, detailing their pain, quality of life, and daily activity. Our goal in this project is to determine potential radiographic biomarkers for PTOA, specifically after ACLR, that correlate with a decrease in functionality from two to ten years post-op. With this information, we hope to be able to diagnose and prevent the onset of PTOA in patients moving forward.

Project Mentor: Dr. Xiaojuan Li, Department of Musculoskeletal Imaging at Lerner Research Institute

**RPTPg-mediated modulation of ErbB1 pY1173 status when exposed to metabolic or respiratory acidosis challenges in human embryonic kidney cells**

**Jainam Shah**, Neuroscience, Eva Gilker, Department of Physiology and Biophysics

Intracellular pH ($pH_i$) is tightly regulated by intracellular buffering, acid-loading, acid-extruding transporter proteins, and intra- and extracellular [$H^+$], [$CO_2$] and [$HCO_3^-$] sensors. The equilibrium between acid-loading and acid-extruding transport activity of various plasma membrane proteins sets steady-state $pH_i$. Appropriate responses to acid-base disturbances require sensors that detect extracellular ($_o$) $[CO_2]_o$, $[HCO_3^-]_o$ and/or $pH_o$. Receptor protein tyrosine phosphate g (RPTPγ) is one transmembrane protein proposed to sense $[CO_2]_o$ and $[HCO_3^-]_o$ via its extracellular carbonic anhydrase-like domain (CALD). The CALD is catalytically inactive, but retains the $CO_2$ or $HCO_3^-$ -binding motif. Monomer- or dimerization of RPTPg's intracellular phosphatase domains transduces the CALD-mediated sensing of $[CO_2]_o$ and $[HCO_3^-]_o$ to downstream signaling proteins that includes the epidermal growth factor receptor (ErbB1). We hypothesize that RPTPg CALD senses $D[CO_2]_o/D[HCO_3^-]_o$ during metabolic acidosis (MAc; 5% $CO_2$/11 mM $HCO_3^-$, pH 7.2) or respiratory acidosis (RAc; 10% $CO_2$/22 mM $HCO_3^-$, pH 7.2), then modulates ErbB1's pY/Y1173 status via phosphatase domain activation/deactivation. This alters ErbB1 kinase activity to ultimately regulate cellular acid-loading or extrusion. HEK293 cells transfected with fluorescent RPTPg-Aquamarine, and ErbB1-Citrine were exposed to control (Ctrl: 5% $CO_2$/22 mM $HCO_3^-$, pH 7.4), MAc or RAc. Immunofluorescence experiments indicate that in cells exposed MAc, or RAc, the pY1173/ErbB1-Cit ratio trend decreases by 11±36% and 29±49% respectively when RPTPg is co-expressed vs. when co-expressed with mCherry-tagged nAChR7-receptor protein (lacking phosphatase activity). There is no change in Ctrl. RPTPg-Aqua/ErbB1-Cit colocalization is not significantly different during Ctrl, MAc, or RAc. Nonetheless, RPTPg-Aqua/pY1173 colocalization trends lower from MAc≈Ctrl>RAc. Furthermore the %-difference in Pearson's coefficient between colocalized RPTPg-Aqua/ErbB1-Cit vs. RPTPg-Aqua/pY1173 increases in the order MAc<Ctrl<RAc. We found consistent RPTPg-Aqua/ErbB1-Cit colocalization during either MAc or RAc, whereas ErbB1-pY1173 dephosphorylation is more prevalent during RAc. This suggests differential ErbB1pY-fingerprints during RAc vs MAc or Ctrl conditions could underlie the alternative responses from downstream acid extruders/loaders.

Project Mentor: Dr. Fraser Moss, Department of Physiology and Biophysics

Capstone Advisor: Dr. Jon Niemi, Department of Neuroscience

## Morphological Resilience of the Foraminifera Genus Cibicidoides at Bass River Through an Ancient Warming Event

**Jasmine Shah,** Cognitive Science

Evolutionary Biology Over 55 million years ago, a rapid and large carbon release through several millennia drove an increase in atmospheric greenhouse gases, causing a global warming perturbation known as the Paleocene-Eocene Thermal Maximum (PETM). It is considered to be one of the best paleo-analogs of current and future climate change. From an evolutionary perspective, the PETM was not solely a mass extinction event but instead is commonly described as a species diversification and migration event; however, several deep-sea taxa, including benthic foraminifera, went extinct. An exception to this was along the US Mid-Atlantic paleo-continental shelf environment, where benthic foraminifera were less affected and in particular the ubiquitous genus Cibicidoides remained abundant. Here I test the shelf refugia hypothesis, which argues that the shelf environment underwent less severe ocean warming, oxygen decline and acidification relative to the deep-sea environment, allowing for Cibicidoides to remain relatively unaffected along the shelf ecosystem. I generated micro-CT images and applied modeling techniques to measure shell morphology and density of well-preserved Cibicidoides specimens recovered from a sediment core collected at site IODP 174AX Bass River located in modern day New Jersey I then compared the results to existing data from global PETM deep-sea sites. The shell morphology measurements allow us to characterize the background population variability, and better understand the physiological response and long-term adaptation within this genus. It will also contribute to the overall understanding of the adaptations of benthic foraminifera, in general, to the environmental consequences associated with the PETM. Our results promise an improved understanding of how marine microorganisms may respond to current climate change.

Faculty mentor: Dr. Tali Babila, Department of Earth, Environmental, and Planetary Sciences Capstone instructor: Dr. Ralph Harvey, Department of Earth, Environmental, and Planetary Sciences

**Evaluating the Impact of Tobacco 21 on Disparities in Cannabis and Tobacco-Cannabis Co-Use Among Youth in Cleveland, Ohio**

**Zaynab Shaheed,** Department of Population and Quantitative Health Sciences, School of Medicine, Case Western Reserve University; Stephanie Pike Moore, PhD, MPH; Erin McClure, PhD; Erika Trapl, PhD

Co-use of tobacco and cannabis is more prevalent among youth than use of each individual substance particularly among minoritized populations. While policies aimed at reducing tobacco use specifically among youth, such as Tobacco 21 (T21), have been shown to effectively and equitably contribute to declines in the prevalence of tobacco use among youth, little is known about how these policies may impact use of cannabis or co-use behaviors. The purpose of this research was to examine the impact of T21 on co-use among high school youth. Data used in this study come from the Cleveland-Cuyahoga County High School Youth Risk Behavior Survey, a repeated cross-sectional study that is collected biannually using complex survey sampling. The City of Cleveland, Ohio adopted T21 in 2016 prior to the state and federal adoption in 2018. We examined trends in the absolute difference between the highest prevalence and lowest prevalence groups with respect to self-reported use of combustible tobacco and/or cannabis in the past 30-days across gender and racial and ethnic groups. We applied a difference-in-differences approach to examine the impact of T21 in Cleveland compared to those residing in the bordering First Ring suburbs of Cuyahoga County using estimates of the prevalence of tobacco and cannabis use behaviors pre-implementation (2013-2015) to post-implementation (2017). Between 2013 and 2023, the disparities observed across demographic groups declined for co-use declined by 27.2%, and by 35.9% for use of tobacco only. Conversely, disparities observed for use of cannabis nearly doubled. T21 was associated with an increase in the prevalence of youth not using cannabis or tobacco as well as a reduced increase in the prevalence of using only cannabis in Cleveland compared to the First Ring suburbs. This research suggests that T21 not only had an impact on the prevalence of use of combustible tobacco products among youth but also the use of cannabis. While T21 appears to have contributed positive trends with respect to tobacco and cannabis, the policy's effects on use only cannabis alone are complex, as evidenced by the increased disparities in cannabis use across demographic groups. Findings highlight the need for a nuanced approach to public health policies, one that considers the potential unintended consequences on related substance use behaviors. Future research should focus on understanding the underlying factors contributing to these shifts and explore additional interventions that could mitigate the rise in cannabis use disparities while continuing to reduce use of tobacco among youth.

Faculty Project Mentor: Stephanie Pike Moore, PhD, Department of Population and Quantitative Health Sciences, School of Medicine, Case Western Reserve University

## The Impact of Climate Change on Children's Health in Developing Countries

**Kaelie Shea,** Anthropology

The purpose of this project is to explore the consequences of climate change and its effects on the health of children within developing countries, as they are the most vulnerable population to the impact of climate change and suffer a double burden due to their residence within the countries that will suffer the most. It is extremely important to consider the impact of climate change in general, however its effects on children are often overlooked or homogenized with how it affects adults. Methodology consists of an extensive literature review including case studies, documents published from WHO and UNICEF especially, and peer-reviewed sources. There are many ways that climate change impacts the health and wellbeing of children, particularly children in developing countries as its changes compromise food and healthcare access, drinking water quality, housing, and more.

Faculty Project Mentor: Dr. Lawrence Greksa, Anthropology dept, CWRU

## Development of Motor Models for Simulating Legged Robotics

**Elijah Shew,** Mechanical Engineering

Robotic mobility is constantly evolving, but traversing complicated terrain or adapting to new circumstances is still a challenge. To solve this problem, researchers at the biologically inspired research lab at CWRU look to the animals for inspiration on how to traverse these complicated terrains. Building the models for these animals are split into two parts; replicating an animal's physical constraints and designing a neural-inspired control system. Both of these are simulated using MuJoCo software. However, as the MuJoCo simulation environment and the real world have slight discrepancies, both of these parts require adjustment when moving these models to the real world. One of the sources of discrepancies in our current models are the motor approximations. The quasi-direct drive Koala V2 motors used for the cat model are currently treated as direct torque input sources. However, this does not account for the internal stiffness, damping, motor inertia and friction loss in the motors. This research approximated these values as having an additive relationship with the PID values set in the control architecture for the system. By running constant velocity with deceleration tests, and by using the reflected inertia given by the motor parameters, and then using these as initial values and fitting this to a step input with known PID parameters, the final values were found to be the final values where found to be $3.4*10^{-3}$ Nm/rad, $1.2*10^{-2}$ Nm*s/rad, $1.1*10^{-3}$ kg/m$^2$, 0.19 Nm. The current model using these values in MuJoCo still has its limitations, but further research will work to overcome these limitations and allow for full implementation in future models.

Faculty Project Mentor: Dr. Roger Quinn, Department of Mechanical and Aerospace Engineering

## Obstructive Sleep Apnea and Panic Disorder:A Critical Review of the Bidirectional Comorbidity

**Katherine Shiells,** Psychology and Cognitive Science

Obstructive Sleep Apnea (OSA), has a population prevalence of 2-4%, and is a sleep disorder that includes repetitive interruptions in breathing during sleep. Symptoms include sudden awakening, increased sympathetic arousal, sleep fragmentation, daytime sleepiness, and is connected to future development of significant health disorders. Panic Disorder (PD) is an anxiety disorder that includes symptoms of intense fear, increased heart rate, elevated blood pressure, and decreased quality of life. 18% of panic attacks occur from a sleeping state, and so, the comorbidity of obstructive sleep apnea and panic disorder is extremely significant in effective clinical treatment in patients. This paper aims to examine the bidirectional relationship between obstructive sleep apnea and panic disorder in the population, and analyze the current, yet limited, literature on the subject. Twelve empirical studies were selected for this review, using the keywords: Sleep apnea or obstructive sleep apnea or apnea; panic disorder or panic or nocturnal anxiety. The studies determined that individuals with both obstructive sleep apnea and panic disorder presented with increased respiratory irregularities which worsened individuals' sleep quality, arousal levels, somatic symptoms, and anxiety. CPAP therapy was shown to significantly reduce these symptoms, especially nocturnal panic, increasing sleep quality and daytime functioning. Future studies should aim to increase sample sizes, as diagnostic and treatment technology is now allowing a deeper analysis of the comorbidity that these two conditions are associated.

Faculty Mentor: Dr. Amy Przeworski (PhD), Department of Psychological Sciences

Key Words: Sleep apnea or obstructive sleep apnea or apnea; panic disorder or panic or nocturnal anxiety

**Real-time assessment of pre-seizure behavioral phenotypes in a mouse model of temporal lobe epilepsy**

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Temporal lobe epilepsy (TLE) is the most common form of epilepsy and affects approximately 50 million patients worldwide. The use of animal models allows researchers to systematically study different aspects of the disease and potential treatments to it, and therefore has improved our understanding of TLE, which has, in turn, decreased patients' mortality rate. Some patients with TLE have also been reported to be able to anticipate the onset of a seizure and demonstrate some behavioral changes, in a phenomenon known as aura. The mouse pilocarpine model of TLE has been shown to be an appropriate animal model to capture some of the key features of the disease, such as damage to the temporal lobe, replication of the latent period of the disease, and localization of seizures to the limbic system. Prior studies have explored the behavioral changes associated with this disease model, but little is known about potential behavioral changes preceding a seizure as seen in the disease. The aim of this study is to classify the behavior before, during, and after convulsive seizures in the pilocarpine model of TLE, in addition to comparing the overall behavior preceding and following pilocarpine treatment. In order to examine behavioral changes, a model was trained using the pose estimation software package DeepLabCut. Pilocarpine-treated mice were recorded before treatment and in one week increments after treatment. The results are expected to reveal significant behavioral changes following pilocarpine treatment, as well as provide some insight into pre-seizure behavioral phenotypes in the pilocarpine model of epilepsy.

Project Mentor: Hod Dana, Department of Neurosciences, Cleveland Clinic Lerner Research Institute Capstone Instructor: Jon Niemi, Department of Neurosciences

**Blind Boxes' Similarities to Gambling: Examining Their Addictive Appeal and Psychological Risks**

**Emily Shu,** Cognitive Science

Blind boxes are a marketing strategy in which mystery products are sealed in packages and remain unknown until users open the box. Reaching 1.3 billion USD in global market value in 2021 to 14.2 billion in 2024, this phenomenon has surged in popularity in recent years, and has become a way to sell exclusive series of figurines and toys. Blind boxes rely on the surprise element of the unboxing experience, and the thrill of uncertainty and reward that come with it. Consequently, there has been growing concern in blind boxes' parallels to gambling behaviors. With randomized odds, variable rewards, and the potential for compulsive spending, blind boxes exhibit mechanics similar to those found in traditional forms of gambling. Since blind boxes are especially popular among a younger audience, it becomes crucial to understand the possible psychological risks that underlie these purchases. This narrative literature review examines the similarities blind boxes have to other forms of mystery boxes (loot boxes, collectible card games) that have been previously connected to problem gambling, and explores the psychological aspects of blind boxes that make them so compelling and addictive. Due to the limited nature of research on blind boxes, all relevant articles were used in the review. The findings demonstrate that while not completely alike to its predecessors, blind boxes share elements that reflect many aspects of gambling, including consideration, prize, and chance.. Additionally, due to the surprise-based element of blind boxes, this strategy is inherently based on pleasure principles that can potentially become addictive, especially to a young audience. These findings suggest further research must be conducted in order to fully understand the impact of blind boxes. Awareness of its potential implications can help lead consumers to make more informed decisions in the future.

Capstone Instructor: Anastasia Dimitropoulos, Department of Psychological Sciences

## Using Polarization-Sensitive Optical Coherence Tomography (PS-OCT) to Image the Internal Structures of the Intact *Manduca sexta* Moth Antenna

**Asha Shukla**, B.S. Neuroscience

The *Manduca sexta* moth is easy to rear in the lab, is relatively large compared to other insects (which aids in dissection), and has a simplistic nervous system. As such, the moth antennal system, from its anatomy to its role in odorant processing, has been well-studied in the context of neuroscience. However, most studies have had to dissect the antenna into cross-sections to analyze its internal anatomy and physiology with various histological and imaging analysis methods. To our knowledge, the existing literature does not include sufficient documentation regarding how to image through the thick cuticle of an unperturbed, full-length antenna. In this study, we introduce antennal preparation methods for imaging full-length antennae via polarization-sensitive optical coherence tomography (PS-OCT), a technology novel to moth antennal imaging studies. By combating challenges, such as the thickness of the antenna's cuticle and the tendency of antennal tissue to auto-fluoresce, we lay the foundation for the non-destructive imaging and identification of the internal structures of the moth antenna.

Project Mentor: Dr. Angela Dixon, Department of Biology and Biomedical Engineering

Acknowledgements: Michael Douglass, PhD student, Rollins Lab at CWRU

**Super-Resolution Microscopy of the Synaptonemal Complex During Meiosis in Drosophila melanogaster**

**Anjelyna Siamphone,** Department of Biology, CWRU; Nicole Crown, Department of Biology, CWRU; Joseph Terry, Department of Biology, CWRU

Crossover (CO) formation is essential for producing genetically diverse gametes during meiosis. Errors in this process can result in chromosome missegregation, a leading cause of miscarriage in humans. The synaptonemal complex (SC), a meiosis-specific protein scaffold, facilitates CO formation by aligning homologous chromosomes and promoting the repair of DNA doublestranded breaks into COs.

While the SC's functional role is well established, less is known about its structural dynamics during CO formation. Specifically, how changes in the SC structure and organization might influence its function. In this study, we utilize super-resolution microscopy to observe SC structure and morphology at sites of CO formation in *Drosophila melanogaster.* Investigating these structural changes could provide insight into the mechanisms that promote CO formation and ensure faithful chromosome segregation.

To investigate structural changes in the SC, we used super-resolution microscopy to image ovary tissue dissected from *D. melanogaster*. Immunofluorescence targeted two key SC proteins: C(3)G, a transverse filament protein, and Corolla, a central element protein. To assess CO formation, we used flies carrying a copy of Narya, a protein that marks sites of COs, fused GFP, enabling direct visualization of this protein under the microscope. Given the SC's extremely narrow space between chromosomes, we employed Stimulated Emission Depletion (STED) microscopy to achieve a higher resolution than traditional confocal imaging.

Our preliminary results indicate that STED microscopy effectively reveals the organization of the SC at a resolution unachievable with traditional microscopy. Additionally, we can observe the co-localization of our CO protein, Narya-GFP, foci with both targeted components of the SC. Further image quantification and analysis are done to characterize distinct changes in SC structure associated with sites of CO formation. Our ability to observe the co-localization of COs and various SC components is a first step toward understanding the relationship between the SC structure and function.

Project Mentor: Dr. Nicole Crown, Department of Biology, CWRU

**Epigenetic Regulation in Cancer Immunotherapy: The Role of DNA Methylation and Histone Modifications**

**Sabrina Silva,** Biology, B.A.

Cancer progression and immune evasion are driven by both genetic mutations and epigenetic modifications, including DNA methylation and histone modifications, which regulate gene expression without altering DNA sequences. These epigenetic changes influence the tumor microenvironment by modulating immune checkpoints, suppressing antigen presentation, and inducing T-cell exhaustion, ultimately contributing to immune escape. Targeting epigenetic regulators, such as DNA methyltransferase (DNMT) and histone deacetylase (HDAC) inhibitors, has shown promise in reprogramming the immune response and enhancing the efficacy of cancer immunotherapies, including immune checkpoint inhibitors (ICIs), CAR-T cell therapy, and cancer vaccines. Recent advancements in epigenetic therapy have demonstrated potential in converting immunologically "cold" tumors into "hot" tumors, improving immune infiltration and treatment response. Additionally, emerging approaches like CRISPR-based epigenome editing and novel small-molecule inhibitors offer innovative therapeutic possibilities. However, challenges such as drug resistance, toxicity, and patient heterogeneity remain significant barriers to clinical success. This review explores the impact of DNA methylation and histone modifications on cancer immunotherapy, highlighting therapeutic strategies and future directions for overcoming resistance and improving treatment outcomes.

Faculty Project Mentor: Nancy Dilulio, Biology Department, CWRU

## Systematic forecasting for the Taurus CMB experiment

**Simon Silverstein,** Physics, Case Western Reserve University

The balloon-borne Taurus experiment will measure the polarization of the cosmic microwave background (CMB) on large angular scales over the course of a month-long flight. This project is to create a python-based computational pipeline for determining the effects that a systematic error in polarization angle would have on subsequent uncertainty in measurements of the universe's optical depth to reionization $\tau$. It will further validate the methods of power spectrum estimation to be employed by the experiment. By understanding these effects and mitigating errors, Taurus may break the double degeneracy in the $\Lambda$CDM + ${}^{\mathrm{P}}m_{\nu}$ model, ultimately lowering the bound on the sum of neutrino masses ${}^{\mathrm{P}}m_{\nu}$.

Faculty Project Mentor: Johanna Nagy, Physics, CAS - College of Arts & Sciences

## In Vitro Studies on Activation and Potentiation of Human Mast Cells by Cysteinyl Leukotriene-Like Metabolites

**Emma Sintic,** Chemistry

Mast cells perform an array of functions within the body, particularly in asthma, where they release various mediators such as histamine, prostaglandins, and leukotrienes. These mediators contribute to an upregulation of asthma-related processes including bronchoconstriction, mucus secretion, and mucosal edema. During allergic reactions, production of immunoglobulin E (IgE) is significantly increased; however, mast cells can also be activated independent of IgE. Specifically, øLTs may activate mast cells via CysLTRs. In LUVA mast cells, øLTs induce phosphorylation of ERK, Akt, and NFkB without the involvement of IgE, suggesting that øLTs may independently activate mast cells and trigger the release of histamine, prostaglandins, and leukotrienes. Western blot analysis confirmed that certain øLTs upregulated phosphorylation in the ERK, Akt, and NFkB signaling pathways. However, these findings are inconclusive and cannot be generalized. Additional time points should be included in experiments to identify the optimal exposure time to the øLTs. Dose-response studies should also be conducted to determine the most effective concentrations of øLTs. Future research should consider these components and incorporate qPCR to quantify inflammatory cytokines and interleukins in response to øLTs stimulation. If øLTs are confirmed to activate mast cells independently of IgE, this could offer a new treatment for asthma, particularly for patients whose existing treatments are insufficient.

Faculty Project Mentor: Mikhail Linetsky, Chemistry, CAS - College of Arts & Sciences

## Estimating Biological Age on the Basis of Abdominal CT for Urologic Cancer Patients

**Jayant Siva,** Biology**;** Dr. Nicholas Heller, Department of Urology, Cleveland Clinic

Assessing biological health beyond chronological age is an emerging area in medical imaging and machine learning. Prior studies have focused on kidney cancer-specific models, limiting their applicability across different abdominal malignancies. This study develops a machine learning model that predicts patient age from abdominal CT scans, using the C4 vertebra as a centroid to provide a standardized view of the abdomen. This approach allows for generalization beyond kidney cancer to broader abdominal oncology. We introduce AI Age Discrepancy, the difference between a machine learning-predicted age and a patient's chronological age. A positive AI Age Discrepancy indicates the model predicts an older-than-expected age, potentially reflecting poorer biological health. Final age predictions were obtained through a weighted average across multiple views, incorporating different aspects of the abdomen. AI Age Discrepancy was a significant predictor of both patients' overall survival and length of hospital stay. Patients with higher AI Age Discrepancy had prolonged hospitalization and reduced survival, independent of known prognostic factors. These findings suggest that AI Age Discrepancy captures a meaningful biological signal, offering a potential imaging-based biomarker for patient risk stratification. By shifting from kidney-specific modeling to a general abdominal cancer framework, this study extends the utility of AI-driven biomarkers in oncology. AI Age Discrepancy may aid in clinical decision-making for all abdominal cancers, providing an additional metric for evaluating patient health beyond traditional assessments.

Faculty Project Mentor: Abdel Halloway, Department of Biology, Case Western Reserve University

Capstone Instructor: Nicholas Heller, Department of Urology, Cleveland Clinic

**Development of a Mouse Model for Geleophysic Dysplasia Type 1 to Investigate Disease Mechanisms and Therapeutic Approaches**

**Divya I. Sivakumar[1],** Connie Lin[2], Sophia T. Gavalas[2], Nandaraj Taye[3], Deborah E. Seifert[2], Zerina Balic[3], Dirk Hubmacher[3], Timothy J. Mead[2,4]

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Geleophysic Dysplasia (GD) is an exceptionally rare, genetic connective tissue disorder characterized by severe short stature, joint contractures, thickened skin, and cardiovascular and pulmonary complications, with a high mortality rate due to progressive heart valve disease and airway narrowing. GD is primarily caused by recessive mutations in ADAMTSL2 (GD1, ~50% of cases) that impair extracellular matrix formation and disrupt TGF-β signaling, which is crucial for tissue development and repair. Despite its severe impact, there are currently no disease-modifying treatments that exist for GD1. To model the disease progression of GD1 and facilitate therapeutic testing, we created a mouse model by introducing the patient-specific ADAMTSL2 c.499G>A (p.D167N) mutation into the *Adamtsl2* locus, creating *Adamtsl2*$^{D167N/D167N}$ mice. These mice exhibit reduced postnatal survival, short stature, and radiographic evidence of significantly shortened limb bones with delayed mineralization. Histological analysis shows a decrease in hypertrophic chondrocytes as well as dysplastic, enlarged aortic, pulmonic, and mitral valves, which are all consistent with the progressive heart valve disease seen in human GD1. Additionally, vesicular bronchial obstruction, similar to *Adamtsl2*$^{-/-}$ lungs, was observed, aligning with pulmonary complications in GD1. Furthermore, *Adamtsl2*$^{D167N/D167N}$ skin is thickened as is witnessed in GD1 patients. Therefore, this mouse model recapitulates critical features of GD1, providing an invaluable tool for investigating the molecular mechanisms of ADAMTSL2 restoration and testing potential therapeutic approaches. Future studies will focus on exploring these mechanisms to develop targeted treatments for GD1, with the goal of improving survival and quality of life for individuals with this debilitating disorder.

Faculty Mentor: Dr. Timothy J. Mead, Department of Pediatrics, Case Western Reserve University School of Medicine and University Hospitals Rainbow Babies and Children's, Cleveland, OH

## Gravitational waves in non-orientable universes

**Ananda Smith**[1], Craig Copi[1], Glenn Starkman[1; 1]Department of Physics, CWRU

Modern cosmology uses general relativity to describe our Universe as a manifold with a local geometry known at any point in space and time. However, general relativity says nothing about the global structure, or topology, of a spacetime manifold; several topologically distinct manifolds can admit the same local geometry. It is therefore worthwhile to investigate observable consequences of topologically nontrivial universes that admit one of the three local spatial geometries (Euclidean, spherical, and hyperbolic) permitted in the current standard cosmological paradigm. In this project, we solved the tensor eigenmodes of the Laplacian, which describe gravitational waves, in the 8 spacetime manifolds admitting Euclidean spatial geometry with non-orientable topology, wherein handedness is not well-defined. We then predict the statistical properties of fluctuations in the cosmic microwave background (CMB) temperature and polarization (E and B modes) within these non-orientable spaces. Future work will compare these predictions to observed CMB temperature and polarization fluctuations to constrain the topology of our Universe.

Project Mentors: Dr. Craig Copi, Department of Physics, CWRU; Dr. Glenn Starkman, Department of Physics, CWRU

**Analysis of a hypomorphic *mei-P26* mutation reveals developmental control of CO patterning mechanisms**

**Ally Solomon**, Biology

Meiosis is a specialized type of cell division, in sexually reproducing organisms, that reduces the chromosome number by half and, thus, produces gametes. In *Drosophila melanogaster*, female production and gamete maturation largely depends on meiosis and germline stem cell differentiation. Proper chromosome segregation requires crossover formation between homologous chromosomes. Furthermore, the proper formation of the synaptonemal complex (SC) is crucial for proper navigation of crossovers during meiosis. Crossover formation is also regulated through mechanisms such as crossover assurance, interference, and the centromere effect. The *mei-P26* gene plays a crucial role in germline development, and mutations in *mei-P26* disrupt meiosis, leading to defects in cell differentiation, reduced crossovers, and increased nondisjunction. However, the underlying cause of these abnormalities remains debated. Here, we investigate the role of *mei-P26* in meiotic crossover patterning using a hypomorphic *mei-P26$^{1}$* mutant. Immunofluorescence imaging of female germaria reveals that *mei-P26$^{1}$* mutants exhibit extended expression of mitotic cell cycle markers, indicating disrupted mitotic regulation. Despite this, differentiation is rarely fully blocked, and mutant cells can still enter meiosis. However, although mutants complete the early stages of prophase, most nuclei fail to assemble a full-length SC. While double-strand breaks are induced and crossovers form in these mutants, both the centromere effect and crossover interference are lost. The requirement of MEI-9 for crossover formation remains intact, suggesting that entry into zygotene commits pro-oocytes to meiotic homologous recombination, ensuring crossover assurance. Our findings support a model in which SC formation is critical for proper crossover patterning. The defects in *mei-P26$^{1}$* mutants suggest that incomplete SC assembly contributes to reduced crossovers and increased nondisjunction. This study provides insight into how developmental timing influences meiotic recombination and underscores the importance of *mei-P26* in ensuring proper chromosome segregation.

Faculty mentor: Nicole Crown, Department of Biology

## Gut-Microbial Production of Aromatic Carboxaldehydes and Their Association with Inflammatory Bowel Disease

**Rachel Son**[1-3], Manish Kumar[1,2], Sarah Preston[1,2], Rober Glowacki[1,2], Kelley Carr[1,2], Philip Ahern[1,2], Florian Rieder[2,4-6], Jan Claesen[1,2], and Ina Nemet[1,2]

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Gut-microbes play an important role in maintaining our health through the alteration of available nutrients and by the production of metabolites. Indole-3-carboxaldehyde (I3A), an aromatic carboxaldehyde (ArA) synthesized by gut microbes from aromatic amino acid tryptophan (Trp), has been associated with various human diseases. Capacity of gut microbes to produce other ArAs remains relatively unexplored.

To explore the gut microbial capacity to produce ArAs from other aromatic amino acids, we developed and validated a stable isotope dilution Liquid Chromatography-Mass Spectrometry (LC-MS/MS) method for quantifying benzaldehyde (BA), 4-hydroxybenzaldehyde (4HBA), and 4-imidazolecarboxaldehyde (4IA) in addition to I3A. We showed that suppression of gut microbes resulted in lower production of those ArAs within the host. Further, we identified multiple commensals with capacity to produce selected ArAs by screening their production in cultures and showed that individuals with inflammatory bowel disease have lower levels of selected ArAs when compared with the control subjects.

Project Mentor: Dr. Ina Nemet, Department of Cardiovascular and Metabolic Sciences, Cleveland Clinic Lerner Research Institute

## A Consistent Mathematical Representation of Zooplankton

**Jiayi Song,** Environmental Geology BA

Zooplankton and phytoplankton in the ocean ecosystem play a critical role in controlling the transport and storage of carbon in the marine carbon cycle. As the predator, zooplankton eat photosynthetic phytoplankton. Analyzing the grazing behaviors and changes in the population of the planktonic community may improve our understanding of the status of ocean ecosystems and predict the future environmental changes in the ocean. Marine biochemical models are important tools for the study of the roles of zooplankton and phytoplankton and are increasingly important in recent years as climate change becomes worse. However, uncertainties in the correct mathematical representation of zooplankton translates into significant uncertainties in model projections. We aim to find the most realistic and consistent formula from selected zooplankton grazing formulas compiled by Rohr et al. in 2023. For model validation, we used 15 published data sets of paired biomasses of zooplankton and phytoplankton. Through model simulations and interpreted data, the scaling exponents of model outputs were compared with the real-world data. We found that the OECO-v2 grazing formulation, combined with a hyperbolic zooplankton mortality performed the best when compared with real-world data. Since we only used simple grazing formulas in the models, future research may focus more on models with more complex formulas and food webs, for example including mesozooplankton species.

Faculty Mentor: Anne Willem Omta, Earth, Environmental, and Planetary Science Department

## Buck DC-DC IC Design

**Anyongyong Zhao**, Department of Engineering (CWRU), **Keyu Song,** Department of Engineering (CWRU)

With the growing demand for efficient and reliable power management solutions in modern electronic devices, DC-DC converters have become essential components in ensuring stable voltage regulation and energy efficiency. Among them, the Buck DC-DC converter is widely utilized in applications ranging from consumer electronics to industrial systems due to its simplicity and effectiveness in stepping down voltage. This project is conducted within the framework of a course on electronic circuit design, aiming to bridge theoretical concepts with practical implementation.

**Methods:** The project involves designing a custom circuit that integrates key modules such as the bandgap reference, hysteresis comparator, and driver circuit, followed by extensive simulation to evaluate its performance, including stability, efficiency, and ripple control. We decided to schematic the circuit via Cadence, which is a wild used software in circuit design. Furthermore, we will also simulate the performance of our entire design.

Key milestones include completing the soft-start circuit and performing initial simulations to validate the core functionality, followed by implementing the sawtooth wave generator and comparator modules. Circuit integration and gate block development are prioritized before progressing to amplifier design and simulation. Future work will focus on refining timing control with a Dead-Time module, finalizing circuit schematics, and preparing for full system simulation to ensure performance and readiness for demonstration.

**Goals:** The primary goal of this project is to design and simulate a high-efficiency Buck DC-DC converter using the TSMC 180nm CMOS process. Specific objectives include understanding the operational principles of Buck converters and leveraging the capabilities of the TSMC 180nm technology for compact, high-performance circuit design.

Project Mentor: Chase Cao, Assistant Professor, Department of Electrical, Computer and Systems Engineering

## Health Literacy in Older Adults: A Rapid Review

**Laurie Song**, Nursing; Samantha DeSimio, Nursing; Siobhan Aaron, Nursing

The U.S. Census reported that the older adult population grew at a record pace in the 2010s and will continue rising rapidly. Older adults are especially vulnerable to low health literacy (LHL) or limited ability to interpret health information. This is particularly concerning in this population as health literacy is key to managing chronic conditions efficiently and in limiting excess healthcare utilization. This review aimed to synthesize recent research on the relationships between health literacy and health outcomes, behaviors, or experiences in older adults. A search was conducted across PubMed, Scopus, and CINAHL, filtering for studies published between January 2020 to December 2025. Inclusion criteria targeted U.S. older adults (≤65), valid or reliable health literacy measures, and health literacy as a comparator of health outcomes or health-seeking behaviors and attitudes. Ten studies met the criteria for analysis.

Findings indicated that LHL was frequently associated with adverse health outcomes and challenging healthcare experiences in older adults. Specifically, LHL was linked to worse health outcomes such as increased burdensome COPD symptoms, frequent postoperative complications, and a greater likelihood of memory loss, depression, and hearing loss. Additionally, LHL was correlated with unfavorable healthcare utilization, such as greater readmission rates, emergency visits, hospitalizations, and increased healthcare costs. LHL was also related to negative health behaviors and experiences such as heightened emotional distress from COPD, worse medication adherence, and greater treatment burden. Conversely, adequate health literacy was associated with more detailed advance care planning discussions and higher satisfaction with care communication. Few studies reported no significant associations between health literacy and related outcomes: COVID-19 infection, preventive attitudes, or medication discontinuation concerns. These findings and the general lack of relevant literature highlight the need for targeted interventions to address health literacy in this population to improve health outcomes and reduce healthcare costs.

Faculty Project Mentor: Siobhan Aaron, School of Nursing

## Addressing the Need for Healthcare-Specific AI Governance in Ohio

**Sabrina Soto**, Political Science; **Paisley Tuel,** Economics

The rapid adoption of artificial intelligence (AI) in healthcare presents both opportunities and challenges, particularly in Ohio, where a lack of AI-specific regulations leaves providers and patients vulnerable. While AI enhances diagnostics, treatment personalization, and operational efficiency, unregulated deployment risks patient safety, data privacy, and algorithmic bias. Unlike states such as California, Massachusetts, and Illinois, which have established AI governance frameworks, Ohio lacks comprehensive oversight.

This study examines Ohio's regulatory gaps through a comparative analysis of state-level AI governance models. We evaluate policies addressing transparency, data privacy, and algorithmic accountability, identifying best practices that could inform Ohio's approach. Additionally, we assess Ohio's existing AI-related policies, highlighting deficiencies that could exacerbate healthcare inequities.

Our findings underscore the need for Ohio to implement structured AI governance. Key recommendations include mandatory AI certification for hospitals, patient consent and transparency requirements, and the establishment of a statewide AI Governance Committee. These measures aim to balance innovation with ethical oversight, ensuring AI enhances rather than undermines healthcare outcomes.

By addressing these gaps, Ohio can lead in responsible AI integration. A proactive regulatory approach will protect patient rights, reduce healthcare disparities, and foster ethical AI innovation, creating a framework that could serve as a national model.

Keywords: Artificial Intelligence; Healthcare Regulation; Ohio Policy; Algorithmic Bias; Data Privacy; Patient Safety; AI Governance

Faculty Project Mentor: Kathryn Lavelle, Political Science

## Enhancing NK Cell Cytotoxicity for Solid Cancers with Small Molecule Therapy

**Nivedita Srinivasan,** Biology B.S., Case Western Reserve University

Immunotherapy has emerged as a powerful strategy to combat cancer, leveraging the body's immune system to recognize and destroy tumor cells[1]. T cells and Natural Killer (NK) cells are at the forefront of these approaches due to their unique cancer-fighting capabilities[1]. NK cells, in particular, offer a safe and promising alternative due to their innate ability to recognize and kill cancer cells without needing prior antigen sensitization[1]. However, NK cell therapies face limitations, particularly their inability to sustain robust and durable tumor clearance in vivo, especially in solid tumors[2]. To address the limitations of current NK cell therapies in treating solid tumors, this project builds on a high-throughput phenotypic screen conducted at the University of Texas Southwestern Medical Center (UTSW), where 150,000 compounds were tested for their ability to enhance NK cell cytotoxicity against ovarian cancer (OVCAR3) cells. Among the hits identified in the primary screen, one compound (NKSM01) emerged as a lead candidate, with over 10% increase in NK cell-mediated killing of OVCAR3 cells compared to the vehicle-treated control. This project extends the investigation of NKSM01 beyond ovarian cancer to assess its ability to enhance NK cell cytotoxicity against other solid tumor models, including pancreatic (PANC1), prostate (PC3), and colon (HCT116) cancer cell lines. The methods involve isolating NK cells from blood, treating them with NKSM01 at varying concentrations, and assessing cytotoxicity using a calcein-based killing assay. Flow cytometry quantifies NK cell viability and cytotoxicity, with alternative LDH and luciferase assays available if needed. This ongoing project is expected to show that NKSM01 enhances the cytotoxic efficiency of NK cells in treating various solid cancers. By leveraging the intrinsic killing mechanisms of NK cells and the efficacy of NKSM01, this research aims to broaden the therapeutic potential of the compound and establish its viability across multiple cancer types.

Faculty Project Mentor: Dr. Emmitt Jolly, Department of Biology, CWRU College of Arts & Sciences

Capstone Instructor/PI: Dr. David Wald, Department of Pathology, CWRU School of Medicine

Capstone Mentor: Indrani Das, Department of Pathology, CWRU School of Medicine

**Development of an in-vitro Nucleic Acid and Quantum Dot-Based Cadmium Biosensor with Potential Multiplexing Capabilities**

**Era Srivastava**, Biochemistry; Sara Desai, Department of Biochemistry; Kevin Liu, Department of Chemistry; Dr. Meghna Thakur, Center for Bio/Molecular Science and Engineering, U.S. Naval Research Laboratory; Dr. Gregory Ellis, Center for Bio/Molecular Science and Engineering, U.S. Naval Research Laboratory; Dr. Igor Medintz, Center for Bio/Molecular Science and Engineering, U.S. Naval Research Laboratory; Dr. Divita Mathur, Department of Chemistry

Due to anthropogenic activity, heavy metal contamination of the environment has become increasingly prevalent. Heavy metal exposure is linked to many severe health issues, including neurological and cardiovascular disorders. Thus, it is imperative to quickly detect and identify metal contaminants. Current biosensors fall short, with weak signals, poor field-deployability, and no multiplexing capabilities. Researchers have extracted operons from bacteria that have innate metal-sensing mechanisms, and reengineered them to produce signals to report on metal presence. Quantum dots (QD) are semiconductor fluorescent nanoparticles with unique photoelectronic properties, allowing for different QDs to have distinct emission spectra while sharing an excitation wavelength.

When placed in close proximity with another fluorophore with spectral overlap, the QD transfers energy to the fluorophore, which emits at a separate wavelength, establishing a donor-acceptor relationship. By linking a QD with a fluorophore through enzyme recognition sequence, we can observe changes in fluorescence based on enzyme presence using a plate reader. We have designed three different quantum dot–peptide-PNA(peptide nucleic acid)-DNA-Dye (QD-PDD) complexes, with each pair linked through different enzyme recognition sequences. This sensor system has exhibited promising results in the presence of the respective restriction enzyme genes in a cell-free environment.

We propose the coupling of a reporter-repressor operon system with the established QD-PDD sensor outlined above to create a multiplexing heavy metal biosensor. With a reporter gene producing a restriction enzyme and a repressor gene regulating reporter expression in response to metals, we can observe fluorescence fold-changes to report on metal presence. This project focuses on the development of the cadmium ($Cd^{2+}$) biosensor component. Upon procedure optimization, the biosensor currently detects $Cd^{2+}$ at the short-term US Military Exposure Guideline level (0.5 μM). In this poster, I discuss the $Cd^{2+}$ biosensor's characterization, optimization of genes, and assessment of its performance in the presence of $Cd^{2+}$.

Project Mentor: Dr. Divita Mathur, Department of Chemistry

**Validating in silico evolutionary predictions for various pharmacokinetic profiles and treatment adherences using an automated continuous-culture bioreactor**

**Anna Stacy[1],** John Joyce[2], Rowan Barker-Clarke, PhD[3], Eshan King, PhD[4], Jacob Scott, MD, DPhil[1,3,4].

[1]Department of Physics, Case Western Reserve University, Cleveland, Ohio; [2]Hawken High School, Gates Mills, Ohio; [3]Translational Hematology & Oncology Research, Cleveland Clinic Lerner Research Institute, Cleveland, Ohio; [4]School of Medicine, Case Western Reserve University, Cleveland, Ohio

Pharmacokinetic–pharmacodynamic (PK-PD) models, which describe how drug concentrations change in a patient and the drug's effect on pathogen growth, can be employed to better understand and predict the evolution of drug resistance. In this project, we seek to design and verify optimal dosing regimens that can be employed in clinical settings to potentially minimize resistant *E. coli* infections. We continue to develop a computational model that generates evolutionary predictions which can be validated with our low-cost automated experimental culture system, the EVolutionary biorEactor (EVE). Specifically, we adapt FEArS (Fast Evolution on Arbitrary Seascapes), a software package for modeling biological evolution, to predict the evolution of drug resistance in *E. coli* for different dosing regimens and pharmacokinetic profiles. We also examine various levels of treatment non-adherence to optimal dosing regimens through computational and experimental methods to understand the effect of non-adherence on mutant persistence. Upon experimental validation, this probabilistic model and EVE integration can be extended to a range of pharmacokinetic profiles, dosing intervals, and treatment adherences to design optimal dosing regimens and evaluate the risks of antibiotic non-adherence.

Project Mentor: Dr. Jacob Scott, Department of Translational Hematology and Oncology Research, Cleveland Clinic

Capstone Instructor: Dr. Idit Zehavi, Department of Physics, CWRU

## The Past, Present and Future of SLNB

**Michael Stanczyk** - Biology

This review explores the development and current application of Sentinel Lymph Node Biopsy (SLNB) in axillary staging, with a particular focus on its role in reducing the invasiveness of lymph node assessment in breast cancer. Lymph node involvement is a critical factor in cancer staging, influencing treatment decisions such as chemotherapy and radiation. The primary objective of this review is to examine the history, advancements, current practices, and future prospects of SLNB in cancer management. Drawing from a comprehensive analysis of recent literature, we discuss the evolution of SLNB from its origins in melanoma and penile cancer to its current widespread use in breast cancer, as well as its comparison to traditional Axillary Lymph Node Dissection (ALND). Key findings highlight SLNB's effectiveness in reducing complications such as lymphedema, improving patient outcomes, and minimizing surgical intervention. However, challenges remain, including false negative rates (FNR) and limitations in specific patient populations, such as those with obesity. The review also delves into innovations such as dual-agent mapping, molecular assays, and the integration of artificial intelligence in lymph node mapping. The findings underscore the need for ongoing refinement of SLNB techniques, especially in post-neoadjuvant chemotherapy settings, to improve precision and patient care. This review contributes to a deeper understanding of SLNB's evolving role in axillary staging and its potential for further optimization in clinical practice.

Faculty Project Mentor: Dr. Julie Lang, Cancer Biology, Cleveland Clinic; Dr. Valerie Haywood, Biology Department, Case Western Reserve University

## Quantifying the Baryon Deficit in Galaxies and Clusters

**Evan Steirman**, Physics & Astronomy

The cosmic baryon fraction $f_b$, the ratio of baryonic matter to total matter in the universe, is constrained by observations of the cosmic microwave background to be $f_b = 0.16 \pm 0.01$. Individual galaxies and clusters of galaxies often fall short of this cosmic value, raising the question of where these missing baryons reside. The severity of this problem depends on the calculation of the baryon fraction within individual galaxies and galaxy clusters, which requires an estimate of the total dark matter within each object's halo. In this project, I analyzed several different halo mass estimation methods and created a new kinematic mass matching relation based on established power laws. This new relation preserves the behavior of other halo mass estimates at galactic scales and provides more physically reasonable estimates of the baryon fraction in galaxy clusters than alternative methods such as abundance matching. This relation provides a new tool to estimate halo masses and assess the fraction of baryons they contain, yielding further insight into the cosmological processes driving large-scale structure formation throughout the universe.

Faculty Project Mentor: Dr. Stacy McGaugh, Department of Astronomy

## Modeling Particle Advection in a Fluidized Bed

**Ben Stites,** Mechanical Engineering

A fluidized bed is a collection of solid particles held in a vessel that has fluid pumped from the bottom, causing the solid particles to float and fluidize. Gas-solid fluidized beds are useful in many industrial processes, and this type of bed is being modeled in this project. Fluidization is incorporated into an existing discrete element computer code through a particle drag model. Individual particles and overall bed behavior will be monitored over time. We explore the impact of particle properties on fluidization behavior.

Faculty Mentor: Stephen Hostler, Department of Mechanical and Aerospace Engineering

**Linking Abortion Attitudes and Religiosity Amongst Religiously-Affiliated Students at Case Western Reserve University**

**Vani Subramony,** Cognitive Science

Attitudes towards abortion are highly influenced by the social world, as well as personal experiences and religious beliefs. For many young people, conversations about abortion are fundamental to their involvement within the political sphere. As such, religiosity has a relationship with attitudes towards abortion, therefore impacting voting decisions and policy shifts. This study aims to find a correlation between self-proclaimed religiosity and abortion attitudes amongst students representing the three major Abrahamic religions: Christianity, Judaism, and Islam. For this project, the researcher developed a scaled questionnaire containing 25 questions, each following the Likert scale (ranging from 'Strongly Disagree' to 'Strongly Agree'). The questions were organized according to topic: childhood religious involvement, personal religious practice, sexuality, and abortion attitudes. The questionnaire also included a basic demographic and open response section, the former to assist the researcher in analysis, and the latter to allow the respondent an opportunity to expand on any preceding questions. The questionnaire was administered to _ individuals, with _ identifying as Christian, _ identifying as Jewish, and _ identifying as Muslim. The data was then gathered and assessed within and between religious groups. From this study, we can begin analysis of the external social factors, specifically religious, that play a role in an individual's attitude towards abortion. Future research can utilize this foundation to draw further connections between individual beliefs and other socio-political issues.

Faculty Project Mentor: Todd Oakley, Cognitive Science

## Investigating the Role of Progesterone Inhibitors and Agonists in Pregnancy Maintenance and Parturition

**Satviki Sudireddi,** Department of Biology, CWRU, Jacqueline Shauh, Department of Reproductive Biology, CWRU

Preterm birth (PTB) is a major cause of neonatal mortality and morbidity due to the immaturity of the neonate organ systems. Currently, no treatments exist to mitigate the risk for PTB. To address this problem, a clear understanding is needed of the hormonal signals that control the process of parturition. In this context, the steroid hormone progesterone (P4) is critical as it is essential for the establishment and maintenance of pregnancy, and its withdrawal is a key trigger for parturition. This study uses two approaches in a mouse model to investigate how P4 signaling influences the timing of birth: 1) a specific P4 receptor (PR) antagonist (RU486) to determine the molecular mechanisms linking loss of P4/PR signaling with the onset of labor; and 2) a potent synthetic P4 analogue, nomegestrol acetate (NOMAC), that will reveal how prolonged PR signaling prevents term parturition. Understanding the mechanisms by which P4 affects labor onset will be critical for developing P4-based therapeutics to mitigate PTB risk. Pregnant mice will be treated with RU-486 or vehicle on gestation day (GD) 14. Eight hours after injection, the uterine tissues will be collected and processed for RNA extraction followed by RT-PCR to analyze the downstream effects on the expression of labor-associated genes (*GJA1, OXTR, PTGS2,* and *FP*). A separate group of pregnant mice will be treated with NOMAC or vehicle starting on the morning of GD18 (term = GD19.5) when systemic P4 levels decline as the principal trigger for parturition. A daily blood draw will be done before injections and subjected to P4 ELISA to determine changes in serum levels.

Faculty Project Mentor: Dr. Sam Mesiano, Department of Reproductive Biology, CWRU

Capstone Instructor: Dr. Jon Niemi, Department of Neurosciences, CWRU

**Differential Cellular Localization of TNFR2 Polymorphic Variants and its Implications on TNFi Responsiveness in Inflammatory Arthritis.**

**Chris Sun[1] (Biology BA)**, Unnikrishnan Chandrasekharan[2], M Elaine Husni[2,]

[1]C. Sun, College of Arts and Sciences, Case Western Reserve University, Cleveland, Ohio, [2]U.M. Chandrasekharan, PhD, Department of Cardiovascular and Metabolic Sciences, Lerner Research Institute, Cleveland, Ohio, [3]M.E. Husni, MD, MPH, Department of Rheumatic and Immunologic Diseases, Cleveland Clinic, Cleveland, Ohio

Tumor necrosis factor-alpha (TNF-α) is a central cytokine in the pathogenesis of immune-mediated inflammatory diseases such as rheumatoid and psoriatic diseases. TNF exerts its effects through two receptors, TNFR1 and TNFR2. Tumor necrosis factor-alpha inhibition (TNFi), which inactivates TNF-α, has transformed the management of these conditions. However, a large subset of patients exhibits inadequate responses, highlighting a need for predictive biomarkers to optimize treatment. While the mechanistic basis of this heterogeneity in TNFi responsiveness remains unknown, previous research suggests that TNFR2 genetic variation, specifically the rs1061622 single nucleotide polymorphism (SNP), may play a role in non-response. This SNP results in methionine or arginine at amino acid position 196 in the TNFR2 polypeptide, giving rise to two variants: TNFR2-M and TNFR2-R. Prior studies have shown that patients harboring the TNFR2-R variant are less responsive to TNFi therapy, yet the mechanistic basis for this poor responsiveness remains unclear. **This study aimed to investigate whether this TNFR2 SNP influences cellular localization, which potentially could explain the differential functional responses in TNFi therapy.** To address this, we expressed Green Fluorescent Protein (GFP)-tagged TNFR2-M and TNFR2-R in cultured human embryonic kidney cells (HEK-293) and human endothelial cells, with GFP as a control. The cellular localization was then observed using fluorescent microscopy. Our results demonstrated that TNFR2-M is primarily localized at the cellular membrane, whereas TNFR2-R is largely localized in the intracellular region. These findings suggest that impaired membrane localization of TNFR2-R could alter TNF-α signaling, potentially leading to reduced therapeutic efficacy of TNFi. This study provides mechanistic insight into the differential responses to TNFi therapy based on TNFR2 genetic variants. Further elucidation of TNFR2-R's intracellular retention mechanisms may inform personalized therapeutic strategies to improve clinical outcomes for patients with inflammatory arthritis.

Project Mentor (Principal Investigator): Elaine Husni, MD, MPH, Department of Rheumatic and Immunologic Diseases, Cleveland Clinic, Cleveland, Ohio

Capstone Instructor: Christopher Cullis, PhD, Department of Biology

**Differential Gene Expression in Recurrent and Non-Recurrent Bladder Cancer Post-BCG Therapy**

**Diya Swain**, Neuroscience major; Shiv Verma; Sanjay Gupta

Bladder cancer is one of the most diagnosed cancers in the United States, and will increase by 49%, from 1,534,500 in 2015 to 2,286,300 annually by 2050. Approximately 75% of newly diagnosed bladder cancer cases are classified as non-muscle invasive bladder cancer (NMIBC). The current standard of care for intermediate- and high-risk NMIBC patients is intravesical Bacillus Calmette-Guérin (BCG) therapy. While BCG remains the gold-standard treatment, up to 60% experience recurrence within two years, and 40% of high-risk NMIBC cases progress to muscle-invasive bladder cancer (MIBC), with reduced survival outcomes. Cancer recurrence remains a major challenge despite the widespread use of BCG therapy, underscoring the need to identify the genes driving BCG resistance and recurrence. This study aims to uncover therapeutic targets associated with BCG-resistant. To investigate BCG resistance, 146 NMIBC patient samples were analyzed across three independent transcriptomic datasets (GSE154261, GSE185264, and GSE199471), comparing non-recurrent and recurrent NMIBC cases.

A total of 56 candidate genes were identified and systematically assessed immune profile in association with BCG-recurrence using the TIMER (Tumor Immune Estimation Resource) software. The result showed the activation of NK cells was predominant in BCG-recurrence patients compared to non-recurrence NMIBC patients. The pathway enrichment analysis using Ingenuity Pathway Analysis (IPA) showed that the Antigen-presenting pathway (APC), Glucocorticoid receptor signaling, PD-1/PD-L1 cancer immunotherapy, and others were significantly overrepresented at -log (p-value). The identified genes were additionally correlated with overall survival rates in NMIBC patients, allowing us to narrow down the list to seven key genes/proteins e.g. ALK, EGFR, RHEB, NTRK3, KRT4, CDK6, and SPRR1B with significant involvement in BCG resistance and recurrence.

The future direction of research will center on validating the functional roles of these genes and assessing their therapeutic implications in NMIBC. Targeting these molecular pathways aims to establish early intervention strategies for high-risk NMIBC patients, facilitate personalized treatment approaches through molecular profiling, and discover novel therapies to reduce recurrence and improve patient outcomes.

Project Mentors: Dr. Sanjay Gupta and Dr. Shiv Verma, Department of Urology, CWRU

This study was supported by Endowment funds to S.G.

**Molecular Sweet Tooth: Does IL-6 Glycosylation Alter Immune Responses?**

**Ryan Szczepanik**, Biochemistry

Interleukin-6 (IL-6) is an inflammatory cytokine produced by many types of human cells, and high levels can indicate an array of activity, including response to foreign pathogens or chronic inflammation. IL-6 is typically secreted at sites of inflammation, where they bind to their coupled receptors, IL-6R (CD126) and gp130, which induces a downstream signaling cascade. Human cells and bacteria cells modify proteins differently after translation. It is unclear whether post-translational modifications of IL-6, specifically glycosylation patterns, are recognized differently by immune cells. This project explores the importance of eukaryotic glycosylation patterns on cytokines and the resulting immune response through a cellular immunology study of recombinant IL-6 derived from a bacterial *E. coli* or eukaryotic HEK293 expression system. Bacterial glycan patterns are typically minimal. The glycosylation pattern and subsequent immune responses are relatively understudied, and the results of the analyses may assist with more accurate data interpretation used throughout all immunological research using recombinant cytokines. Previously we found that IL-6 can down-regulate the expression of the IL-7a (CD127) chain on T cells. We will stimulate peripheral blood mononuclear cells (PMBCs) with IL-6 made in either E. coli or HEK293 cells. In order to determine the impact of IL-6 on the activity of immune cells, surface staining and intracellular cytokine staining (ICS) will be performed. The stained cells/structures of interest will then be analyzed via flow cytometry and GraphPad.

Project Mentor: Dr. Carey Shive, Department of Pathology, Case Western Reserve University and VA Northeast Ohio Medical Center

**The role of social support in moderating the relationship between peer pressure and psychotic-like symptoms in racial and ethnic minority adolescents**

**Eliana Tandy,** Majors in Psychology and Spanish.

It is widely known that both social support and peer pressure are powerful group forces that can affect people's decision-making abilities. In addition, because of the potential cognitive control deficits that accompany those who experience psychotic-like symptoms, it is possible that individuals at risk for psychosis may be more susceptible to the effects of peer pressure. What remains unknown is how this force of social support interacts with the pre-existing relationship between peer pressure and psychotic-like symptoms. Therefore, the purpose of this study is to examine whether or not social support moderates the relationship between peer pressure and psychotic-like symptoms in racial and ethnic minority adolescents. In order to analyze this, data from self-report measures was collected from participating adolescents ages 13 to 18 who identify as a racial or ethnic minority, and who were recruited via online advertisements and physical fliers. The Prodromal Questionnaire – Brief screened for psychosis risk, the Multidimensional Scale of Perceived Social Support, Online Social Support Scale, and Social

Connectedness Scale evaluated levels of social support, and the Peer Pressure Inventory and Peer Pressure Questionnaire – Revised assessed how adolescents respond to peer pressure and the degree to which adolescents feel pressure from their peers to either do or not do certain things, respectfully. My first hypothesis is that increased levels of peer pressure lead to increased psychotic-like symptoms. Building upon this, I also hypothesize that social support moderates the relationship between peer pressure and psychotic-like symptoms such that higher levels of social support reduces the relationship between peer pressure and psychotic-like symptoms. The implications of this study are crucial, as the results can be used to potentially establish social support initiatives for racial and ethnic minority adolescents who experience psychotic-like symptoms and therefore are more susceptible to the effects of peer pressure.

Key Words: social support, peer pressure, psychotic-like symptoms

Faculty Project Mentor/Capstone Instructor: Sarah Hope Lincoln, The Department of Psychological Sciences

**RNAi Screen of Candidate Proteins Related to Meiotic DSB Protein, Vilya, In D. Melanogaster**

**Zion Tasew**, Biology, Oscar Bautista, Dept. of Biology

Meiosis is a vital cellular division process, occurring in sexually reproducing organisms where diploid cells undergo two rounds of division, generating haploid gametes, while also facilitating diversity. This is done through recombination and chromosomal segregation; however, errors in either will cause chromosomal missegregation, resulting in aneuploidy, a major contributor to miscarriages and infertility(Ohkura, 2015). At meiotic recombination's core is the reciprocal exchange of genetic information between homologous chromosomes, known as crossovers (COs). Programmed DNA double-stranded breaks (DSBs) are necessary for COs as these breaks are repaired by protein machinery into COs. Little is known about the totality of protein interactions and molecular machinery driving the meiotic process and more knowledge would give insight into where chromosome segregation failures arise. This project's goal is to discover more proteins possibly interacting with Vilya, a meiotic DSB protein discovered to be required for the formation of DSBs that will mature into COs(Hawley, et. al,2015). The objective is to use RNAi to analyze phenotypes indicative of a failure in the meiotic DSB and CO formation program, as this would indicate the possible importance of a protein to the meiotic program. We will screen nine genes shown to have possible interactions with Vilya. Six interactions were discovered through a proximity labeling experiment preceding mass spectrometry(MS), while three were found using the Molecular Interaction Search Tool(MIST). I am in the process of generating data and preliminary results will be presented at Intersections.

Faculty Mentor & Capstone Instructor: Nicole Crown, Department of Biology

## Impact of Endothelial GLUT1 Reduction on ONL Length and COS Quantification on Retinal Structure and Function in Type 1 Diabetic Mice

**Melanie Taylor,** Neuroscience

Diabetic retinopathy (DR) is a leading cause of vision loss among individuals with diabetes, characterized by retinal inflammation, oxidative stress, and vascular dysfunction. The glucose transporter GLUT1 plays a crucial role in retinal glucose regulation, but its overactivity in hyperglycemic conditions may exacerbate retinal damage. This study investigates the effects of endothelial GLUT1 reduction on retinal function and inflammatory damage in a type 1 diabetic mouse model. Using Tie2-Cre transgenic mice crossed with floxed Slc2a1 (GLUT1) allele carriers, we generated a conditional knockdown (CKD) model to selectively reduce GLUT1 expression in endothelial cells. We hypothesized that CKD mice may exhibit decreased outer nuclear layer (ONL) thickness and cone outer segment (COS) counts but would experience functional recovery under hyperglycemic conditions. Western blot analysis confirmed reduced GLUT1 expression in CKD mice. ONL measurements indicate the confirmation of expected trends that non-diabetic CKD mice had thinner ONLs compared to controls, but diabetic CKD mice demonstrated ONL recovery. COS quantification supported this trend, with diabetic CKD mice showing increased COS counts relative to the non-diabetic CKD mice. These findings suggest that reducing GLUT1 in endothelial cells may alter the progression of DR, potentially mitigating retinal deterioration under diabetic conditions. Mice were examined at the 4-week and 8-week post-diabetes period. Electroretinogram analysis was also used to further assess retinal function and GLUT1's role in DR pathology. Experiments are still ongoing to determine if there is a significant difference in measurements between diabetic and non-diabetic mice of different genotypes.

Principal Investigator: Dr. Ivy Samuels, Louis Stokes Cleveland VA Medical Center

Faculty Mentor: Dr. Jon Niemi, Department of Neurosciences

**Racial and Ethnic Diversity in Professional Orchestra Musicians: Strategies for Increasing Diversity at U.S. Orchestras**

**Nicholas Taylor,** Business Management

The lack of racial and ethnic diversity in professional orchestra musicians has become an increasingly prominent topic in the performing arts industry. Despite growing awareness and efforts to improve representation on stage, orchestras face significant challenges in creating diverse ensembles. This study explores how the racial and ethnic representation of professional orchestral musicians compares to the U.S. population, revealing significant disparities, and examines the systemic barriers within music education and professional hiring that hinder musician diversity. Drawing from demographic data, literature on diversity, equity, and inclusion (DEI), and insights from professionals currently in the field, this study seeks to uncover trends and disparities in orchestral diversity initiatives. The areas of focus will include equitable access to music education, audition and hiring practices, and broader systemic inequities in the classical music field. The study also analyzes programs and initiatives spearheaded by orchestras around the world that address these barriers and offer strategies for other professional orchestras to implement. This study also uses The Cleveland Orchestra (TCO) as a case study, revealing insights into the challenges of creating a diverse ensemble and analyzing their existing programs. Building upon these insights, and informed by recommendations from institutions like the Sphinx Organization and the League of American Orchestras, this study examines the impact of educational programs, equitable hiring processes, and community engagement initiatives to address diversity challenges. This study, informed by published literature, expert recommendations, and the TCO case study, offers professional U.S. orchestras feasible steps to begin achieving greater diversity through various educational, community engagement, and artistic programs.

Faculty Mentor: Diana Bilimoria, Organizational Behavior

## Cordelia Cosmetics

**Cordelia Teeters**, Business Management, Supply Chain Management

Cordelia Cosmetics explores the creative and entrepreneurial process of developing a makeup brand from concept to potential market launch. This project investigates the question: What are the key steps in designing and developing a cosmetic product while building a brand as a student entrepreneur?

The significance of this study lies in its real-world application, providing insight into how aspiring entrepreneurs can navigate product design, branding, and business strategy with limited resources. As the beauty industry continues to evolve, independent brands must balance creativity with business practicality to stand out in a competitive landscape. This project serves as a case study for students looking to enter the beauty industry, demonstrating how innovation and strategic planning can drive brand success.

The methodology includes hands-on product development, from formulation and packaging design to brand identity creation. Additionally, business development strategies such as budgeting, sourcing, and marketing are explored to understand the feasibility of launching a student-led brand.

Expected outcomes include a roadmap of the cosmetic development process, insights into the challenges of student entrepreneurship, and an understanding of what it takes to build a compelling brand in the beauty industry. This project highlights the intersection of creativity and business strategy, showcasing the potential for student entrepreneurs to bring innovative beauty concepts to life.

Project Mentors: Kevin Lenahan, Weatherhead Schl of Management; Michael Goulder, Weatherhead Schl of Management

**Constrained Density Functional Theory in QuantumESPRESSO via a Driver for PyCDFT**

**James Telzrow**, Computer Science and Mathematics (Secondary), Case Western Reserve University

Accurately modeling electron transfer rates is crucial to understanding an incredibly wide variety of chemical and biological systems. One such common and experimentally veriied model is Marcus theory, which has been used to describe rates of electron transfer in systems such as redox low batteries, photovoltaic cells, and more. It predicts that the electron transfer rate constant between an electron donor and acceptor depends exponentially on the reorganization energy and Gibbs free energy change associated with the transfer. An important quantity in the pre-exponential of Marcus rate constant expressions is the electronic coupling Hab , an element of the Hamiltonian matrix comprised of the reactant and product states in the electronic transfer reaction.An accurate calculation of Hab usually involves the orbitals and wavefunctions of the system under consideration. Often, these are determined using Hartree Fock (HF) or Coniguration Interaction (CI) calculations. However, HF methods often produce inaccurate results due to their omission of electron correlation energy contributions, and CI methods are usually too computationally expensive for most chemical systems. Density Functional Theory (DFT) calculations are far more eficient, and although ground-state DFT often gives rise to inaccurate Hab values due to self interaction error, there exist long-range methods to calculate very accurate Hab values using Constrained DFT (CDFT). CDFT is a DFT-based method in which the Hamiltonian is modiied with a constraint that enforces charge separation between speciied donors and acceptors. In this presentation, I will present a patch for the QuantumESPRESSO DFT code and a driver for PyCDFT, a Python package for managing CDFT and electronic coupling calculations. I will also present benchmarking results in comparison to published data on a set of organic dimers at varying distances, which veriies the accuracy of my implementation.

Project Mentor: Dr. Robert Warburton, Department of Chemical and Biomolecular

## Co-Op Experience at Bendix Commercial Vehicle Systems

**Nathan Thain**, Electrical Engineering

This presentation will cover my experience as a Co-Op engineering student at Bendix Commercial Vehicle Systems during Summer 2024 and Fall 2024. It will cover my experience as a Co-Op, the corporate experience, Co-Oping through Case's Co-Op Office, Bendix as a company, and various looks into my day-to-day and larger working profiles at Bendix. The goal of this presentation is to provide Case students and faculty with insight into the Co-op process as a Case engineering student, what to expect from a Co-op rotation, and how to best prepare and excel in such a rotation.

Industry Mentor: Cody Kuepfer, Bendix Commercial Vehicle Systems
Capstone Instructor: Gregory Lee, Department of Electrical, Computer, and Systems Engineering

**Transcriptomic Reprogramming Associated with Stemness in Castration-Resistant Prostate Cancer**

**Leah Tharian,** Biology, CAS - College of Arts & Sciences; Shiv Verma, Sanjay Gupta

Prostate cancer is the most commonly diagnosed malignancy among men in the United States. It progresses from a hormone-sensitive stage to hormone-resistant prostate cancer or castration-resistant and metastatic stage. Cancer stem cells (CSCs), a subpopulation within the tumor, exhibit unique properties of self-renewal and multilineage differentiation. These characteristics are thought to contribute significantly to therapy resistance, disease recurrence, and mortality. However, the role of CSCs in the transition from hormone-sensitive to hormone-resistant stages remains unclear.

We analyzed the stem cell-associated functions and biological characteristics of a subpopulation of CD133+ cells isolated from established primary human prostate cancer cell lines. Compared to CD133− cells, the CD133+ cells from castration-resistant prostate cancer exhibited enhanced clonogenic and tumorigenic potential, increased sphere-forming capacity, and the ability to serially reinitiate transplantable tumors in NOD-SCID mice. To characterize the transcriptomic profile of these stem cell-enriched (CD133+) cells, RNA-Seq was performed and analyzed. Ingenuity Pathway Analysis (IPA) identified upregulated pathways, including mitochondrial dysfunction, oxidative phosphorylation, and sirtuin signaling, suggesting their role in CSC survival and therapy resistance. Gene Set Enrichment Analysis (GSEA) revealed that genes associated with oxidative phosphorylation—such as *ATP1A3, COL6A2, CRIPAK1, EGR1, FKBP5, HCLS1, HLA-DRA, miR-24, miR-6820, NELFA, REXO, RYR3,* and *TNFRSF19*—were among the top 25 differentially upregulated genes in CD133+ cells. Additionally, mitochondrial genes-including *MT-CO2, MT-CO3, MT-CYB, MT-ND1, MT-ND2, MT-ND3, MT-ND4, MT-ND5,* and *MT-ND6*-were significantly overrepresented. Notably, sirtuin family members *SIRT3, SIRT4, SIRT5,* and *SIRT7* were also enriched in CD133+ cells compared to CD133− cells.

These findings reveal the activation of a transcriptomic program linked to stemness in castration-resistant cells following stem-cell enrichment, further supporting the growing evidence of CSC involvement in this process. Moreover, this study identifies additional candidate genes and molecular pathways that may serve as potential therapeutic targets for castration-resistant prostate cancer.

Project Mentor: Sanjay Gupta, Ph.D., Department of Urology, Case Western Reserve University, School of Medicine.

This study was supported by Department of Defense Grants W81XWH-18-1-0618, W81XWH-19-1-0720, and Endowment funds to S.G.

**Biochemically Inspired Sensing Reaction for the Detection of Antimicrobial Resistance**

**Vaibhav Thirumalai,** Biochemistry, CAS - College of Arts & Sciences

The implementation of effective and widely accessible testing methods for Antimicrobial Resistance (AMR) continues to be a pressing issue in public health. The requirement of bulky hardware and extensive automation makes testing challenging, especially in areas with limited access to the resources. We introduce an accessible nanoparticle and magnetic bead based system specifically designed for rapid AMR testing. We oxidize β-lactamases-specific antibodies and link them to a thiolated magnetic bead with PDPH crosslinking and leverage magnetic separation, antibody-antigen binding, platinum nanoparticles and decomposition of hydrogen peroxide in presence of the nanoparticles to generate easily visible and large bubbles. This facilitates detection of AMR-associated enzymes from blood samples. The efficacy of the nanoparticle system was tested using two clinically relevant AMR enzymes— *Klebsiella pneumoniae* carbapenemase-2 (KPC-2) and Sulfhydryl variable-1 (SHV-1) β-lactamases as model targets. Presence of bubbles was detected using an AI system.

Project Mentor: Mohamed Draz, Biomedical Engineering, MED - School of Medicine

## Anatomical Variability in Cranial Nerve Branching and Fascicle Patterns

**Geetha Thomas**, Department of Neuroscience, Case Western Reserve University

Cranial nerves, particularly the vagus nerve and its associated branches, play a crucial role in autonomic, sensory, and motor functions of the body, especially in the head and neck. While Vagus Nerve Stimulation (VNS) is an established therapy for epilepsy, depression, and other disorders, patient responses vary widely. One potential contributing factor to this variability is the anatomical differences between people in terms of nerve fascicular organization, including patterns of splitting and merging. Despite the potential clinical significance of these variations, they remain poorly characterized. This study utilized high-resolution microCT imaging to analyze the fascicular organization of the vagus, glossopharyngeal, and hypoglossal nerves as well as the sympathetic trunk, in human cadaveric specimens. Fascicle splitting and merging patterns, as well as distances between major nerve branches, were analyzed to identify structural variability. Additionally, these measurements were compared across donor age, sex, and dementia status. By mapping these anatomical differences, this study aims to improve understanding of cranial nerve microanatomy and improve neuromodulation of these nerves. These findings may refine neurosurgical techniques, improve electrode design and placement, and inform future studies on age-related and neurodegenerative changes in nerve structure, providing a foundation for improved clinical applications in neuromodulation and neurological disease management.

Project Mentor: Dr. Andrew Crofton, Department of Anatomy, Case School of Medicine

Faculty Sponsor: Dr. Jon Niemi, Department of Neuroscience, Case School of Medicine

## Growth of $KTaO_3$/Oxide Heterostructures

**Arianna Thornton,** Department of Materials Science and Engineering; Dr. Alp Sehirlioglu, Department of Materials Science and Engineering, CWRU

Josephson diodes (JDs) are an emerging technology that exhibit nonreciprocal superconductivity under inversion and time-reversal symmetry breaking conditions. This phenomenon is known as the Josephson diode effect (JDE). JDs are essential to the research on superconductivity and electron spin behavior that is advancing the fields of spin electronics (spintronics) and quantum computing. To facilitate their application in emerging electronic technology, there is an interest in creating field-free JDs (which do not require an external magnetic field to break time-reversal symmetry). Superconductivity and nonreciprocity have been observed in heteroepitaxial oxide structures, including $LaAlO_3$/$KTaO_3$ (LAO/KTO) and $LaAlO_3$/$SrTiO_3$ (LAO/STO). Studying additional oxide heterostructures, such as KTO/STO, could accelerate the development of JDs. The potential for magnetic doping of KTO makes it a promising candidate material for field-free JDs. However, the high volatility of K makes the deposition of a KTO film difficult with traditional physical vapor deposition techniques. Here, we propose a method for KTO deposition that uses pulsed laser deposition (PLD) and allows for high stoichiometric control over the resulting film. Our approach involves adding excess K to the PLD targets to account for scattering and re-evaporation. The amount of excess K can also be adjusted to intentionally introduce point defects into the film. This technique will facilitate research into the KTO/STO system and accelerate the development of field-free JDs.

Project Mentor: Professor Alp Sehirlioglu, Department of Materials Science and Engineering, CWRU

## A Tale of Two Insurgencies: British Interpretations of the Malayan and Kenyan Emergencies

**Jeffery Tong,** History

With the onset of the fifties, the age of colonialism began to set, marking the sunset of the British Empire. This research examines fifties, British decolonization by observing the cases of Malaya and Kenya. By comparing these cases, this research aims to build on pre existing literature on policing methods and racial thoughts that the British notoriously championed.

Though racial rhetoric during the Malayan Emergency was less noticeable, compared to the Mau Mau Rebellion, colonial officials in both insurgencies used language that demonized the insurgents. This rhetoric not only influenced how the British treated the insurgents but also how they portrayed themselves and their actions. Relying on colonial official correspondences, field studies, memorandums, letters, and more, these cases expose the broader pattern of British over policing during decolonization. By examining these parallels, this research contributes to the growing historiography of imperial legacies.

Faculty Mentor: John Broich, Department of History

## The Impact of Mining Operations on the Health and Culture of Yanomami populations in the Brazilian Amazon

**Jose M. Torrado Rivera,** Anthropology

This paper will analyze anthropologically the current health challenges experienced by the Yanomami, an Amazonian indigenous group who live in semi-isolation on the Venezuelan-Brazilian border, with focus on the communities living in Brazil. Despite their protected status within Brazil, illegal mining operations have contributed to deforestation and pollution within the Yanomami territory, directly affecting their traditional way of life as well as their access to traditional foods and clean water. Furthermore, the extended contact with non-indigenous populations has introduced infectious diseases of which indigenous peoples lack immunity to. The correlations between specific diseases and mining operations are extensive and one of the goals of this paper is to analyze their combined effects. This paper will also examine how changes experienced by the Yanomami as a result of mining have also contributed to cultural adaptations especially regarding their overall well-being, health and nutrition. Finally, this paper will also analyze potential impacts and effectiveness of external organizations and initiatives aiming at protecting Yanomami communities, their territory and enhancing their well-being. By raising awareness and reaching a critical understanding of the structural factors leading to the challenges experienced by the Yanomami people, this paper can also foster the cross-cultural understanding of similar challenges faced by other indigenous groups in the Amazon and other areas around the world.

Capstone Advisor: Dr. Katia Almeida, Department of Anthropology

**Design of Safer Separation System for Hobby Rocketry and Accompanying Launch Vehicle**

**Julian Town,** Department of Mechanical and Aerospace Engineering

This project aims to improve safety in hobby collegiate rocketry, where copious amounts of black powder are used in "charge wells" to separate sections of a launch vehicle. This is a necessary function, as all rockets need to deploy parachutes to slow the vehicle during descent. The amounts of black powder used, somewhere between 3 to 5 grams on average, are quite dangerous during assembly and integraΘon due to its explosive nature material and its exposed locaΘon in the rocket. Through this project, a separaΘon methodology and device will be developed that greatly reduces the risk of injury without impacΘng flight funcΘonality. By researching several alternaΘve concepts such as compressed CO2 gas canisters and electrical actuators, it was determined that the most cost- and space-effecΘve approach was limiΘng the amount of black powder used and containing the blast as much as possible. This led to a design that decreased the required black powder mass by approximately 75 Θmes. Upon launch, the "staΘonary" and "separaΘng" secΘons are held together with dowel pins aΣached to a plate. When the secΘons need to separate, an electrical match ignites a small chamber filled with black powder, essenΘally pulling the pin out of pockets in the "separaΘng" secΘon. Springs pushing on plates in the "separaΘng" secΘon assist the secΘons in separaΘng. The device will be manufactured pending further analysis. Device effecΘveness will be confirmed by several ground tests, and a final test to demonstrate flightworthiness.

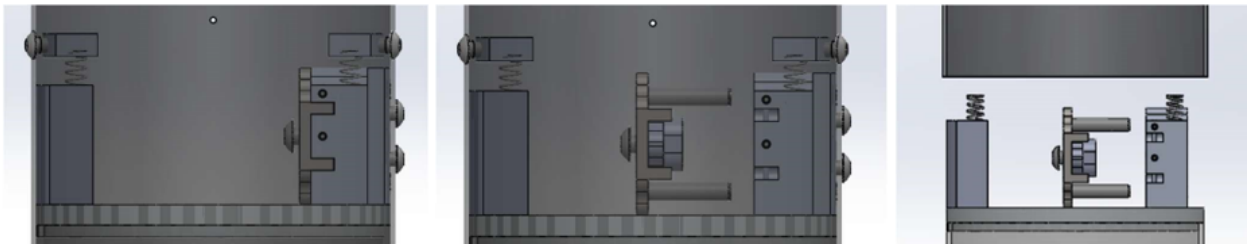

Figure 1: Proposed Device Operation

Faculty Mentor: Dr. Stephen Hostler, Department of Mechanical and Aerospace Engineering

Capstone Instructor: Dr. Majid Rashidi, Department of Mechanical and Aerospace Engineering

**Identifying Potent Inhibitors Against Slingshot homolog-1 – The First Step in Validating a Novel Therapeutic Strategy Against Alzheimer's Disease**

**Khoi D. Tran**, Biochemistry; A. Shivalinga, Department of Pathology, CWRU School of Medicine; X.Y. Zhao, Department of Pathology, CWRU School of Medicine; D.E. Kang, Department of Pathology, CWRU School of Medicine, Louis Strokes Cleveland VA Medical Center; J.A. Woo, Department of Pathology, CWRU School of Medicine

Neurodegeneration and the disruption of neuroprotective mechanisms induced by amyloid-β (Aβ) and tau accumulation are the central hallmarks of Alzheimer's Disease (AD). However, the molecular mechanism that regulates Aβ production and how neurotoxic signals between Aβ and tau are transmitted has not been fully understood, posing an obstacle in developing disease-modifying therapy for AD. The phosphatase Slingshot homolog-1 stands out as a promising therapeutic target as it exerts significant activities relevant to AD. First, SSH1 activates the F-actin-severing protein Cofilin. Activated Cofilin plays a key role in promoting Aβ production and transmitting neurotoxic signals between Aβ and tau in cells and *in vivo* models for AD. Second, SSH1 also inhibits the autophagy receptor SQSTM/p62 and suppresses neuroprotective Nrf2 signaling. Hence, pharmacological targeting of the SSH1-Cofilin and SSH1-p62 pathways represents a potential therapeutic strategy to simultaneously reduce Aβ and tau pathologies as well as enhance neuroprotection and autophagy in AD. The first step to test this therapeutic strategy is to identify potent SSH1-inhibiting compounds. In this project, we screened for more than 2,700 FDA-approved compounds using an *in vitro* SSH1 phosphatase activity assay. This preliminary screening allowed us to identify up to 44 compounds showing high SSH1 inhibitory. From there, we conducted an extensive literature review to select nine compounds based on their reported pharmacological properties and neuroprotective effects for further validation of their efficacy and potency. Finally, we have identified the compounds A and B2 as potent SSH1 inhibitors suitable for further testing in cells.

Faculty Project Mentor: J.A. Woo, Department of Pathology, CWRU School of Medicine

**Virtual H&E Staining from 3D MUSE Imaging of the Vagus Nerve Using Generative Adversarial Networks (GANs)**

**Quan Tran,** Biomedical Engineering; Dr. James Seckler, Department of Biomedical Engineering; Dr. Michael Jenkins, Department of Biomedical Engineering; Dr. Andrew Shoffstall, Department of Biomedical Engineering

Traditional histopathology, primarily relying on hematoxylin and eosin (H&E) staining, is essential for clinical diagnostics but suffers from significant drawbacks, including prolonged processing times, staining variability, and irreversible tissue damage. Three-dimensional Microscopy with Ultraviolet Surface Excitation (3D MUSE) imaging addresses these limitations by enabling rapid, high-resolution, volumetric imaging of peripheral nerve tissues, while preserving its integrity. Unlike conventional histological techniques, 3D MUSE efficiently captures detailed morphological and structural information, distinctly visualizing key nerve structures such as fascicles, perineurium, epineurium, and other types of axon fibers without requiring additional sample processing or tissue destruction.

To harness the rich volumetric data provided by 3D MUSE imaging, we developed a deep learning framework based on Generative Adversarial Networks (GANs) to translate 3D MUSE images into realistic virtual H&E representations. Our GAN architecture accurately reproduces essential peripheral nerve histological details, including clear delineation of fascicular boundaries, detailed perineurial morphology, and epineurial connective tissue characteristics. Quantitative evaluations, including Structural Similarity Index (SSIM) and Fréchet Inception Distance (FID), confirmed the structural accuracy and visual fidelity of the generated virtual histology images compared to physically stained counterparts. This GAN-driven virtual staining pipeline minimizes staining inconsistencies and maintains nerve tissue integrity. As this is an ongoing project, future improvements will focus on training with larger datasets, performing targeted fine-tuning, and experimenting with more advanced GAN architectures to enhance translation accuracy and overall image quality.

Faculty Mentor: Dr. James Seckler, Department of Biomedical Engineering

## Characterization of Spinal Serotonergic Innervation in Lumbosacral Segments of ALS Mice

**David Trent**, Neuroscience and Business Management; Dr. Yu-Shang Lee, Department of Neurosciences, Cleveland Clinic Lerner Research Institute

Serotonin acts as a modulator of glutamate and plays a crucial role in ALS pathogenesis as the misregulation of glutamate can lead to excitotoxicity, a leading indicator of ALS and other neurological disorders. The objective of this study was to characterize serotonergic innervation in lumbosacral segments of ALS mice, comparing lumbosacral cross sections of $SOD1^{G93A}$ mice and WT mice, stained with ChAT, 5HT, and SERT, to determine the prevalence of serotonergic denervation after the onset of ALS. Intensities of 5HT and SERT were further categorized by location within the cross-section and similarly compared between groups. Identifying and quantifying differences in intensity of 5-HT and SERT in $SOD1^{G93A}$ and WT mice leads to a greater understanding of the pathogenesis of ALS, supporting efforts toward potential therapeutic avenues to treat the dysfunction.

Faculty Mentor: Yu-Shang Lee, Department of Neurosciences, Cleveland Clinic Lerner Research Institute

Capstone Instructor: Jon Niemi, Department of Neurosciences, Case Western Reserve University School of Medicine

## More Health, Less Crime: What's The Impact of Medicaid Expansion on Financially Motivated Crimes

**Aaron Triffleman-Miller**, Economics & **Christopher Vera**, Economics

A small body of literature investigates the impact of Medicaid expansion from the passage of the 2014 Affordable Care Act (ACA) on criminal behavior in the U.S. The U.S government spending on crime reduction and crime prevention programs and Medicaid programs greatly impacts the available federal funding left for Americans who may still be uninsured in any kind of medical insurance. According to a KFF report "Most of the 25.3 million people ages 0-64 who are uninsured are adults in working low-income families". In our proposed research, we assess the long-term effect of Medicaid expansion on financially motivated crimes in states that have adopted the ACA in 2014 and the short-term effect of Medicaid expansion on financially motivated crimes in states that later adopted the ACA after 2016. Non-Medicaid expansion states will be used as the study's control group. Therefore, we are expanding the time scope and modifying the observed crimes to an older study conducted by Qiwei He and Scott Barkowski. Instead of examining data from 2010 to 2016, this paper will use data that includes: state crime rates from the FBI UCR, Medicaid Expansion status from KFF, demographic characteristics of age, race, and economic conditions from NHGIS, and government per capita spending on health, public welfare, and education from the U.S. Census Bureau spending from 2010 to 2022. This paper will utilize a DID model with added state and time fixed effects to evaluate the effect of Medicaid expansion on financially motivated crime. We hypothesize that the adoption of Medicaid expansion is associated with a decrease in financially motivated crimes in ACA states based on the Economic Deprivation Theory. The study's findings could have benefits for efficiently reallocating government resources, such as allocating more funding to healthcare programs to completely cover any American medically uninsured.

Project Mentor: Professor Jenny Hawkins, Department of Economics

**Investigation of Bifidobacterium breve in Bacterial Vaginosis**

**Julia T Hochstetler**, Department of Biology; Alyssa R Hamm, Department of Pathology, Case Western Reserve School of Medicine; Gina R Lewin, Department of Pathology, Case Western Reserve School of Medicine.

Bacterial vaginosis (BV) is a vaginal condition that affects nearly 30% of reproductive-age women worldwide. BV is characterized by the dominance of a diverse community of anaerobic bacteria and increases the risk for a series of adverse health outcomes, including sexually transmitted disease acquisition, preterm birth, and cancer. Within a year of antibiotic treatment for BV, over half of cases reoccur. Despite this high recurrence rate, little is known about many of the bacteria associated with BV and how they persist after antibiotic treatment. We recently identified two *Bifidobacterium breve* isolates obtained one month apart from the same BV-positive individual, before and after unsuccessful clindamycin treatment. The *Bifidobacterium* genus has been estimated to be present in the vaginal tract of 10% of healthy women, and some studies have shown higher proportions among BV-positive individuals, yet the function of bifidobacteria in the vagina is not elucidated. Therefore, our goals are to use these isolates to study the role of *B. breve* in the vagina and how it can persist over time despite antibiotic treatment. To address these questions, we performed genotypic and phenotypic analyses of both isolates. To compare the genotypes of the isolates, we extracted DNA, then sequenced, assembled, and annotated their genomes. The sequencing data was assembled into genomes of 27 and 30 contigs. The isolates have highly similar genomic sequences, with an average nucleotide identity > 99.99%, although differences in nucleotide bases exist in several genes. This reveals that these isolates are not genetically identical, despite originating from the same person. Our current efforts are focused on investigating potential differences in the phenotypes of these isolates, including virulence and antibiotic resistance. These findings will improve our knowledge of *B. breve* in the vaginal tract and contribute to our understanding of BV treatment resistance.

Faculty Project Mentor: Gina R Lewin, PhD, Department of Pathology, Case Western Reserve School of Medicine

## Exploring Site-Specific DNA Demethylation Using an Inducible FKBP*-Regulated dCasMini-Tet1 System

**Kaitlyn Turner,** Chemical Biology

CRISPR/Cas technologies have been widely used for programmable DNA modifications, but challenges remain regarding the technologies' applications in epigenetic editing. Many CRISPR-based technologies have incorporated spatial and temporal control for precise genomic editing. However, current dCas DNA demethylation tools are limited due to their large size, which reduces packaging efficiency in lentiviral vectors.

To address these limitations, we have developed a miniaturized dCasMini which allows for efficient packaging into lentiviral vectors. This system is fused to a Tet1 catalytic domain which acts as a 5-methylcytosine dioxygenase, an essential enzyme involved in DNA demethylation. This process is regulated through an FKBP* destabilization domain at the N-terminus to obtain inducible temporal control of the Tet1 domain. The construct additionally contains an HA epitope tag for protein detection through various techniques such as Western Blotting.

This construct was developed through restriction enzyme digest using AscI and PmeI, and amplification of the Tet1 domain was accomplished through PCR. Verification of amplification and digest were completed using gel electrophoresis. The Tet1 construct was subsequently cloned into lentiviral vector V5.5-DD containing a destabilization domain and V5.5-DF containing a destabilization domain along with a fluorescent marker. To confirm the inducibility of the construct, we will begin Western Blot analysis to assess protein induction and expression levels in response to our stabilizing ligand Shield-1.

Faculty Project Mentor: Yufan Wang, Chemistry, CAS - College of Arts & Sciences

## Rotary Inverted Pendulum

**Aaron Underwood,** Mechanical Engineering

The rotary inverted pendulum is another take on the classic example of a rotary pendulum, where rather than attempting to control the inverted pendulum through linear motions, it is instead controlled through rotational motions. The problem, as with a normal inverted pendulum, is that the pendulum is being held in a lonlinear, unstable position, and will constantly attempt to fall back to a stable position. In order to account for this, the use of a control system will shift the pendulum by rotating a motor directly attached to the pendulum in question, and through monitoring with an encoder will attempt to balance the pendulum and maintain that unstable position. While mechanically simple, the control system and mechanics of the build must be quite precise, and acts as a stepping stone between what students learn in controls, and seeing how controls are used in real life. As such, this is mostly an experiment to design a low cost system which closely resembles a prominent question brought up through controls for students to see and experience. The method used to do this is just to largely find designs which have worked for other students in the past, and to design the current system to be as simple as possible for others to follow. As such, while the goal is to take past students discoveries and expand on them, the first goal is to design a walkthrough that any student should hopefully be able to pick up and make their own system, and show that it results in a working controls system, with the extended goal of showing multiple control methods if time permits.

Faculty Project Mentor: Majid Rashidi, Department of Mechanical and Aerospace Engineering, Case School of Engineering

## “So You Think You Know Struggle?”: A Literary Analysis on the Roles of Racial Identity and Race-Related Stress in Black American Activism

**Kamarea Valentine,** Psychology, CAS - College of Arts & Sciences

Pursuing social and economic justice and autonomy is a historical testament to the Black American way of life. Throughout U.S. history, the Black activist manifests as an embodiment of the Black American's pursuit towards a prosperous world of justice and free will. The present literature review critically analyzes four studies that employ surveys to investigate the concurring factors of racialization and race-related stress as either predictors or correlates of Black American activism. Current literature demonstrates a significant correlation between race-related stress and low- and high-risk activism orientations. Pro-Black racialized perceptions of self and race-related stress also present a significant role in predicting the presence of low- and high-risk activism orientations. The implications of these findings can provide insight for community organizers in the development of base-building amongst Black American youth activists.

Faculty Project Mentor: Sharon Milligan, Mandel School of Applied Social Science, SAS - Mandel School of Applied Social Science.

**Effects of Rotation on DST and the Rheology of Dense Suspensions**

**Antonio Maia,** B.S. Engineering Physics with Concentration in Computer Science

Discontinuous Shear-Thickening (DST) in dense suspensions is a phenomenon where viscosity increases abruptly under shear rate due to particle interactions. Many recent studies have focused on the frictional contact network and non-affine linear velocities and their correlations. However, the role of particle rotation near or at jamming in influencing the onset and magnitude of DST remains poorly understood. In this study, we use Python-based simulations to model 3D dense suspensions and analyze how particle rotation, friction, and system size affect the formation of clusters that drive jamming. Preliminary results suggest that the number of counter-rotating particles increase with both packing fraction and applied stress. We observe that the counter-rotating particle clusters grow in size and number as the shear rate increases, leading to earlier and more abrupt jamming. Understanding these mechanisms will provide new insights into the physics of DST and could enable the development of more efficient materials processing techniques.

Faculty Project Mentor: Abhinendra Singh, Macromolecular Science and Engineering, ENG - Case School of Engineering

**Active Learning in Biochemistry: Comparing Synchronous and Asynchronous Instruction Before and After Course Redesign**

**Amol Verma**, Chemistry

Online STEM education continues to grow, but asynchronous formats often struggle to match the engagement and retention levels of traditional in-semester courses. This study investigates whether incorporating structured, case-based active learning into biochemistry instruction can improve content retention and student engagement—especially in asynchronous settings. We will compare four student cohorts: (1) a historical synchronous biochemistry course using traditional lecture-based instruction, (2) a historical asynchronous version of the course, (3) a redesigned synchronous course featuring weekly structured active learning, and (4) a revised asynchronous course incorporating those same active learning assignments. All groups will receive comparable instructional content and assessments. Survey data will also be collected to evaluate student engagement, confidence, and perceived learning gains. This study takes advantage of both historical course records and prospective experimental data to measure the effects of course format and active learning structure. The project is currently in the development phase. However, we hypothesize that students in the redesigned courses—particularly those in the asynchronous group—will demonstrate increased content retention and engagement compared to their counterparts in the original course formats. If successful, this work may offer practical, evidence-based strategies for improving online STEM education, making asynchronous courses more engaging, equitable, and effective. The findings could support the adoption of structured, research-based active learning models for both in-person and remote science instruction.

Faculty Project Mentor & Capstone Instructor: Dr. Rekha Srinivasan, Department of Chemistry, Case Western Reserve University

## Uric Acid in Cockroach Ganglia

**Anna Vo,** Chemistry

This study investigates whether cockroach ganglia produce uric acid under starving conditions. Unlike humans, cockroaches do not utilize the urea cycle or nitrogen waste disposal. Previous findings have suggested the presence of a trehalose pathway and indicate that thoracic ganglia may play a role in uric acid production. This research seeks to determine if starving conditions influence uric acid synthesis in these ganglia, providing insights into the metabolic flexibility of cockroaches under stress. To test this hypothesis, a biochemical assay utilizing uricase and horseradish peroxidase was adapted, a method commonly used to detect uric acid in biological systems via luminescence. Initial experiments focused on optimizing reaction conditions by varying concentrations of uric acid, the enzymes, and buffers to establish reliable standards for micro scale analysis. These standards were then used to evaluate uric acid production in ganglia extracts under controlled conditions, with further analysis ongoing to validate the findings. The results have a potential to uncover the metabolic pathways within the nervous system of cockroaches, particularly under stress. If ganglia are found to produce uric acid during starvation, it could suggest a previously unrecognized role of the nervous system in metabolic regulation. Contributing to a broader understanding of invertebrate physiology and the mechanisms underlying survival.

Mentor: Ryan Arvidson, Biochemistry

Capstone Instructor: Drew Meyer, Chemistry

## Eco-Energy Monitor

**Hunter Voithofer,** Electrical Engineering

The Eco-Energy Monitor project aims to develop an affordable and user-friendly system for monitoring household energy consumption in real-time. With rising energy costs and increasing concern over environmental sustainability, individuals are seeking practical tools to help reduce their energy usage. However, most consumer energy monitors are either limited to monthly data or too expensive for the average household. This project addresses that gap by creating a low-cost, accurate, intuitive energy monitoring system to empower users to track and improve their energy efficiency. The system uses affordable hardware components such as the ACS712 current sensor, ZMPT101B voltage sensor, and an ESP32 microcontroller. These devices can sample household power consumption and convey this information to a user-friendly interface. The interface is a standard web browser that enables the user to easily understand the energy consumption data and consequently identify areas of consumption, receive notifications, and, therefore, make changes towards reducing consumption. The project adheres to IEEE standards for electrical measurements and prioritizes low power consumption to guarantee that the monitor does not negate energy savings. The development includes integrating sensors with the ESP32, creating a web-based interface, and conducting thorough testing to confirm accuracy, reliability, and usability. The system will be restricted to standard household devices, excluding high-voltage applications or predictive analytics, and will concentrate on delivering real-time feedback for everyday users. By combining affordability, simplicity, and effectiveness, the Eco-Energy Monitor project seeks to democratize access to real-time energy data and contribute to more sustainable household energy practices.

Faculty Project Mentor/Technical Advisor: Nick Barendt, AVP for Research, Case Western Reserve University

Capstone Instructor: Gregory Lee, Department of Electrical, Computer, and Systems Engineering, Case Western Reserve University

## Subjective Cognitive Function in Adults with Epilepsy and Healthy Controls Using the Memory Assessments Clinics-Scale for Epilepsy (MAC-E)

**Shejuti Wahed,** Neuroscience & Psychology; Dr. Robyn Busch, Cleveland Clinic Neurological Institute

Subjective cognitive complaints are frequently endorsed by adults with epilepsy. The Memory Assessments Clinics-Scale (MAC-S) has been widely used to evaluate subjective cognitive functioning in adults with epilepsy, including its relationship with objective memory and psychological factors, and to evaluate changes before and after epilepsy surgery. However, the MAC-S has limitations, such as its length and outdated items, and it was originally designed for older adults with memory issues and may not be as relevant for younger patients with epilepsy. The MAC-E, or Memory Assessments Clinics-Scale for Epilepsy, was developed to reduce the length of the MAC-S and remove outdated items and items that do not relate well to epilepsy. The result is a revised 30-item questionnaire with 5 factors: working memory, attention, retrieval, semantic memory, and episodic memory.

Normative data for the MAC-E has not yet been developed, and changes in subjective cognitive functioning in adults before and after epilepsy surgery have not been studied with the MAC-E. Thus, the goal of this study is to characterize baseline subjective cognitive functioning in both healthy controls and in adults with epilepsy in relation to demographic and disease variables. We also aim to evaluate the change in subjective cognitive function from before to after epilepsy surgery and its relationship with demographic, disease, and surgical variables. The results will provide us with normative data for the MAC-E that can be used to generate standard scores in patients with epilepsy for clinical interpretation, as well as factors associated with changes in subjective cognitive functioning following resective surgery for pharmacoresistant epilepsy. Together, these aims will refine the assessment of subjective cognitive functioning in epilepsy.

Project Mentor: Dr. Robyn Busch, Department of Neurology and Epilepsy Center, Neurological Institute, Cleveland Clinic

Capstone Instructor: Dr. Jon Niemi, Department of Neurosciences

## Effortful Prosocial Behavior in Relational Contexts

**Olivia L Wang,** Department of Neurosciences, CWRU; May Kristine Carlon, Center for Brain Science, RIKEN; Naoko Shiono, Center for Brain Science, RIKEN; Yoshinori Nanjo, Center for Brain Science, RIKEN; Noriyo Noguchi, Center for Brain Science, RIKEN; Yasuo Kuniyoshi, Center for Brain Science, RIKEN

Prosocial behaviors are actions that benefit other people. They occur in varying situational contexts, carrying different motives, costs, and benefits that may affect one's execution of them. When more physical effort is required to perform a prosocial behavior, people experience greater apathy, in which they behave less prosocially compared to when the same behavior benefits themselves. While people generally exhibit greater instances of prosocial behavior towards familiar faces than strangers, it is unclear as to the extent of how these relational contexts modulate the effort invested in them. Thus, this project is a preliminary study aiming to characterize how one's friendships, a key type of relationship in people's lives, are associated with their execution of effortful prosocial behavior. A total of 31 participants were recruited for a questionnaire and behavioral task. The questionnaire measured the quantity and quality of their friendships, while the behavioral task required participants to decide how much physical effort to exert to benefit themselves, a friend, and a stranger. Results indicate that participants chose to exhibit less effort to benefit strangers than towards their friends or self, and that the quantity of one's friendships is positively associated with the effort invested in prosocial behavior towards strangers. These findings provide insight into the relationship between social connectivity and prosociality, suggesting that having more friends might promote increased prosocial behavior toward strangers.

Project Mentor: Yasuo Kuniyoshi, Social Cognition and Behavior Collaboration Unit, Toyota Collaboration Center (BTCC), Center for Brain Science, RIKEN

## Exosome Optimization and Loading for Neurological Delivery

**Victoria Rose Warady**, Department of Biomedical Engineering, Case Western Reserve University; Jun Zhang, Manuel Camacho Martinez, Qingzhong Kong

Exosomes are defined as extracellular vesicles ranging 30-150 nm in diameter, which are secreted by cells and play a critical role in many processes, including cell-cell communication, reprogramming, and spreading of viruses and pathogenic protein aggregates. Exosomes show minimal immunogenicity/toxicity, high stability in blood, and outstanding capacity to cross biological barriers, including blood-brain barrier (BBB). These properties make exosomes a highly attractive candidate for delivery of therapeutic agents, including various drugs and biologics (peptides, oligonucleotides, RNAs, etc.), for neurological disorders, such as brain cancers and Alzheimer's Disease.

The Kong lab aims to develop human cell-derived exosomes for safe and effective delivery of therapeutic non-viral DNAs to the CNS for gene therapy of brain diseases such as Alzheimer's disease and prion diseases. This treatment strategy faces multiple challenges, including optimization of exosome production and isolation, introduction of DNA to exosomes, and assessment of the DNA delivery and expression efficacy in the CNS. We isolated exosomes from M17 (a human neuroblastoma cell line), developed an electroporation protocol for introducing a GFP plasmid into the purified exosomes, and tested the plasmid-containing exosomes in mice. Our preliminary data show GFP expression in the brain after peripheral administration, demonstrating the proof-of-concept feasibility of our exosome-based non-viral gene therapy approach for CNS diseases. Further optimization and testing are underway.

Project Mentor: Dr. Qingzhong Kong, Department of Pathology, School of Medicine, Case Western Reserve University.

## Glioblastoma: Recent Advancements and New Targets

**Micah Wayne**, Biology

Glioblastoma is an incurable, aggressive brain cancer that has an average survival rate of 12-15 months. This paper will discuss recent advancements in glioblastoma research and possible targets for treatment. While glioblastoma with Isocitrate dehydrogenase mutations, Methylated-DNA-protein-cysteine methyltransferase (MGMT) promoter methylation, and CD34 expression all provide more positive outcomes for standard treatments, new possibilities such as AMPAR-inhibitors, Anaplastic lymphoma kinase inhibitors, and extracellular signal-regulated kinase inhibitors are providing new treatment avenues. By using more targeted drugs that conform to the subtype of glioblastoma a patient has, hopefully survival time can be extended as we continue our attempts to cure glioblastoma.

Faculty Mentor: Nancy Dilulio, Department of Biology

## The role of Intellectual risk gene NDST1 in Synapse development

**Destini Weller**, Neuroscience; Dr. Peng Zhang, Department of Neurosciences; Dr. Qin Xu, Department of Neurosciences

Synapses are basic units for neuronal communication in the brain, whereas synaptic dysfunctions contribute to impairment in cognitive function in mental illness. Mutations of NDST1, a gene crucial for the biosynthesis of the heparan sulfate glycan, have been found to be involved in autosomal recessive intellectual disability. Yet whether NDST1 is causative for the disease remains undetermined. Our published work found that heparan sulfate is critical for normal synapse development, prompting us to investigate a novel hypothesis that deletion of NDST1 leads to abnormal synapse development and function. To test this hypothesis, the lab has established a NDST1 conditional knockout mouse model in which AAV9-hSyn-Cre or AAV9-hSyn-YFP were injected into NDST1 flox/flox mouse brains at the postnatal day 0.

My Capstone project aims to determine in which cells NDST1 was deleted and their consequence on the formation of excitatory synapses by using quantitative immunofluorescence staining and imaging techniques. The success of my project will validate the knockout of NDST1 and provide a novel mechanism through which NDST1 deficiency contributes to the related brain disorders.

Faculty Project Mentors: Dr. Peng Zhang, Department of Neurosciences

Capstone Mentor: Dr. Jon Niemi, Department of Neurosciences

## Crystallization of Amorphous Alloys using In-Situ X-ray Diffraction

**Benjamin Wellnitz**, Department of Physics; Dr. Matthew Willard, Department of Materials Science and Engineering, CWRU

Soft magnets are commonly used in AC power applications, such as the power grid, due to their ability to switch their magnetization direction very easily under an applied field. Improving soft magnetic properties to reduce power loss is critical for a sustainable future. Nanocrystalline soft magnets are a newer type of magnet that achieves their softness through a microstructure composing many nano-sized grains embedded in a non-uniform (amorphous) structure. Nanocrystalline magnets are typically formed by annealing an initially amorphous structure. Here we investigate the crystallization process while annealing $(Fe_{0.29}Co_{0.60}Ni_{0.11})_{88}Zr_7B_4Cu_1$ nanocrystalline soft magnets. Using a heating stage attachment to the Rigaku SmartLab Multi-Purpose X-Ray Diffraction (XRD) System in the Swagelok Center for Surface Analysis of Materials at CWRU we can probe the crystalline structure over time. During these XRD experiments, we measure the diffracted X-ray intensity of peaks at specific angles which create a pattern that is unique to specific crystal structures. An amorphous structure will show a broad scattering peak rather than sharp diffraction peaks. By collecting XRD measurements over time we can see the transformation between amorphous (broad scatter) to crystalline (sharper peaks). We can use the XRD data to estimate how far along the crystalline transformation is at each point in time. An in-situ investigation of the crystalline kinetics will ensure a stronger understanding of how fast and when crystallization takes place.

Project Mentor: Professor Matthew Willard, Department of Materials Science and Engineering, CWRU

**The Many Fates of a Fishing Ship: The Exploitation and Modification of European Technologies in 17th Century Wabanaki, Beothuk, and Inuit Communities**

**Walter Wexler**, History, CAS - College of Arts & Sciences

When technologies like metals, ships, and guns were introduced to Indigenous nations in North America during the colonial period, they underwent a complex process of reconstruction. Items were not taken on due to some sense of objective superiority. They were also often not used as they were originally intended. At times, items were entirely rejected in favor of technologies invented by native peoples. Indigenous peoples from across the continent wrestled with technological change to survive and maintain sovereignty. This manifested differently in different cultures and different colonial contexts.

My comparative of firearms, metals, and maritime technology exploitation among the Wabanaki nations in what is now called Maine and Southeastern Canada, Beothuk peoples in Newfoundland, and the Inuit of Southern Labrador, prove this claim. In a relatively compact geographical area, with similar colonial players, from the 1670s through the 1730s, a wide variety of technological exploitation, modification, and outright rejection occurred. By tracing the fate of a hypothetical European fishing ship carrying muskets, iron tools, and fishing equipment, I show how these communities used European technologies as a modifiable resource. Beothuk craftspeople scavenged ships for nails that were hammered into arrowheads which mimicked stone tools. Inuit sailors used ships to carry entire families, repurposing European vessels as Indigenous Umiaks. Wabanaki privateers stole fishing ships and used them to raid up and down the coast of Maine to preserve their land against settler encroachment.

This research was conducted using a combination of archaeological and manuscript sources. This combination of disciplines is important to illustrate historical contexts where information is sparse. The research is informed by past studies on the modification of trade copper and firearms adoption in the Great Lakes. I expand inquiry eastwards to New England and the Maritimes, and into the depths of the Atlantic Ocean.

Project Mentor: Dr. John Broich, Department of History

Capstone Instructor: Dr. Gillain Weiss, Department of History

**Glial Knot is required for experience-dependent synaptic refinement during an olfactory critical period**

**Abigail Wilkov**, Department of Neurosciences, Case Western Reserve University School of Medicine; Hans Leier, Alexander Foden, Heather Broihier

Early in life, some synapses are strengthened, and unnecessary connections are eliminated in an activity-dependent manner which is mediated by glia in a process known as synaptic refinement. Abnormal synaptic refinement is implicated in autism spectrum disorder and other neurodevelopmental disorders, raising the need for robust experimental models in which the underlying mechanisms can be identified. Work from our lab and others has established the *Drosophila melanogaster* olfactory system as an ideal model for studying synaptic refinement. We have previously demonstrated there is a critical period for experience-dependent synaptic refinement in olfactory sensory synapses which are pruned by glia in response to ethyl butyrate (EB) exposure. We identified Knot, a DNA-binding transcription factor, as a hit in a forward genetic screen for glial genes required in synaptic refinement. It is established that Knot mediates head segmentation, wing formation and neurogenesis, but its potential function in glia is unknown. Here we show that Knot is required for experience-dependent glial pruning of olfactory sensory neurons during critical period EB exposure. We are currently working to classify the glial subtype responsible for this phenotype during the early life critical period. Our results demonstrate a novel role of Knot in glia, which we anticipate being a starting point for exploration of glial Knot's function in experience-dependent synaptic refinement. Mutations in EBF3, the Knot ortholog in humans, causes syndromic neurodevelopmental disorder; thus, our research on glial Knot may illuminate novel responsibilities of this transcription factor in human disease.

Project Mentor: Heather Broihier, PhD, Department of Neurosciences

Faculty Sponsor: Ashley Nemes, PhD, Department of Neurosciences

**The Importance of DLK in Amyloid Plaque Formation in an Alzheimer's Mouse Model**

**Sarina Wills,** Department of Neurosciences; Dr. Manish Dwivedi, Department of Neurosciences; Yiwen Zhang, Department of Neurosciences, Veda Valamuri, Department of Neurosciences; and Dr. Catherine Collins, Department of Neurosciences

Alzheimer's Disease (AD) is a neurodegenerative disorder characterized by progressive memory loss and is the leading cause of dementia and a top cause of death in the United States. Key pathological features of AD include amyloid plaques, and dystrophic neurites, which are swollen, damaged neuronal projections that surround amyloid plaques. The cellular pathology of dystrophic neurites, amyloid plaques, and their contributions to cognitive impairment can be studied in the 5x FAD transgenic mouse, which over expresses multiple known mutations that are linked to AD pathogenesis. Previous students in the Collins lab discovered that the axonal kinase DLK localizes to dystrophic neurites. DLK is an upstream regulator of MAP Kinase signaling and has been previously studied for its roles promoting regeneration and degeneration of damaged axons. A potential function for DLK in dystrophic neurites has not previously been examined.

The goal of this study has been to confirm the observation that DLK localizes to dystrophic neurites and begin to investigate its function in this location. To confirm the specificity of the antibody for DLK, we used conditional knockout mice in which essential DLK exons are floxed, crossed into the background of the 5xFAD transgene (5xFAD; *Dlk-f/f* mice). Cre or GFP control was introduced in the hippocampal DG by stereotactic injection. I will present data from this experiment that demonstrates effective knockout of DLK. Intriguingly, staining for beta-amyloid appears more intense at lesions that lack DLK. To further probe the effect of DLK inhibition on beta-amyloid, we treated mice for 7 days with the DLK inhibitor GNE-3511. This led to a striking induction of beta amyloid. These data suggest a previously unappreciated role for DLK at dystrophic neurites in restraining the generation of amyloid beta plaques.

Project Mentor: Dr. Catherine Collins, Department of Neurosciences, CWRU

Faculty Mentor: Dr. Jon Niemi, Department of Neurosciences, CWRU

**Discovery of Unusual Amino Acids in Cyanobacterial Metabolites and Corresponding Alterations in Biological Activity**

**Hannuo Xie,** Chemical Biology Major

Cyanobacterial blooms have been a topic of environmental and public health concern due to their ability to produce a suite of toxic metabolites in bodies of water, impacting ecological health and water security. The potent hepatotoxin microcystin-LR and its congeners are the most well-studied cyanotoxin to date. However, there remains limited knowledge regarding other cyanobacterial metabolites produced during these blooms, such as the micropeptins, microviridins, microginins, and ferintoic acids. This project focused on one of the novel micropeptins discovered by the Bertin laboratory with unprecedented amino acid composition and configuration, detailing its isolation and characterization through comprehensive analytical methods. Moreover, chymotrypsin inhibition assay of this metabolite was conducted in concert with other novel cyanobacterial metabolites to probe the biological implications of these amino acid alterations, and significant changes in chymotrypsin inhibition were observed after administration of two of the micropeptins, which provoke further investigations into the biological activities of these novel metabolites. The presence of these unusual amino acids along with their differing biological activities implies a need for greater understanding of the biosynthesis of these metabolites and their potential biological applications.

Keywords: harmful algal blooms, cyanobacterial metabolites, chemical biology, peptides, chymotrypsin inhibition

Faculty Mentor: Matt Bertin, Ph.D., Department of Chemistry, Case Western Reserve University

**Permeation of Polyacrylamide Hydrogels inside Complex Coacervate Droplets**

**Kai Yamagami** (Physics) & Svetlana Morozova (Macromolecular Science and Engineering).

Liquid-liquid phase separation underpins the formation of biomolecular condensates in cells. Biomolecular condensates can compartmentalize biomolecules without membranes and regulate functions such as stress response and gene regulation. Notably, biomolecular condensates exist in crowded and elastic environments. For example, nuclear condensates are surrounded by chromatin network, and stress granules associate with the cytoskeleton. However, the role of elastic networks in phase behavior and whether networks permeate phase-separated droplets remains elusive in cellular contexts. Recent theoretical work has predicted that the balance of elasticity, surface tension, and wetting energy determines distinct phases of droplet-network interactions. Under high surface tension and wetting energy, the network is cavitated, as confirmed by past research using oil droplets in silicone gels. While theory predicts network permeation under low surface tension and wetting energy, we lack experimental validation in this crucial condition, which is prevalent in the cellular environment. Here, we use a synthetic system where complex coacervate droplets are grown inside polyacrylamide hydrogels; since both gels and coacervates are aqueous, surface tension and wetting energy are low. We probed the droplet-network interactions under confocal microscopy by fluorescently conjugating the hydrogel and complex coacervate. At various elastic moduli ranging from 30 Pa to 2000 Pa, we observed gel permeation within complex coacervate droplets where the degree of permeation is larger for stiffer gels. We also studied how the polymer concentration within the complex coacervate and the ionic strength of the environment affect the degree of permeation. We can understand that permeation is a competition between the elastic deformation energy required to push out the network and the wetting energy to wet the network in the complex coacervate. Our result provides an experimental validation of permeation and suggests that permeation may play a critical role in the mechanical control of biomolecular condensates' size and material exchange.

Faculty Mentor: Dr. Svetlana Morozova (Macromolecular Science and Engineering).

Capstone Instructor: Dr. Idit Zehavi (Physics).

**Investigating the Role of Septate Junction Proteins and Membrane-associated Guanylate Kinase, in Trafficking, Localizing, and Maintaining Voltage-Gated Calcium Channels at the Active Zone**

**David Yang**, Department of Neuroscience, Case Western Reserve University School of Medicine; Marina Bostelman, Paola Van der Linden, Lauren Fennema, Heather T. Broihier

Synapse is the site of communication between a neuron and another cell, conveying information about everything – from thoughts to memory to sensation to motor action – in our brain and body. The voltage-gated calcium channel (VGCC) at the synapse promptly converts electrical stimuli to chemical neurotransmitters, enabling synaptic communication. Despite its vital role at the synapse, mechanisms of VGCC trafficking, localization, and maintenance at the axon terminal are poorly understood. Using the neuromuscular junction of *Drosophila* as an *in vivo* model, 50 synapse-related proteins and their relationship to VGCC were screened. Here, I report the knockdown effects of a family of synaptic cell adhesion molecules – septate junction (SJ) proteins – and their pre- and postsynaptic intracellular binding partners – membrane-associated guanylate kinases (MAGUKs) – on the localization/concentration of VGCC. A presynaptic knockdown of the alpha and beta subunits of the Na+/K+ pump, tricellular cell junction proteins, and the MAGUK CASK reduced VGCC localization/concentration, highlighting the complexity of maintaining VGCCs as organized clusters at the presynapse. Notably, a knockdown of the MAGUK Disc large (Dlg)/postsynaptic density-95 (PSD-95) at the postsynapse increased VGCC localization/concentration at the presynapse, revealing a novel player in presynaptic homeostatic plasticity (PHP).

Project Mentor: Heather Broihier, Neurosciences, MED - School of Medicine

## The Functional and Structural Overview of Human Poly-ADP-ribose Polymerase 3 (PARP3) on DNA Single-strand Break Repair (SSBR) Pathway

**Junseo Yang,** B.S. Biochemistry CWRU

DNA serves as the blueprint of all living organisms, yet it is constantly subjected to damage, requiring robust repair mechanisms to maintain genome integrity. Eukaryotic organisms have various response systems to mitigate such abnormalities and ensure genomic integrity. Poly (ADP-ribose) Polymerase 3's (PARP3) is one of the DNA damage repair proteins involved in the single-strand break repair (SSBR) pathway. PARP1 and 2 have been extensively studied and produced therapeutic drugs like PARP Inhibitors that are in clinical use for treating breast cancers with mutations in BRCA1/2 (Talazoparib and Olaparib), ovarian and peritoneal cancer (Niraparib), and prostate cancer (Rucaparib; which also inhibits PARP3 in addition to PARP1 and 2). However, the molecular mechanism of PARP3 in the DNA damage repair pathway remains relatively unexplored compared to PARP1 and PARP2. Based on the preliminary research, PARP3 exhibits lower binding affinity to DNA SSB sites than PARP 1 and 2, especially sterically hindered nick sites within mono-nucleosomes. While PARP1 and 2 perform poly ADP-ribosylation (PARylation), PARP3 mono-ADP-ribosylates (MARylation) histone tails, Histone PARylation Factor 1, and PARP3 itself. Exploring the binding affinity of PARP3 to SSB sites, an Electrophoretic Mobility Shift Assay (EMSA) has been performed with various SSB sites in nucleosome contexts with different spatial availability. PARP3 was demonstrated to be highly nick-specific with low non-specific binding. Notably, the binding affinity of PARP3 is greatly affected by the location of the nick site as it has a notably lower binding affinity to the nick sites occluded by histone cores. The MARylation activity of PARP3 quantified using Western blot analysis with Biotinylated $NAD^+$ and fluorescent Streptavidin antibody demonstrated the positive correlation between PARP3's binding affinity and functional activity. Moreover, the MARylation analysis showed that H2B and H3 are MARylated by PARP3.

Project Mentor: Dr. Tae Hun Kim, Department of Biochemistry, Case Western Reserve University School of Medicine

## Role of CD47-SIRPalpha Signaling in DLK Mediated Microglial Phagocytosis Axonal Injury

**Basak Yavuz**, Neuroscience; Dr. Catherine Collins, Department of Neurosciences, School of Medicine

After sciatic nerve injury, many pathways are activated including a stress signaling pathway that is regulated by Dual Zipper Kinase (DLK). DLK is a neuronal kinase that regulates MAP Kinase signaling in response to axonal damage. Previous work in the Collins lab found that following nerve injury, DLK activation in damaged motoneurons leads to the loss of upstream synapses, a process called 'synapse stripping'. This project seeks to better understand the process of synapse stripping. Here we investigated the localization of CD47 and SIRP-alpha, which is -the cluster of Differentiation 47- a transmembrane protein that is usually located on the surface of the cell. CD47 is also known as an integrin-association protein because it is a protein that is ubiquitously expressed as a transmembrane receptor. Also, CD47 has a "do not eat me" function. Cells that express CD47-expressing transmembrane proteins can be protected from phagocytosis by binding to SIRPalpha protein on macrophages. Additionally, SIRPalpha is a transmembrane protein that acts as an inhibitory receptor, which interacts with CD47 to regulate phagocytosis and other immune responses. Using immunohistochemistry (IHC) and confocal microscopy, I have characterized and quantified the localization of CD47 on individual synaptic boutons of motoneurons, including cholinergic boutons marked by the VaChT transporter and glutamatergic neurons marked by VGLUT1. My current data are inconclusive due to high variability between samples for CD47 staining. Future research can investigate further look at other synaptic markers and its injury and DLK dependency.

Project Mentor: Dr. Manish Dwivedi, Dr. Lauren Reilly-Jankowiak and Dr. Catherine Collins

Capstone Mentor: Dr. Jon Niemi

**Comparison of Shape and qMRI between contralateral and ipsilateral knees in subjects 10 years following ACLR**

**Patrick Y. Yeh**, Department of Biology, Case Western Reserve University; James R. Peters, Xiaojuan Li

The standard treatment for an acute ACL tear is ACL reconstruction (ACLR), however, longterm studies have shown that ACLR has little effect on the pathology of post-traumatic osteoarthritis (PTOA) as close to 50% of those who undergo a reconstruction will develop osteoarthritis within 14 years of surgery. The typical clinical diagnosis of PTOA is done according to the Kellgren and Lawrence grading, which requires the clinician's objective interpretation of radiographs. Studying the differences between injured and uninjured bilateral morphological and quantitative MRIs (qMRIs) may allow for alternative ways to identify markers of PTOA. The patella, femur, and tibia bones from bilateral MRI of ipsilateral (ACLR operated) and contralateral (healthy) knees obtained 10 years after ACLR for 10 subjects were automatically segmented using META's Segment Anything Model 2 (SAM2). Segmentations were then manually inspected and corrected and used to create combined shape and orientation models of the bones. Shape scores, T1r.

Faculty Project Mentor: James Peters, Biomedical Engineering, CCF - Cleveland Clinic

## Advances in Solid Tumor CAR-T Cell Therapy

**Catherine Yu**, Biology, CAS - College of Arts & Sciences

Chimeric antigen receptor (CAR) T cell therapy has recently been approved (in 2017) for treatment of hematological cancers by the FDA. CAR-T cell therapies work by modifying a patient's T cells to target and destroy cancer cells. Despite their success in blood cancers, there are currently no approved CAR T-cell therapies for treatment of solid tumors. Early phase I clinical trials have demonstrated the safety and feasibility of CAR T-cell therapies in solid tumors. However, their efficacy remains limited due to challenges such as poor tumor trafficking and a lack of good target antigens. This paper reviews clinical trials, as well as preclinical in vitro and in vivo models to explore how CAR T-cell efficacy can be improved by selecting optimal constructs, enhancing T-cell trafficking, and addressing other limitations.

Faculty Project Mentor: Nancy Dilulio, Biology, CAS - College of Arts & Sciences

## Identifying Key Risk Factors for Alzheimer's Disease Through Logistic Regression Analysis

**Haochen Yu,** B.S Statistics

Alzheimer's Disease (AD) poses a growing challenge to public health worldwide due to its substantial socio-economic impact. This project aims to address the research question: Which demographic, genetic, and lifestyle factors most significantly predict the risk of AD? By using a dataset with over 74,000 observations, I focus on key variables including age, education level, country of residence, family history of Alzheimer's, and the presence of the APOE-ε4 allele. My work seeks to advance the understanding the risks of AD, supporting early diagnosis and targeting intervention strategies.

My methodology begins with exploratory data analysis (EDA) to assess variable distributions, detect outliers, and explore correlations. Subsequently, I used logistic regression on a 70/30 training-test split to build a predictive model. The study found that age, having a family history of Alzheimer's, and having the APOE-ε4 allele increase the probability of being diagnosed with Alzheimer's disease. The model achieved an area under the ROC curve (AUC) of 0.791, demonstrating moderate discriminative capability. These findings reinforce the importance of genetic and familial factors in AD risk.

Faculty Project Mentor: Dr. Jenny Brynjarsdottir, Mathematics, Applied Mathematics, and Statistics, College of Arts & Statistics, Case Western Reserve University

Capstone Instructor: Dr. Jenny Brynjarsdottir, Mathematics, Applied Mathematics, and Statistics, College of Arts & Statistics, Case Western Reserve University

**Exploring the Complexities of Colorectal Cancer Through a Multi-Omics and Network Medicine Approach**

**Mucen Yu**, Biology, CAS - College of Arts & Sciences

Colorectal cancer (CRC) remains a major public health challenge due to its high incidence and mortality rates worldwide. This study employs a multi-faceted approach to identify and repurpose existing FDA-approved drugs for CRC treatment using a combination of network medicine and multi-omics analysis. Gene ontology (GO) biological pathway analysis is integrated with network proximity analysis (NPA) to systematically identify drugs that may impact key biological processes involved in CRC pathogenesis. The methodology includes the identification of CRC-associated genes, construction of CRC disease modules, and evaluation of drug-target interactions within the human protein-protein interaction (PPI) network. Initial findings have highlighted promising candidates such as Trimebutine, which demonstrates potential effects on crucial signaling pathways implicated in cell proliferation and survival. Further validation will involve detailed literature reviews and large-scale pharmacoepidemiological studies to assess the drugs' effectiveness and safety in broader patient cohorts. This approach has the potential to accelerate the drug repurposing pipeline and enhance the precision of CRC therapy, ultimately improving patient outcomes.

Faculty Mentor: Nancy Dilulio, Biology, College of Arts & Sciences

**Development of Securinine-derivative containing Liposomes for Inhibition of Thioredoxin Reductase I as a novel treatment for Acute Myeloid Leukemia**

**Ian Zagorac**, Chemistry

Acute Myeloid Leukemia (AML) is a clonal malignancy characterized by an accumulation of immature blast cells in the blood and bone marrow, representing approximately 25% of adult leukemias. Despite standard chemotherapy using cytarabine and daunorubicin, known as the "7+3" regimen, patient outcomes remain poor, with median survival between 5-10 months and a five-year survival rate around 18.2%. Consequently, innovative therapeutic approaches are critically needed.

Securinine, an alkaloid isolated from Securinega suffrictosa, was identified in a small-molecule screen as a potent inducer of myeloid differentiation in AML cells, independent of conventional differentiation pathways. Although initially promising, securinine exhibited various off-target effects, the most significant being its interaction with GABA-A receptors, resulting in pro-convulsant and spastic side effects. Despite these limitations, securinine served as a lead molecule for further drug development.

Through focused medicinal chemistry optimization, the Tochtrop and Wald groups developed S250 from securinine derivatives. Drug Affinity Responsive Target Screening (DARTS) revealed that S250 binds to Thioredoxin Reductase I (TrxR1), an important regulator of cell metabolism and redox homeostasis. Mass spectrometry analysis confirmed that S250 binds irreversibly and covalently to the selenocysteine residue at the C-terminal active site of TrxR1.

However, S250 exhibits limited pharmacokinetics and an extremely short half-life, primarily due to irreversible off-target binding to human serum albumin caused by structural similarity between albumin residues and the active site of TrxR1. Liposomes represent an ideal delivery platform to address these pharmacokinetic challenges by encapsulating hydrophobic compounds, enhancing stability, and facilitating targeted intracellular delivery via endocytosis. Inspired by the FDA-approved liposomal formulation CPX-351, we developed S250-loaded liposomes approximately 150 nm in diameter, achieving high encapsulation efficiency. This formulation is expected to enhance selective drug delivery to AML cells, reduce off-target interactions, and significantly improve therapeutic efficacy. Collectively, these findings position liposomal-encapsulated S250 as a transformative candidate for AML therapy.

Faculty Mentor: Gregory Tochtrop, Department of Chemistry

**Difference in Maladaptive Behavior between Preschool and School-age children with PWS**

**Syed Sudman Zaman,** Psychology, CAS - College of Arts & Sciences

Prader-Willi Syndrome (PWS) is a genetic disorder caused by the lack of gene expression on the paternally inherited chromosome 15q11.2-q13 region, with primary genetic subtypes including paternal 15q11-q13 deletion (DEL) (65-75% of cases) and maternal uniparental disomy 15 (mUPD) (20-30% of cases). Clinically, PWS presents with severe hypotonia, poor appetite, feeding difficulties in infancy, and hyperphagia in early childhood, along with self-injury, temper tantrums, and manipulative behaviors. Research suggests that the DEL subtype is associated with increased mood swings, skin-picking, and a higher likelihood of overeating and food theft compared to mUPD (Butler et al., 2004, as cited in Holsen et al., 2009), yet studies on sex differences in PWS-related behaviors remain limited, with only one prior investigation (Gito et al., 2015). Much of the literature focuses on older children and adults, leaving early childhood behavioral patterns underexplored, despite evidence that younger children (ages 1-6) frequently exhibit tantrums and resistance to routine changes, while older children (ages 6-18) display more ritualistic and self-injurious behaviors (Sarimski et al., 2012). This study explored gaps in the literature on PWS maladaptive behavior regarding sex differences and age groups to understand the distinctive features of maladaptive behavior in PWS. We hypothesized that school-aged children, males, and those with DEL would exhibit more externalizing behaviors than preschool-aged children, females, and those with mUPD. Maladaptive behaviors were assessed in 79 participants (53% male, 47% female), with 57% having DEL and 43% mUPD, categorized into preschool (2-5 years old, 56%) and school-age (6-11 years old, 44%) groups. The Vineland Adaptive Behavior Scales-II was used to evaluate behavioral differences across age, sex, and genetic subtypes. Results will be reported, and findings from this study will aid in developing targeted interventions to support caregivers and clinicians in managing maladaptive behaviors and improving outcomes for young children with PWS.

Faculty Mentor: Anastasia Dimitropoulos, Psychological sciences, College of Arts & Sciences

## How do Latin American Citizens Perceive and Respond to Power? A Cognitive Sociopsychological Approach to Regimes

**Saidi Zelaya**, Cognitive Science

Surprise plays a significant role in shaping social behavior, particularly in moments of compliance and resistance. This paper examines the relationship between expectancy violations and social compliance in Latin America, analyzing how cognitive socio-psychological factors shape responses to authority-driven directives within the region's unique historical and cultural context. Expectancy violations trigger cognitive dissonance and heuristic decision-making, influencing compliance, resistance, or social reevaluation. Historical and cultural context in Latin America modifies these processes. The legacy of colonialism, authoritarian rule, and collectivism has produced strong cultures of compliance. These cultures are often reinforced or adapted through mechanisms of surprise, such as propaganda, misinformation, or abrupt changes in political rhetoric. These examples are prominent in Latin America's political history, where surprise has been strategically leveraged to maintain control. For instance, Venezuela's use of censorship and misinformation, as well as Chile's Pinochet regime's psychological compliance strategies, show how expectancy violations can reinforce obedience or suppress defiance. Through a systematic review of literature on expectancy violations, schema theory, and social influence to analyze the roles of cognitive biases within sociopolitical systems. By analyzing the mental components that constitute surprise and compliance, this study advances existing literature on Latin America's political history to more comprehensive conversations around persuasion, power, and defiance. Furthermore, this analysis acknowledges the implications for activism, governance, and policy in these parts of the world where power and compliance relations are still transforming. Ultimately, this study reveals how specific psychological mechanisms of expectancy violation are deployed within Latin American sociopolitical contexts to influence social compliance, offering new insights into the interaction between cognitive processes and cultural-historical factors in shaping collective behavior.

Capstone Instructor: Vera Tobin, Department of Cognitive Science

**The Influence of Otaku Culture on the Consumption and Production of ACGN Content in China**

**Sijia Zhang,** Asian Studies and Economics

This research examines how Japanese otaku culture—originally associated with niche interests such as anime, comics, and games—has been adapted and commercialized within China's ACGN (Animation, Comics, Games, and Novels) industry. Specifically, it investigates the question: *In what ways do Chinese ACGN production and consumption reflect the interplay of resistance, localization, and absorption of Japanese otaku culture within China's socio-digital ecosystem?* Building on **Dick Hebdige's** subcultural theory, **Hiroki Azuma's** notion of database consumption, and **Henry Jenkins's** participatory culture framework, this project analyzes primary data from digital platforms (Bilibili, Douyin), textual content (fan fiction, cosplay videos), and relevant policy documents.

The significance lies in understanding how fan-driven innovations—such as user-generated content, "danmu" (on-screen comments), and fan art—shape new forms of media engagement. These practices have not only challenged traditional media hierarchies but also prompted corporate platforms to monetize fandom through premium memberships, algorithmic recommendations, and targeted advertising. At the same time, cultural and political factors, including state censorship, steer the ways in which Japanese-style narratives and aesthetics are localized, hybridized, or restricted. Preliminary findings suggest that China's strict regulations lead to inventive fan workarounds (e.g., coded language to bypass content filters) and the emergence of hybridized productions blending Chinese historical elements with Japanese anime tropes.

By highlighting patterns of grassroots creativity, commercial co-optation, and evolving regulatory landscapes, this study demonstrates that Chinese otaku culture functions both as a site of imaginative transnational exchange and a space of subtle resistance. The results underscore that while digital platforms foster vibrant participatory cultures, they simultaneously enmesh fans and creators in commercial and ideological frameworks. Future directions include comparative analyses with other East Asian markets and closer scrutiny of how recommendation algorithms may homogenize content at the expense of cultural diversity.

Faculty Mentor: Lihong Shi, Department of Anthropology

## Pathological Inflammation Alters Oligodendrocyte Differentiation and Function

**Annie Zhao,** Chemistry and Cognitive Science

Multiple Sclerosis (MS) is an increasingly prevalent chronic immune disease that is characterized by the demyelination of neurons in the brain. It presents as the most common demyelinating disease of the central nervous system. Oligodendrocytes, a type of glia in the central nervous system, play a crucial role in controlling MS progression. These specialized oligodendrocyte cells wrap layers of myelin sheath around the axons of neurons to increase the speed of signal transmission. If MS is prolonged and demyelination becomes chronic, oligodendrocytes are severely impacted and the remyelination of neurons becomes difficult. This can cause neurodegeneration and consequences such as severe vision loss and decline in movement.

The differentiation from Oligodendrocyte Progenitor Cells (OPCs) to mature oligodendrocytes is inherent to determining proper oligodendrocyte function. Maturation is strongly influenced by the environment these OPCs are placed in. Interferon gamma (IFNg), a cytokine associated with MS, is widely used to simulate an MS environment for these cells because those with MS show significant upregulation of this inflammatory molecule in the central nervous system. In this study, OPCs were cultured and treated with IFNg to use in further experimentation, where IFNg decreases differentiation of oligodendrocytes and increases immune function of the neuron. The aim of this study is to find the gene, or genes, that are responsible for the decreased differentiation of OPCs in the mature oligodendrocyte lineage and also the upregulation of immune functions. Understanding exactly how oligodendrocytes are affected can elucidate potential therapies for these specialized cells in MS conditions, thereby paving the way for new treatment modalities that harness the innate regenerative capacity of oligodendrocytes.

Faculty Menor: Jon Niemi, Department of Neurosciences

Private Investigator: Paul Tesar, Department of Genetics and Genomic Sciences

## High Fat Diet Decreases Time to First Evidence of Atrial Fibrillation

**Eileen M. Zhao**[1], Biochemistry, Shannon Hanmer[1], Sathyamangla Prasad[1], Kenneth Laurita[1,5], Robert Koeth[1,2,3], Jonathan Smith[1,3], Mina K. Chung[1,2,3], Sarah M. Schumacher[1,3], John Barnard[3,4], David R. Van Wagoner[1,3], Julie H. Rennison[1,3]

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Atrial fibrillation (AF) is characterized by episodes of rapid and irregular heart rate. While it is known that obesity increases AF risk, the impact of a high fat diet (HFD) on atrial structural and electrical remodeling in the context of AF is unclear. We hypothesized that a HFD accelerates AF onset. Wild-type (WT) and cAMP responsive element modulator IbΔC-X heterozygous (TG) mice were fed HFD (45kcal% fat) or matched control diet (CD, 10kcal% fat) beginning at 4 weeks. AF burden was assessed weekly by electrocardiography (ECG) through 15 weeks. Body weight was increased ($p<0.05$) in WT HFD compared to WT CD in female and male mice but was not altered in TG HFD compared to WT HFD. Left atrial (LA) weight was increased ($p<0.0001$) in TG CD and TG HFD compared to WT CD and WT HFD in both male and female mice. LA weight was not increased in WT HFD or TG HFD compared to WT CD or TG CD. ECGs were evaluated to identify the timepoint that AF was first evident. AF was not evident in WT CD males and females. AF was first observed in WT HFD males at 8 weeks and WT HFD females at 14 weeks. In TG males, AF was first evident in CD and HFD at 6 weeks. Notably, all TG HFD males were in AF by 8 weeks, 2 weeks earlier than TG CD males. In TG females, AF was observed at 6 weeks. All TG CD and TG HFD females were in AF by 11 weeks. Our data suggests that AF onset occurs earlier in HFD-fed female WT, male WT, and male TG mice. Future studies will extend HFD duration, evaluate AF burden, and examine the mechanisms underlying AF susceptibility in mice fed a HFD.

Faculty Mentor: Dr. Julie Rennison, Department of Cardiovascular and Metabolic Sciences, Cleveland Clinic Lerner College of Medicine

## The impact of changes in seawater temperature on the growth pattern of shellfish

**Lihong Zheng,** Environmental Geology, College of Arts & Sciences

Seafood is a high-quality source of protein for people in many countries and regions, but climate change can adversely affect the growth and quality of edible shellfish products. Our project investigates how increasing seawater temperature influences the growth rate of edible shellfish. A MATLAB model based on the Dynamic Energy Budget theory was used to analyze and calculate the mass variation patterns and growth rates of 10 edible shellfish species as a function of the seawater temperature. We found an increasing growth rate with increasing water temperature in all analyzed species. The mathematical relationship between seawater temperature increment and the relative growth rate was roughly linear. Finally, we extended our analysis with 8 extra salt-water shellfish species to investigate whether there exists a relationship between the optimal growth temperature of shellfish species and their sensitivity to temperature change. Analyzing the linear correlation coefficient (r value) and applying a p-test, we found no significant correlation between these two variables.

Faculty Mentor: Anne Willem Omta, Ph.D., Earth, Environmental, and Planetary Sciences, College of Arts & Sciences

**Development of a Web Tool for Predicting m5C Writer Motifs in RNA Sequences for NSUN2 and NSUN6 Using Staem5-LM**

**Yifei Zheng**, Systems Biology; Tianyi Li, Computer and Data Sciences; Yuanxi Li, Computer and Data Sciences

RNA methylation plays a crucial role in gene expression and the regulation of cellular processes. NSUN2 and NSUN6 are two members of the Sun RNA Methyltransferase Family that catalyze the transfer of 5-methylcytosine (m5C) at different motifs. While NSUN2 primarily targets tRNA, NSUN6 methylates 3' untranslated regions (3'UTRs) at the consensus sequence CTCCA, influencing mRNA stability and translation regulation. Downregulation of NSUN6 correlates with poor cancer prognosis, making it a promising therapeutic target. To identify m5C sites and determine whether they are catalyzed by NSUN2 or NSUN6, we built a web platform on a previously reported m5C RNA-coding package and trained it with large language model (LLM) embeddings. The platform analyzes published wet lab-derived human mRNA datasets visualized with IGV (Integrative Genomics Viewer) to extract and validate m5C sites. It then classifies the sites based on the distinct sequence and structural preferences of NSUN2 and NSUN6, distinguishing their respective contributions to m5C modification. The platform utilizes Staem5LM, a machine learning algorithm that integrates traditional bioinformatics features with RNAFM embeddings. It employs a stacked ensemble learning architecture with five classifiers: Support Vector Machine, LightGBM, XGBoost, GBDT, and ExtraTree, optimized using

Bayesian parameter tuning. The online tool offers real-time motif prediction and visualization, allowing researchers to input RNA sequences, identify potential m5C sites, and differentiate between NSUN2- and NSUN6-catalyzed methylation. It leverages sequence- and structurespecific data, capturing NSUN6's preference for targeting hairpin loops. By blending LLMbased predictions with experimental IGV data, the tool significantly enhances m5C motif prediction accuracy. Experimental results indicate that Staem5-LM outperforms existing models, achieving higher accuracy, sensitivity, and AUC values, offering a valuable platform for RNA modification research and potential therapeutic target identification.

Project Mentor: Dr. Jing Li, Department of Computer and Data Sciences

Capstone Mentor: Dr. Fu-Sen Liang, Department of Chemistry

## Optimization of Tunability in Metalenses using Liquid Crystals

**Elizabeth Zhou**, Department of Physics**,** Andy Linginger MORE Center

A metalens is a flat, ultrathin lens that uses diffraction for sub-wavelength nanostructures to focus light, offering a compact alternative to conventional optics. However, the limitations of modifications in metalens post fabrication are a well-known stumbling block in expanding its use in real-world applications. To overcome this limitation, the infiltration of the lens with a nematic liquid crystal has been proposed. By changing between the nematic and isotropic phases of the liquid crystal, a focal distance shift of 80μm was observed. Control over the orientation of the liquid crystal (planar/hometropic) in relation to the metalens structure will allow for greater tunability. In order to further optimize this tunability as well as the focal capabilities of the lens itself, this project will design and fabricate metasurfaces using the Two-Photon-Polymerization (TPP) technique.

Faculty Project Mentor: Giuseppe Strangi Department of Physics, Idit Zehavi Department of Physics

**Lysosomal Breakdown of Glycosaminoglycans by β-Glucuronidase is Critical for CNS Myelination**

**Isabel Zhou**, Neuroscience; Keenan Hope, Yiwen Zhang, Dr. Dhananjay Yellajoshyula, Department of Neurosciences

The development of oligodendroglial progenitor cells (OPCs) into myelinating cells, which facilitate axon myelination, plays an essential role in neural circuit plasticity. Prior studies have shown that OPC maturation into myelinating cells is highly sensitive to the extracellular matrix (ECM) content and composition. Major ECM components, such as proteoglycans and their associated sugars known as glycosaminoglycans (GAGs), are key inhibitors of remyelination in conditions like spinal cord injury and multiple sclerosis, as demonstrated by the enzymatic removal of their GAG side chains.

In previous studies, we identified a cell-autonomous role for a GAG metabolism pathway within oligodendrocytes that regulates their development. This pathway is controlled by THAP1, a transcription factor whose loss of function leads to the neurodevelopmental movement disorder dystonia. These findings led us to hypothesize that GAG metabolism in the CNS is a crucial regulatory component of CNS myelination during development. To test this hypothesis, we used a mouse model with complete loss of β-Glucuronidase (GUSB), a lysosomal enzyme responsible for GAG degradation, encoded by the gene *Gusb*. Loss-of-function mutations in *Gusb* cause Sly syndrome or Mucopolysaccharidosis type VII, an autosomal recessive disorder associated with severe neurodevelopmental defects characterized by the accumulation of undegraded GAGs in the CNS.

In a mouse model with complete loss of GUSB activity ($Gus^{mps}$), we observed decreased myelin content and white matter volume, concomitant with a reduced number of mature oligodendrocytes during early development, resulting in hypomyelination of the CNS that persists into adulthood. Ultrastructural analyses of the corpus callosum revealed a significant reduction in the number of myelinated axons in the adult CNS. These results underscore the importance of regulating GAG breakdown in early development for proper myelin generation.

Project Mentor/Principal Investigator: Dr. Dhananjay Yellajoshyula, Department of Neurosciences, CWRU School of Medicine

Capstone Mentor: Dr. Ashley Nemes, Department of Neurosciences

## Enhancing AI Painting Attribution

**Chengling Zhuge**, Physics

This research builds upon prior studies using high-resolution scanners to extract surface height maps from oil paintings in order to train AI models to distinguish brushwork by different contributors (e.g., master vs. apprentice). However, such models often fail to generalize across different canvases. The original goal was to help AI differentiate between canvas texture and pigment layers, yet a major bottleneck was the scarcity of data—each high-resolution scan can take up to three days per painting.

To address this, I propose generating large datasets using digital painting, where pen pressure, position, and time are precisely tracked and used to synthesize height maps—effectively bypassing the need for expensive scanning equipment. The project consists of two processes. Process A focuses on digital painting using Krita, an open-source software. I modified its brush engine using C++ and Python to simulate realistic oil paint behaviors (e.g., pressure influencing pigment density rather than stroke width). Over time, this allows for constructing a model that translates stylus data into plausible height maps, potentially revealing individual artists' digital habits.

Process B targets real oil painting: I paint controlled brushstrokes with varying parameters and scan them to train AI to understand brushstroke characteristics. This isolates features within height maps without the noise of complex artwork.

Together, these processes aim to enhance AI’s ability to interpret and attribute brushwork, offering insight not only into computational models but also into the material understanding of painting and art history.

Faculty Project Mentor: Michael Hinczewski, Department of Physics; Andrew Van Horn, Departments of Physics and Art History; Andrew Lininger, Department of Physics

Capstone Instructor: Idit Zehavi, Department of Physics