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Skin Punch Biopsy Device with Adjustable Blade Sizes for Basal Cell Carcinoma Diagnosis

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Basal cell carcinoma (BCC) is the most common form of skin cancer and can lead to further physiological complications if left untreated. According to Mayo Clinic, BCC often presents as a slow-growing bump, sore, or rough area on the skin. The bump may be skin-colored, pearly, or have visible blood vessels. As BCC grows, it may become itchy, bleed, or painful. It can also form an ulcer that oozes clear fluid or bleeds when touched.

A current standard biopsy technique for diagnosis is known as punch biopsy, which involves using a circular blade with a handle to manually extract a sample of the patient's BCC lesion; however, conventional punch biopsy devices come in set diameters, are single-use, and require a relatively long time to operate. These limitations prevent physicians from quickly retrieving a personalized punch sample from all BCC size presentations. Consequently, conventional skin biopsy tools result in waste production and significant operation efforts, increasing patient discomfort during the procedure.

Our design aims to simplify and streamline the process of taking a biopsy by allowing different size punches and reusing of tips via autoclaving. The easily exchangeable tip would also save time for the physician and shorten clinic visit durations for patients. Since the ergonomic handle can securely attach to blades of multiple diameters, a single device will be able to accommodate various BCC lesion sizes. As a result, our innovation will reduce the waste associated with one-use punch biopsy devices. Future device design will also include a motorized pushing mechanism for the blade, allowing the device to obtain a quick sample within seconds of activation.

Our new device will allow healthcare providers to easily adjust blade sizes for convenience. Additionally, the ergonomic handle shape will alleviate hand cramping and repetitive strain injuries (RSIs) in physicians from continuously administrating punch biopsies. With the planned motorized blade mechanism to be developed next semester, the overall discomfort time for the patients will also be decreased.

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

Investigating the effects of CCF101 on MIA PaCa-2 Pancreatic Cancer Cells

Naimisha Adira, Department of Biology, Case Western Reserve University

Pancreatic ductal adenocarcinoma (PDAC) is a deadly cancer that shows limited response to conventional chemotherapy and radiation treatments. PDAC lacks the needed apoptosis mechanisms that these therapies are attempting to activate (PDAC deletes p53, the master regulator of apoptosis). A potential solution is to develop treatments that do not require p53/apoptosis. Our lab has validated that PDAC and other cancers use epigenetic gene silencing factors of the ISWI/CHD family to prevent the epithelial differentiation that terminates tissue precursor replications. To translate these molecular observations towards therapy, the lab developed a firstin-class ISWI/CHD inhibitor, CCF101. I evaluated the effects of CCF101 on chemo-refractory PDAC cells MiaPaCa2. I found that the half-maximal inhibitory concentration was 4μM at 72 hours. I confirmed that these cell cycle exits were not via apoptosis, using a fluorometric caspase 3 assay. I therefore evaluated for cell cycle exits by mesenchymal to epithelial differentiation. A key transcription factor driver of mesenchymal fates, SOX9, was downregulated. I am presently measuring for markers of epithelial differentiation, and also examining the morphology of the cells for evidence of terminal epithelial differentiation. In conclusion, CCF-101 inhibited the proliferation of chemo refractory PDAC cells without activating apoptosis (non-cytotoxic), however further investigation is needed to determine whether the reduction was due to induced terminal differentiation or another mechanism.

Principal Investigator: Dr. Yogen Saunthararajah. M.D. Department of Hematologic Oncology and Blood Disorders, Cleveland Clinic
Project Mentors: Dr. Ghazaleh Hajmousa, Department of Hematologic Oncology and Blood Disorders at Cleveland Clinic; Dr. Jean Burns, Department of Biology, Case Western Reserve University

Investigating sex and brain hemispheres differences in a clinically relevant model of Traumatic Brain Injury

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Traumatic brain injury (TBI) is a leading worldwide cause of death and financial burden, with TBI-related issues costing $80 billion annually in the United States. Each year, 3.5 million people in the U.S. sustain a TBI, and 5.3 million live with TBI-induced disabilities. TBIs can range from mild to severe, with a wide spectrum of symptoms and disease progression. In our lab, we utilize a clinically relevant model that induces a multimodal TBI (mmTBI), incorporating aspects of global concussive impact, acceleration/deceleration injury, and early-phase blast wave exposure. This produces a highly reproducible brain injury that is characterized by early axonal degeneration progressing to neuronal cell death, blood-brain barrier (BBB) breakdown, systemic metabolic abnormalities, and neurobehavioral impairments reminiscent of human TBI. Despite extensive characterization, sex differences and hemispheric regional differences have not yet been fully characterized in this mmTBI model. This is an important area of investigation, because of the existence of sex differences in human TBI patients. For example, females generally report worse outcomes than males. Investigating these differences is crucial, as it could enhance our understanding of the underlying mechanisms of TBI in different patient populations and inform clinical decision-making regarding treatment and developing therapies. With this project we aim to determine whether TBI generates significant phenotypic differences between male and female and any pathological difference between brain hemispheres to further characterize the mmTBI model. To accomplish this, we will assess various TBI consequences, such as neuroinflammation, axonal degeneration, and BBB deterioration, in both the left and right hemispheres and in male and female mice at 3 weeks, 6 months and 12 months after injury.

Project Mentor: Andrew Pieper, MD/PhD, Department of Psychiatry, School of Medicine

Should We Open The Closet Doors?: Leonardo da Vinci, Isaac Newton, and the Search for Queer Representation

Nandana Ahuja, History and Philosophy of Science & Medical Anthropology, CWRU

In searching for historical representation, the queer community often points to Leonardo da Vinci and Isaac Newton as early examples of gay and asexual figures. This paper will first explore the historical evidence supporting these claims, arguing that while there is limited yet intriguing evidence regarding Leonardo's orientation, the arguments concerning Newton often come from a significant lack of concrete evidence.

Following this analysis, the paper will explore the functions these historical claims serve within the queer community for representational purposes. By labeling past figures, one can claim that queer identities have always existed and argue against ideas that the LGBTQ+ community is a recent development. However, these anachronistic interpretations can overlook the complexities of historical identities and often need to acknowledge cultural norms informing the evidence (or lack thereof).

Lastly, this paper will evaluate the historical accuracy of attributing modern identities to figures in the past, considering how understandings of sexuality have evolved. Overall, this analysis will assess the functions of these attempts at historical labeling and evaluate whether the goals of representation are genuinely served.

Project Mentor: Aviva Rothman, Department of History, CWRU

The Ripple Effect: The Impact of ADHD-Associated Sleep Problems on College Students

Samia Ahuja, Department of Psychology and Sociology

Attention-Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder that includes symptoms of inattention, hyperactivity, and impulsivity. Symptoms often begin in childhood and continue into adulthood. Individuals with ADHD are more likely than their peers to have sleep problems, which often worsen with age. ADHD and sleep problems are closely linked, each making the other's symptoms worse. Among the individuals already diagnosed with ADHD, 55% of children and 80% of adults report sleep issues, including insomnia, difficulty falling asleep, staying asleep, daytime sleepiness, and poor sleep quality. As of 2024, approximately 25% of college students are diagnosed with ADHD. The purpose of this narrative literature review is to examine the ways in which sleep problems associated with ADHD impair the academic performance and executive functioning of college students. In this review, literature from the fields of psychology, sleep medicine, education, and occupational therapy was examined. The collective findings indicate that students with ADHD-associated sleep problems are constantly feeling tired and unfocused, unable to retain information and complete assignments on time. These students experience challenges with procrastination, prior organization, low motivation, and absenteeism, which makes it difficult for them to complete coursework and meet deadlines. Additionally, ADHD-associated sleep problems also impair their executive functioning skills, such as planning and organization, self-regulation, and time management. Lower motivation and self-esteem and reduced working memory as a result of sleep problems make it challenging for students to successfully meet the demands of college life. The implication of these findings show the need for target interventions and support systems in higher education for students with ADHD-associated sleep problems.

Faculty Mentor: Anastasia Dimitropoulos, Department of Psychological Sciences

Psychosocial Impairments in Pediatric Oncology Patients

Daniel Albano, Psychology

Cancer is the leading cause of death in children and adolescents worldwide. Every year, approximately 400,000 children and adolescents are diagnosed with cancer the most common being leukemia, brain cancers, lymphomas and solid tumors. In diagnosis, treatment and survivorship, patients and their families are exposed to highly stressful situations. In addition, literature on the experience of highly distressing events in childhood has suggested that children with Adverse Childhood Experiences (ACEs) are at greater risk for developing physical and mental health complications. This paper seeks to analyze the diagnosis and treatment of pediatric cancer as an ACE that puts patients at a higher risk of developing post-traumatic stress symptoms and psychosocial impairments. The databases Web of Science, Scopus, and PsychINFO were used with key phrases “pediatric oncology/cancer”, “post-traumatic stress disorder/PTSD”, and “developmental disorders” to identify relevant literature. Studies suggest pediatric cancer patients experience post-traumatic stress symptoms, ADHD symptoms, and physiological effects related to areas involved in social cognition at greater rates than the public population. Overarching research supports pediatric cancer patients being at higher risk for exposure to traumatic events, experiencing post-traumatic stress symptoms, and developing neurocognitive impairments compared to healthy children.

Targeting ADAMTS6 to rescue aortic wall integrity in chronic and severe Marfan syndrome mouse models

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Marfan syndrome (MFS) is a connective tissue disorder that often damages the eyes, skeleton, blood vessels, and heart. It is associated with aortic wall insufficiency in which aortic aneurysm and dissection can occur, causing significant morbidity and mortality. Marfan syndrome is caused by a single-point mutation in the FBN1 gene that encodes for fibrillin-1. Fibrillins are microfibrils necessary for the stability of the aortic extracellular matrix. RNAscope in situ hybridization shows Adamts6 and Fbn1 are co-expressed in aortic smooth muscle cells in the prenatal and postnatal mouse aorta, as well as an increase of fibrillin-1 levels in the absence of Adamts6. ADAMTS6 binds directly to fibrillin-1 and proteomics identified an ADAMTS6 cleavage site in fibrillin-1, verifying that ADAMTS6 targets fibrillin-1. This lends to the possibility that deletion of ADAMTS6 could regulate fibrillin-1 availability in MFS. Therefore, we utilized two models of MFS: a severe mouse model and a chronic mouse model, to test and compare the role of conditionally inactivating Adamts6 in aortic smooth muscle cells.

Adamts6 was conditionally inactivated in aortic smooth muscle cells in both MFS models. Mice aortas were extracted, processed, and sectioned. Aortas were stained with elastin, alcian blue, picrosirius red, or antibodies and echocardiogram testing was performed. Conditional inactivation of Adamts6 in both models of MFS, displayed histologic improved aortic wall structure, including increased levels of fibrillin-1 staining, reduced proteoglycan pooling and collagen accumulation, decreased elastin breaks, and restored aortic wall medial thickness. Echocardiogram analysis revealed improved heart function and reduced aortic diameter in the Adamts6- smooth muscle cell-deficient mice. The findings herein suggest that ADAMTS6 regulation of fibrillin-1 microfibrils is a key necessary event in aortic wall maintenance.

Project Mentor: Timothy Mead, Department of Pediatrics, Case Western Reserve University School of Medicine

T-Cell Contribution to Platelet Activation in Tumor-Bearing Mice

Jaidah Allen, Neuroscience Major, Case Western Reserve University

Anthony Sloan, PhD, Department of Cardiovascular and Metabolic Sciences, Cleveland Clinic

Studies have shown that cancer associated thrombosis is the second leading cause of death in cancer patients, including glioblastoma (GBM) patients. Despite this knowledge, there has been limited exploration in how T-cells regulate platelet function in cancer. Our preliminary data from the lab has shown that GBM patients have hyperctive platelets relative to healthy patients, as well as lab mice who have brain tumors. This research aims to answer the question, "How do T-cells contribute to platelet activation in tumor-bearing mice?" Our hypothesis is that tumor-bearing mice lacking T-cells will not show the same increase in platelet activation

My research will carry out several different experimental methods. PCR plating for regulating gene expression, which involves preparing a master mix (primer, H2O, SYBR), adding it to cDNA, and analyzing the samples using QuantStudio. As well as, platelet activation using flow cytometry. For this, platelets will be isolated from mouse blood, treated with antibodies (CD62P), and stimulated with thrombin and then analyzed in the Accuri Flow Cytometer.

This study also includes two major experiments: first, comparing platelet activity between JAMA-1 knockout mice, which has hyperactive platelets, and wild-type mice. Our hypothesis is that wild-type mice will show lower platelet activity. The second experiment involves Four-Core Genotype (FCG) mice, which allows us to differentiate whether platelet reactivity is influenced by chromosomal factors or hormonal. By stimulating platelets with thrombin, we hope to map out platelet reactivity profiles for different genetic and hormonal groups before and after tumor implantation. These findings will help contribute to understanding the role of T-cells in cancer associated thrombosis.

Principal Investigator: Justin Lathia, PhD, Department of Cardiovascular and Metabolic Sciences, Cleveland Clinic

Tabletop Mechanical Tester for Secondary Education

Leo Allen, Mechanical Engineering, CWRU

Tensile testing is a key method for evaluating critical material properties, such as elastic modulus and yield strength. However, the high cost and large size of conventional tensile testing equipment limit its accessibility for middle and high school educators. This project seeks to design and build a low-cost, compact tensile testing machine suitable for use in secondary education, particularly for teaching about composite materials. The machine will enable students to fabricate and test composite samples, providing hands-on learning of material properties. The project will involve the development of both the mechanical and electrical components, along with a software program to operate the device. The machine will accurately measure force using a load cell, with manual adjustment of displacement. The resulting data will be expected to align with outcomes from professional-grade testing equipment, ensuring the educational device's reliability.

Advised by Steve Hostler, PhD, Mechanical Engineering, CWRU

Improving the Interlayer Bonding Strength of 3D Printed Polymer Composites via an Alternating Thermal Stimulus.

Leo Allen, Mechanical Engineering, CWRU

Additive manufacturing of polymer composites offers many advantages over traditional methods, such as reduced manufacturing time, energy consumption, and material waste. One promising approach is 3D printing thermoset polymers through in-situ polymerization using a thermal stimulus, where the polymer cures when exposed to heat. This process can be activated by a low-power laser, allowing the material to cure during printing. However, a common challenge in additive manufacturing is the anisotropic properties resulting from weak bonding between layers. This study aims to improve interlayer bonding strength by varying the intensity of the thermal stimulus during printing. By pulsing the laser, sections of each layer remain uncured, while other sections are fully cured. The subsequent layer is then deposited over these regions, allowing both layers to cure together. This simultaneous curing is expected to result in stronger bonding compared to layers that are fully cured upon deposition. The printing process involves extruding resin via a three-axis gantry system, with a laser pulsed to selectively cure sections of each layer. The printed samples will undergo tensile testing to determine interlayer bonding strength, with comparisons made against control samples printed with the laser continuously on or off in alternating layers. It is hypothesized that pulsed-laser samples will exhibit the highest bonding strength. Differential scanning calorimetry (DSC) will confirm that the printed parts are fully cured through the propagation of the polymerization reaction across layers. This method is expected to significantly enhance the interlayer bonding strength of 3D-printed thermoset composites, addressing a major limitation in additive manufacturing.

Advised by Steve Hostler, PhD, Mechanical Engineering, CWRU

A biofilm-tropic Pseudomonas aeruginosa bacteriophage uses the exopolysaccharide Psl as receptor

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The bacterium Pseudomonas aeruginosa is responsible for between 10% to 20% of the infections present in most hospitals. Bacteria can form multicellular clusters called biofilms, which are often present in Pseudomonas aeruginosa infections and make antibiotic treatment of bacterial infections more challenging. Key biofilm properties are regulated by the signaling molecule cyclic-di-GMP, which increases when the bacteria contact a surface. Among these properties, the exopolysaccharide Psl is vital to forming the biofilm matrix. In our studies, we have discovered a P. aeruginosa bacteriophage, which we have called Clew-1. We have found that infections by Clew-1 are dependent on its attachment and binding to Psl as a receptor. Via plating and biofilm experiments, we have also determined that Clew-1 can disrupt the biofilms of P. aeruginosa and replicate in biofilm bacteria. Because Clew-1 relies on Psl for infection, it does not form plaques on wild-type bacteria under standard in vitro conditions, where Psl production is low. This suggests that standard isolation methods may overlook bacteriophages adapted to targeting biofilm markers for infection. Notably, the method we used to isolate Clew-1 can be readily applied to other P. aeruginosa strains and even to other bacterial species, potentially leading to the discovery of additional biofilm-targeting bacteriophages and broadening their therapeutic applications.

Project Mentor: Dr. Arne Riestch, Microbiology

SoFIE-GEL Image Tracking

Adam Aly, Senior, Mechanical & Aerospace Engineering

Solid Fuel Ignition and Extinction - Growth and Extinction Limits (SoFIE-GEL) is a NASA combustion experiment recently performed in the International Space Station (ISS). In the experiments, PMMA solid spheres were burnt in microgravity in low speed forced flows without buoyancy. The controlling variables in the experiments include flow speed, oxygen percentage, pressure and the amount of solid preheating. The PI of this NASA experiment is CWRU's Emeritus Professor, James Tien.

The objective of this project is to image track various parts of the flame present for several SoFIE-GEL tests to aid the characterization of the growth and extinction phases of the flame.

Image tracking has been done on an image database from up to three different cameras that recorded the SoFIE-GEL tests. Images were analyzed by a handwritten MATLAB algorithm and then the data for each tracked image frame was compiled into a video. The image tracking investigated various visual flame characteristics including sample surface position (to determine rate of surface regression), outer flame boundary, flame standoff distance, and flame tip position.

The end product is an attempt to create empirical correlations between qualitative growth and the previously discussed controlling variables: flow speed, oxygen percentage, pressure and the amount of solid preheating.

Faculty Project Mentor: **Ya-Ting Liao**, Assistant Professor, Department of Mechanical and Aerospace Engineering, Case School of Engineering

PI: **Dr. James Tien**, Professor Emeritus, Mechanical and Aerospace Engineering

Mitigating Joint Misalignment in Exoskeletons by Improving Measurement Precision

Emmanuel Amos, Department of Mechanical & Aerospace Engineering, Case Western Reserve University, Cleveland.

Hybrid lower limb exoskeletons have emerged as a promising technology for improving mobility and quality of life for individuals with spinal cord injuries (SCI) through assisted walking and rehabilitation. However, these devices face a common issue: misalignment between the exoskeleton and the user's joints, which can result in discomfort, pressure sores, and even injury. Such misalignments hinder the effectiveness of exoskeleton-assisted rehabilitation by limiting proper motion transfer and causing potential health issues. This project seeks to address these challenges by developing an adjustable, lightweight exoskeleton component for precise limb alignment.

Our design introduces a lead screw-based telescopic actuator with integrated gears that allow for fine adjustments to fit a range of limb lengths and alignments. By manually adjusting this actuator, either by hand or with a drill, we aim to significantly reduce the occurrence of misalignment, providing a more customized fit, and reduce the time taken to customize the fit per individual. The actuator enables adjustments within a specific length range to accommodate diverse body proportions while maintaining the exoskeleton's structural integrity and support.

Initial prototypes were fabricated using an M16 lead screw to meet strength and weight requirements. While the first design was robust, it was revised to optimize weight, speed, and ease of assembly. These refinements included a switch from an M16 lead screw to an M10 lead screw with the addition of carbon fiber rods for support, and worm gears to helical gears to reduce adjustment time and improve usability. This project can potentially improve the comfort, safety, and overall experience of exoskeleton users in rehabilitation settings, contributing meaningfully to SCI recovery efforts.

Project Mentor: Dr. Sandra Hnat D. Eng, Department of Mechanical & Aerospace Engineering; Case Western Reserve University, Cleveland.

Exploring Extracellular Vesicles as Biomarker Carriers for Alzheimer's Disease Utilizing Proximity-Based Protein Labeling (BioID)

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Liquid biopsies offer a promising, non-invasive diagnostic method for detecting disease biomarkers in blood, valuable especially when traditional tissue biopsies aren't feasible. With longer life expectancies, dementia disorders, particularly Alzheimer's Disease (AD), have become a significant health concern. A potential diagnostic approach for AD involves analyzing extracellular vesicles (EVs) in the bloodstream, which may contain disease-specific biomarkers. Some studies suggest that EVs in blood carry AD biomarkers, such as Amyloid beta (Aβ). However, it remains unclear if these EVs originate from neurons, as current methods lack specific markers for brain-derived EVs.

Our approach employs proximity-dependent protein labeling with biotin ligase BirA fused to CD63, enabling specific tracking of neuronal EVs. We developed a toolkit called "ExoBioID" to biotinylate proteins near CD63, a membrane protein found in CD63-positive exosomes, allowing for selective tagging. ExoBioID can be adapted to target specific cell types through promoter selection, such as GFAP for astrocytes or Syn1 for neurons, enabling differentiation of brain-derived EVs. Once tagged, these biotinylated sites can be visualized using streptavidin-647, providing a reliable tracing method.

We hypothesize that neuron-specific expression of the BirA-CD63 fusion protein will generate biotin-labeled EVs, allowing recovery from blood or other fluids. Confirming the presence of neuron-derived EVs in the bloodstream could enable accurate liquid biopsies for dementia diagnosis. This approach holds promise for verifying neuronal origin in blood EVs, marking a critical step toward advancing early and precise diagnostic methods for Alzheimer's Disease and related dementias.

Project Mentor: Gunnar Poplawski, Lerner Research Institute, Center for Immunotherapy & Precision Immuno-Oncology, Cleveland Clinic, Cleveland, OH

Molecular Mechanisms of Extracellular Matrix Hydrogel Therapy in Cardiac Repair

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

This study investigates the molecular mechanisms underlying extracellular matrix (ECM)-hydrogel-mediated cardiac tissue regeneration. We derived hydrogels from different sources of pig hearts to deliver as an injectable therapy. Protein expression for the pig hearts and treated mice was analyzed via proteomics. Secondarily, to overcome the limitations of hydrogel durability as a cardiac therapy, we modified the decellularized heart matrix (DHM) to be UV cross-linkable. We then compared four different formulations of UV cross-linkable DHM hydrogels. In addition, cross-linking parameters were varied to prolong the degradation rate and improve hydrogel duration and resistance to stress. Finally, the biocompatibility of the hydrogels was assessed via cell viability. Our findings suggest that chemically modifying DHM can achieve a broad range of physical properties and maintain biocompatibility, providing a foundation to further investigate DHM as a therapeutic strategy for cardiac repair.

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

FLT3-ITD signaling continuously degrades p53 by the ubiquitin-proteosome pathway explaining chemo-resistance

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FLT3-ITD AMLs drive resistance to chemotherapy, yet the mechanisms remain unclear. This study explores how FLT3-ITD signaling leads to continuous degradation of p53, a tumor suppressor protein, via the ubiquitin-proteosome pathway, contributing to chemo-resistance. Cell death could be induced in FLT3-ITD AML cells by stabilizing p53 and blocking its degradation, which would be applied in a new therapeutic strategy. Key findings include that the deubiquitinase USP7 plays an important role in regulating p53 degradation in FLT3-ITD AML cells. Inhibiting USP7 or the proteasome increased p53 levels and activated apoptosis in FLT3-ITD AML cells yet not in FLT3 wildtype cells. This pattern was shown in other regulatory proteins, such as CEBPA, which is involved in granulocytic differentiation and also subject to degradation in the presence of FLT3- ITD. Data from TCGA further indicate that FLT3-ITD and TP53 mutations are mutually exclusive, as FLT3-ITD can act as a functional substitute for TP53 genetic alterations by degrading p53. These results bolster the idea that continuous proteolytic degradation of p53 and CEBPA, which usually occur in a temporary, regulated manner, may lead to aggressive expansion of progenitor cells in FLT3-ITD AML. This study suggests that repurposing proteosome inhibitors could provide an effective treatment for relapsed or refractory FLT3-ITD AML by preserving p53 function, enhancing chemotherapy efficacy and potentially offering a novel approach to overcoming resistance in AML treatment.

Project Mentor: Dr. Xiaorong Gu, Center for Immunotherapy & Precision Immuno-Oncology & Department of Translational Hematology and Oncology Research, Taussig Cancer Institute; Lerner Research Institute; Cleveland Clinic, Cleveland, OH, USA

Developing a therapeutic strategy for targeting metabolic vulnerability of TET2 mutant Leukemia

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This study investigates targeting the metabolic vulnerability of TET2 mutant leukemia, which appears in up to 30% of myelodysplastic syndrome (MDS) and acute myeloid leukemia (AML) cases and is a primary mutation in myeloid neoplasms (MN). We aimed to explore how TET2 mutant cells are dependent on glutamine metabolism for therapeutic purposes. Using CRISPR-Cas9 to create isogenic TET2 wild-type and TET2 knockout cells derived from a myeloid leukemia line, we conducted untargeted metabolite analysis. We found significant metabolic changes, especially in amino acid and glutamine pathways. TET2 knockout cells showed altered glutamine and glucose metabolism, marked by upregulation of glutaminase (GLS1) and glutamate dehydrogenase (GLUD1). This shift leads to an increased reliance on glutamine in TET2 knockout cells. Metabolic flux analysis with dual-labeled glucose and glutamine confirmed that TET2 knockout cells consumed glucose at a similar rate but exhibited slower glycolysis, accumulating glucose-6- phosphate. TET2 knockout cells relied less on glucose for ∂KG production, which is a crucial TCA cycle component, instead depending more on glutamine. This glutamine addiction makes TET2 knockout cells more sensitive to glutamine restriction and GLS1 inhibitor CB839. CB839 treatment reduced ∂KG and other downstream TCA metabolites significantly in TET2 knockout cells, effectively limiting cell growth. This study suggests combining TET2 inhibitors, like Eltrombopag, with glutaminolysis inhibitors, CB839, as a novel therapeutic strategy for treating TET2 mutantdriven leukemias and potentially broader leukemia types, and this approach may suggest a new way for biomarker-driven therapies in myeloid neoplasms.

Project Mentor: Dr. Xiaorong Gu, Center for Immunotherapy & Precision Immuno-Oncology & Department of Translational Hematology and Oncology Research, Taussig Cancer Institute; Lerner Research Institute; Cleveland Clinic, Cleveland, OH, USA

Dysphagia Prevalence and Presentation in Patients with the Behavioral Variant of Frontotemporal Dementia (bvFTD)– A Systematic Review

Elishka Bailey, Case Western Reserve University, Communication Sciences

Dysphagia, or a swallowing problem, is a symptom of several medical conditions and is important to many life functions including nutrition, hydration, and saliva management. Difficulty swallowing can lead to malnutrition, non-oral feeding, aspiration pneumonia, and death. Despite its high prevalence in neurodegenerative disease, it's unclear whether dysphagia is present in the behavioral variant of frontotemporal dementia (bvFTD), a clinical subtype of frontotemporal degeneration (FTD). This systematic review aimed to assess the quality of evidence on reported dysphagia and its characteristics in patients with bvFTD. Due to some evidence of changes in eating and swallowing associated with bulbar progression and neural pathway degeneration in bvFTD, we hypothesized that dysphagia would also be reported. MEDLINE with Full text, Web of Science Core Collection, CINAHL Plus with Full Text, and APA Psycinfo were systematically searched for studies reporting dysphagia presence/absence and presentation in participants with bvFTD. Out of 157 studies selected, 22 met the inclusion criteria for this systematic review. Specific dysphagia presentation regarding swallowing physiology was reported in 9 studies, including 71 patients, most commonly exhibiting choking or coughing while swallowing. 13 studies mentioned dysphagia presence, without specific presentation characteristics or clinical swallowing assessment, including 612 patients; this was noted as swallowing problems from caregiver questionnaires, occurrences of accidental ingestion, and/or observed lack of self-perception of swallowing. Findings demonstrate that dysphagia was reported in some patients with bvFTD, though often through non-standardized, observational measures. Limitations include small sample size and the lack of comprehensive swallowing assessment. Further research is warranted to determine dysphagia prevalence and to characterize changes in swallowing physiology in patients with bvFTD according to standard swallowing screening and assessment tools.

Project Mentor: **Dr. Rachel Mulheren**, CCC-SLP, Assistant Professor, Case Western Reserve University, College of Arts and Sciences, Department of Psychological Sciences, Program in Communication Sciences

Investigating the knockdown of NOCFLY protein in Drosophila Melanogaster in various Neuronal types

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

DATI is a transcription factor in fruit flies that is conserved in humans and is required in the neural circuit of female flies that allows them to accept or reject males during courtship, an important decision making process.

Of the 500 targets of DATI that are conserved in humans, 20% of those genes are potential candidates for Alzheimer's Disease (AD) or encode proteins that bind to APP, the central gene of familial AD. One such gene is the transcriptional repressor NOCFLY. The molecular function of this protein has been described as being involved in calcium ion binding in the neuron, but its biological function has not been established yet. It is being hypothesized that the NOCFLY protein is necessary in order for calcium to bind to the neuronal membrane, which dictates the generation of action potentials and processing of information in the flu brain. Its homolog in humans, KCNIP4, was recently identified as a candidate for sporadic AD. In order to further study the role of NOCFLY in fruit flies, locomotion assays can be used to discover more about which processes in neurons NOCFLY has an effect on. The knockdown will occur using the following constructs: elavGal4, which targets all neurons, ChaGal4, which targets cholinergic neurons, and hsGal4 drivers, which targets neurons in the optic lobe and central nerve cord. Once the assays were completed, a one-way ANOVA was used to analyze the number of flies that were able to reach the benchmark for locomotion for each genotype. This revealed that ChaGal4 and ElavGal4 constructs had p values that were statistically significant in comparison to the control group.

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

Sickle Cell Blood Characterization: Hypercoagulation & Hemolysis

Bhavya Bansal, Medical Anthropology CWRU

This research aims to investigate the unique hemolysis and coagulation patterns of sickle cell disease (SCD) patients. Particularly how hypercoagulation can differ from the normal coagulation process. We seek to develop microfluidic chips that stimulate microcapillary conditions. We also seek to understand hemolysis by microfluidic systems mimicking capillary flowrates through pressure driven syringe needle-based methods outside of the body and draw conclusions on how red blood cells react to shear flow rates to see if they are subject to more hemolysis compared to the red blood cells of a patient not impacted by Sickle cell disease. These innovative tools will enable the study of clot formations and typical bodily reactions under controlled environments, easing the way we are able to replicate the complexities of the human circulatory system. These methods are also a simple low cost approach for mimicking blood flow. In the early stages of the development and background research of this technology we have seen promising results with the quantitative data collected for sickle cell disease patients compared to non-affected patients in understanding the hemolysis patterns of these red blood cells. Developing technology that can simulate bodily conditions is quite a feat, however it allows scientists to have technology that they are more easily study disease with than with clinical patients. Ultimately, this project has the potential to revolutionize drug discovery and development by providing a platform to evaluate the efficacy of novel therapies designed to mitigate hypercoagulation, hemolysis, and other associated complications in sickle cell disease patients.

Project Mentor: Rucha Natu Mechanical and Aerospace Engineering; Robert Ward

Stellar Populations in Simulated Galaxies

Katherine Barber, Department of Astronomy, Case Western Reserve University

In large galaxy clusters, the intracluster light (ICL) is closely tied to the evolutionary processes that shape the cluster, making it key to understanding cluster evolution. In this project, I use the Illustris-TNG simulations of galaxy clusters to explore the age and metallicity of intracluster stars for later comparison to observations of the Virgo Cluster using the Hubble Space Telescope (HST). I analyzed the largest galaxy cluster in the TNG-50 simulation to measure the radial profile of the ICL stars' stellar ages and metallicity. I found that the stars are predominantly old (6-10 Gyr) and metal-poor. Additionally, I looked at the properties of ICL stars in small fields, comparable in size to HST's field of view, revealing significant variations in stellar properties from field to field. I also found in individual fields and the radial profile that a significant portion of the ICL stars are more metal rich than previous HST surveys of the Virgo ICL stars found. This indicates that the more metal rich stars have been missed in earlier studies due to observational constraints. Moving forward, I will use the simulated ICL properties to create color magnitude diagrams (CMDs) for the new HST infrared imaging our team will receive in the next year. These CMD models will help clarify the connection between observations and the true underlying intracluster star population in Virgo.

Mentor: Chris Mihos, Department of Astronomy

Improving Wind Turbine Performance Through Airflow Redirection

Austin Sung[1,2,] **, Jiro Batt**[1], **Kevin Hu**[1,2], **Paul Racanelli**[1,2], Majid Rashidi[3], PhD and PE
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Wind based energy production has been an eminent investment into the future of energy production both nationally and globally. Wind energy promises a clean, cheap alternative to fossil fuel based energy and is likely to only keep growing in the future. As wind energy production grows, increasing the performance of wind turbines promises greater returns. Thus, it was sought to increase the performance of wind turbines through redirecting airflow. It was henceforth investigated how the performance of a wind turbine may be enhanced through redirecting airflow through a wind turbine. The experiment assesses the efficacy of a simple airflow redirection device in increasing power generation; the airflow redirection device was composed of two quarter cylinders mounted on either side of a wind turbine. The airflow redirection device aims to funnel wind flowing past the blades of a wind turbine through the blades. Turbine power generation equations imply that by increasing the wind velocity through a wind turbine, the power will increase at a cubic rate though still limited by Betz Law. This experiment uses two identical wind turbines, one mounted within the airflow redirection apparatus and the other serving as a control device. The hourly and total power generated, measured in kilowatt hours, from the two turbines was compared over a period of three weeks of operation during November at Case Western Reserve University's farm. Though over a relatively short period of time and using non-industrial grade wind turbines, this experiment aims to provide a basis for future research into flow redirection to increase turbine performance.

Modeling Microcephaly in Cortical Organoids Generated from Patient-Derived iPSCs with the IER3IP1 Mutation

Kayleigh R. Bauer[1,2], Biomedical Engineering, Case Western Reserve University; Andy Y. Chen[1], Lucie Y. Ahn[1], Ashleigh E. Schaffer[1]

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The IER3IP1 gene codes for the Immediate-Early Response-3 Interacting Protein-1. IER3IP1 is involved in endoplasmic reticulum-golgi body transport and regulates the secretion of extracellular matrix proteins needed during neurogenesis and neuronal migration. The homozygous leucine 78 proline (L78P) mutation in the IER3IP1 gene causes MEDS, which is a rare pediatric neurological disease that presents with a triad of microcephaly with simplified gyration, epilepsy, and permanent neonatal diabetes mellitus. While the Schaffer lab has previously attempted to genetically engineer mouse models to study MEDS, the pathogenic homozygous recessive mutation in the IER3IP1 gene was found to cause embryonic lethality. My goal was to validate the cortical organoid model for use in characterizing the IER3IP1 phenotype in a three-dimensional culture that would capture the cytoarchitecture of a mammalian cortex and provide a clearer picture into the disease pathology of MEDS. I generated cortical organoids using three isogenic patient-derived induced pluripotent stem cell (iPSC) lines that demonstrated a significant decrease in IER3IP1 protein expression in the homozygous recessive L78P mutant line compared to the L78P wild type and L78P heterozygous mutant lines. Heterozygous inheritance of the mutation does not cause disease in humans, so I hypothesized that only the homozygous recessive L78 organoids would recapitulate microcephaly as observed in MEDS. I measured the area of cortical organoids over time to track the microcephaly phenotype. My results indicate that between days 24 and 46, the cortical organoid model demonstrates the microcephaly phenotype expected from the homozygous L78P IER3IP1 mutation in MEDS.

Project Mentor: Ashleigh Schaffer, PhD, Department of Genetics and Genome Sciences, Case Western Reserve University School of Medicine

A Whole Blood-based Assay for Assessing Red Blood Cell-mediated Microcapillary Occlusion in Sickle Cell Disease

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Sickle cell disease is an inherited blood disorder characterized by the production of sickle hemoglobin. Under hypoxia, HbS polymerizes, causing red blood cells to become sickle-shaped and less deformable. These sickled RBCs can occlude capillaries and contribute to organ damage. Existing methods of assessing RBC-mediated capillary occlusion require multiple pre-processing steps which makes them inoperable outside sophisticated research labs. Here, we present an alternative method to assess RBC-mediated microvascular occlusion under hypoxia using whole blood.

This method uses a PDMS microfluidic device composed of 6 micropillar arrays with interpillar distances decreasing from 12 μm at the inlet to 3 μm at the outlet, mimicking the capillary network. Whole blood samples from HbAA and HbSS were suspended in a solution containing an oxygen-reducing enzyme and incubated for 30 minutes at 37°C to achieve deoxygenation. After 15 minutes of perfusion, images were obtained and occluding RBCs and WBCs were counted manually. The occlusion index (OI) was calculated to represent the percent occlusion of the microcapillary network.

Hypoxic OI for HbSS whole blood samples (HOI-WB) was significantly higher than for HbAA. WBCs made minimal contribution to the microcapillary occlusion thus HOI-WB was mainly driven by RBCs. Moreover, HOI-WB was significantly higher in SCD indicating the assay's sensitivity to HbS-induced RBC impairment. We further showed that full deoxygenation was achieved after 5 minutes-incubation, which was sufficient to measure occlusions effectively. This assay utilizes a small blood volume, eliminates need for auxiliary equipment, and minimizes the expertise required to run the assay. These improvements in efficiency and simplicity bring us closer to rapid, bedside monitoring of RBC-mediated microcapillary occlusion, and enabling adoption in resource-limited settings.

Project Mentor: Dr. Umut Gurkan, Department of Mechanical and Aerospace Engineering, Case School of Engineering

Effects of a Combination Therapy Targeting the Meningeal Lymphatic Vasculature on Alzheimer's Disease Physiopathology

Ankita Bhatnagar, Departments of Neuroscience and Psychology, Case Western Reserve University; Dr. Antoine Louveau, Department of Neurosciences, Cleveland Clinic Lerner Research Institute

Alzheimer's Disease (AD) is a devastating neurodegenerative disorder that still suffers from limited therapeutic offer. Previous studies in the laboratory have shown that the degeneration of the meningeal lymphatic vasculature, a network of vessels ensuring homeostasis of the fluid dynamic and immune populations, is a central factor in age-associated cognitive dysfunction. We found that we can prevent age-associated cognitive decline through the boost of lymphatic vessel growth via providing an exogenous source of VEGFc (the main lymphatic growth factor), or removing CD49a, which is an integrin that limits lymphatic function with aging. Preliminary data, however, suggest that either of these treatments only has limited to no effect on AD physiopathology using the 5xFAD mouse model of AD. Given that VEGFc and CD49a regulate lymphatic function through independent pathways and mechanisms, we want to investigate how combinatorial therapy may further improve lymphatic function and affect AD physiopathology. In this study, 5xFAD mice at age 4 either received VEGFc treatment, removed CD49a from their lymphatic vessels, or a combination of both treatments. Two months later, tissues were harvested from these mice. Meningeal lymphatic morphology and function was assessed, and the amyloidosis pathology of the 5xFAD mice was assessed using histology. The aim of this project is to determine if the degree by which lymphatic function is improved is a factor determining the efficiency of targeting the meningeal lymphatic system for the treatment of AD.

Project mentor: Dr. Antoine Louveau, Department of Neurosciences, Cleveland Clinic Lerner Research Institute
Faculty sponsor: Dr. Ashley Nemes, Department of Neuroscience, Case Western Reserve University

UPBoints: A Custom Event Management Platform

James Bish, Computer Science and German, CWRU

Calvin Cai, Computer Science, CWRU

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Charles Lin, Computer Science, CWRU

John McCormick, Computer Science and Economics, CWRU

Annika Markoff, Computer Science, CWRU

Carson Williams, Computer Science, CWRU

Chelsea Zheng, Computer Science, CWRU

UPBoints is a project inspired by the need for an event management system to configure custom events for campus organizations. Organizations such as UPB (University Program Board) program events for up to 6,000 students, necessitating an efficient and secure system to track attendees and handle events. UPBoints is a web platform coupled with physical devices (terminals) to check in attendees, distribute vouchers and points for different activities, and track event statistics. The physical terminals take a case ID swipe to verify student registration and points earned, and have the ability to function offline. On the web platform, event attendees are able to view remaining food vouchers, available prizes, and accumulated points, and will be able to redeem these points as raffle tickets for various prizes. Event managers are able to create and configure events, requiring features like location, description, dates, times, activities, food, and prizes, and are also able to view event statistics and track attendees. Event administrators are able to manage groups and assign physical terminals to events. The platform interfaces with CampusGroups, a platform already in use by the CWRU community to create events, improving the speed of checking in attendees and adding event management functionality to facilitate smoother events.

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

Reflections Through Art: Exploring Self-Discovery and Meaning in Self-Reported Interactions with Art

Laura Blanco, Psychology and Cognitive Science double major. Case Western Reserve University

Art provides a unique way for individuals to explore their emotions and aspects of their identity. Previous studies suggest that engaging with art can deepen self-knowledge, encouraging selfreElection and personal growth. This study explores how people interpret and make meaning from their interactions with selected artworks, focusing on what individuals learn about themselves through these experiences. By analyzing participants' reElections and self-reported stories, the project aims to explore how personal interactions with art are associated with deeper self-awareness and introspection. The project also aims to assess the perceived meaningfulness of the interaction.

Using a mixed methods approach,the study combined qualitative and quantitative analyses to explore the personal insights and self-discovery participants gained after engaging with self-selected artworks. Qualitative coding was applied to identify recurring themes in participants' self-reported anecdotes, and a quantitative scoring system was used to evaluate the meaningfulness of these interactions, showcasing how participants interpreted and connected with the art. By combining these approaches, the study highlights the potential of how art can act as a mirror, reElecting aspects of the self and encouraging personal insight.

We expect the results to show that participants found meaningful insights and gained self-knowledge through their interactions with art, demonstrating how art can serve as a tool for self-discovery and personal learning. We expect these results to provide new perspectives on art's impact on personal growth and self-understanding, ultimately showcasing its role in creating transformative experiences.

Faculty Mentor: Joshua Wilt, Psychological Sciences, Case Western Reserve University

Capstone Instructor: Julie Exline, Psychological Sciences, Case Western Reserve University

Remote Oscilloscope Probe

Yaw Boateng, Electrical Engineering, Case Western Reserve University; **Joshua Cook,** Electrical Engineering, Case Western Reserve University; **Paul Kim,** Electrical Engineering, Case Western Reserve University

This project provides evidence on the feasibility of a wireless oscilloscope probe. Oscilloscope probes have 3 parts: the probe connector, the transmission wire, and the connector to oscilloscope. Our project presents data and test results that demonstrate the tradeoffs of replacing the transmission cable of the oscilloscope probe with a wireless transmission medium e.g. Wi-Fi. These tests and data are limited to audio signals under 10 kHz in the voltage range of 0 V-3.3 V. Our data consists of characterizing the conversion time and accuracy of a 10-bit ADC on the Teensy 4.0 microprocessor. Upon accurate conversion of the analog signal into digital codes, it is transmitted via serial communication to a second Teensy 4.0, which then sends the digital data to a DAC, which outputs the reconstructed analog signal. These are tested at different frequencies with the aim of reducing the overall time between when data is probed by the ADC to when it is output by the DAC. Following the serial transmission of the ADC digital codes from microcontroller A (transmitter) to microcontroller B (receiver), microcontroller B sends the data over SPI to be reconstructed by the DAC. Given the overall signal chain, each section is tested at different frequencies to inform the most optimal sampling frequency for the overall system given the available hardware, budget and design complexity intended.

Project Mentor: John Gibbons, Department of Electrical Engineering and Computer Science

Comparison of artificial intelligence with manual observation for behavioral data collection among Agouti (Dasyprocta leporina)

Chelsea J. Brea, Department of Biology, Case Western Reserve University

Behavioral observations are routinely used to monitor the welfare of zoo-housed animals. However, behavioral studies often involve highly time- and labor-intensive manual observation methods, which limit the opportunities for further behavioral analysis. Observation research at zoos is also often limited to daytime observations conducted during normal operating hours. With the advancements in AI technology, possibilities for behavioral observation are expanded, lessening the need for manual data collection approaches, and simultaneously expanding the variety of studies that can be conducted, such as observations of nocturnal animals or observations over longer periods. Kibsi is an AI-based computer platform used in zoos and aquariums as a way to track patterns such as space use in habitats, behavioral trends, and responses to environmental changes. We utilized a custom Kibsi model to evaluate agouti (Dasyprocta leporina) behavior including activity, proximity to other agoutis, and location within the habitat, through the analysis of Annke camera footage. Simultaneously, manual data was collected by Cleveland Metroparks Zoo volunteers during 20-minute observation intervals. The Kibsi-generated data was compared to manually recorded data, both live in-person scoring and data generated from camera observations, in specific time intervals using a Chi-squared test. The Kibsi profile differed significantly from live- and camera-scored sessions, with Kibsi showing less success in identifying agouti when present, additionally tagging agouti as inactive when exhibiting subtle stationary behaviors such as grooming or feeding. The results of our study indicate that human observation is more effective in measuring animal behavior, while the automated model may be applicable in conjunction with manual scoring methods or with further refinement.

Faculty Sponsor:

Dr. Noah T. Dunham, Department of Biology, Case Western Reserve University; Research Curator, Cleveland Metroparks Zoo

Project Mentors:

Dr. Noah T. Dunham, Department of Biology, Case Western Reserve University; Research Curator, Cleveland Metroparks Zoo

Dr. Diana Koester, Department of Biology, Case Western Reserve University; Research Curator, Cleveland Metroparks Zoo

Reconstructing Vagal Anatomy (REVA)- Histology Immunohistochemistry Lab

Keith Brennan, Biomedical Engineering, Case Western Reserve University

The vagus nerve, the body's longest cranial nerve, is an essential information pathway for autonomous bodily functions such as heart rate, digestion, and immune response. Mapping the nerve's structure provides insights into its function and shape, offering crucial information for potential medical applications. The REVA project aims to examine the vagus nerve of 50 individuals of diverse ages, sexes, and races. These factors impact nerve structure, from the outer epineurium surrounding the entire nerve, to the perineurium encasing each fascicle, down to the neurofilaments within each fiber that surrounds electrical impulse-carrying axons.

In the histology immunohistochemistry lab, extracted nerve tissue is grossed, where different nerve segments are painted, cut, and labeled based on size and position. The grossed tissue is then processed in a tissue processor, which dehydrates and impregnates each segment in paraffin wax medium. These wax blocks are subsequently embedded with paraffin into a mold, then cut by a microtome for slide preparation. Each slide is then stained with hematoxylin and eosin, contrasting the epineurium and perineurium. High-resolution imaging is completed on each slide and quality control is conducted to determine the number of good images. Good images consist of slides with intact, well-displayed, and well-stained tissue. These good images, useful for data collection, have their blocks re-cut and stained with Myelin Basic Protein (MBP) and Neurofilament (NF), to visualize myelination concentration and axon integrity.

Segmentation is performed on the good images to create a dataset from measurements based on tissue staining. Since accurate nerve mapping relies on these images, the final step of slide and wax block organization is vital for re-cutting or re-imaging to maintain a maximum number of good images.

Project Mentor: Jennifer Coleman, Histotechnologist Manager, Case Western Reserve University

Principal Investigator: Andrew Shoffstall, Nord Distinguished Associate Professor, Department of Biomedical Engineering, Case School of Engineering, School of Medicine, Case Western Reserve University

Determining the role of immune cell subsets in the development of inflammation in the TNFDARE murine model of Crohn's disease-like ileitis

Fiona Brooks[1,3], Kristina Williams[1], **Neha Khandekar**[1,3], Bianca Islam, MD, PhD[1,2], Fabio Cominelli, MD, PhD[1,2]

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[3]Case Western Reserve University, School of Medicine, Department of Biochemistry

Inflammatory bowel disease (IBD) is an autoimmune disease characterized by persistent inflammation in the lower gastrointestinal tract. Crohn's disease (CD) is a subtype of IBD that develops severe inflammation and fibrotic strictures in the ileum. Many studies suggest that aberrantly functioning regulatory T-cells,CD4+ T-cells, and CD8+ T-cells play a role in the development and progression of IBD. Our laboratory is characterizing the role of the adaptive immune system in the development of IBD by utilizing a mouse model of CD-like ileitis, the TNF delta ARE (TNFDARE) model. TNFDARE mice chronically overexpress the proinflammatory cytokine TNF-alpha. The murine model closely mirrors human CD because they develop ileal inflammation. The goal of this study is to determine which T-cell subset is responsible for inflammation in the TNFDARE model by using the well-established adoptive T-cell transfer model with RAG-deficient mice. Unfractionated immune cells and isolated CD4+ and CD8+ T-cell subsets from the mesenteric lymph nodes of donor TNFDARE mice were adoptively transferred by intraperitoneal injection into RAG2-deficient mice. Over the course of six weeks, weights of all mice were monitored, and histopathology from the ileum and colons of all groups were analyzed at the end. Findings suggest that mice injected with CD4+ T-cells exhibited similar inflammation (e.g. spleen weight and colon pathology) to the group injected with unfractionated immune cells. Interestingly, mice injected with CD8+ T-cells have significantly less disease (same parameters evaluated above). Additional studies will have to determine if CD8+ T-cells play a role in disease. Further understanding the role of specific immune cell subsets in disease development will help generate better-targeted therapies for Crohn's disease.

Project mentor: Bianca Islam, MD, PhD, Digestive Health Research Institute

Interactive Fluid Simulation Web App

Sean Brown, Data Science and Computer Science, CWRU; **Chase Shriver**, Engineering Physics, CWRU; **Liam McCall**, Engineering Physics, CWRU; **Olugbadebo Adesina**, Computer Science, CWRU

Fluid dynamics describes the flow of liquids and gasses. It allows engineers and scientists to model phenomena such as airflow over wings, water currents, and drag and lift forces. Especially for complex components, computer-assisted fluid simulation is a critical part of the design process. Existing fluid simulators, however, are not very accessible to the average person. They are often complex, hard to understand, and expensive. Many high-fidelity fluid simulators require a deep knowledge of math and physics. Just setting up a simulation requires extensive parameter tuning, which amateurs or hobbyists will likely struggle with. Popular simulators, like ANSYS Fluent and COMSOL Multiphysics, come with high licensing fees and require considerable computing resources, making them hard to run on a standard laptop or desktop.

We created an interactive fluid simulation web app that lowers the barriers to entry, emphasizing user friendliness and real-time interactivity. Our project allows users to model a flow system in real-time. Given an initial state, users can place objects in a fluid and see how they behave. They can customize the parameters and get instant feedback on how the behavior changes. One of the most common applications of fluid simulation is predicting aerodynamic performance, where the lift and drag are critical factors in wing design. Using their cursor, users can draw their own wing, see its performance, and quickly make changes if necessary. This process is much more accessible and easier for beginners than it is in existing simulators, where merely creating an object to test can be quite involved.

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

Isolation of antibacterial neuropeptides from the immune induced Blaptica dubia cockroach brain

Nidhi Byragoni[1] (Neuroscience) and Angela Dixon[1,2]
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[2] Department of Biomedical Engineering, School of Engineering, Case Western Reserve University

On a global scale, bacterial infections are a major cause of death and pose significant threats to the field of public health and infectious disease. Although many infections can be treated with antibiotics, bacterial resistance to antimicrobials increases as bacteria evolve, adding to a growing problem of the inefficiency of antibiotic resistance. To further understand bacterial immunity, cockroach models have been widely used, as they exhibit an extraordinary ability to fend off various threats to their overall health. The American cockroach in particular lives in environments rich with pathogenic substances, yet very few end up infected by these pathogens. When exposed to bacterial and viral organisms, American cockroaches have shown to develop resistance by possessing neuropeptides with antimicrobial properties as an innate immune defense mechanism. In contrast, the Blaptica dubia, or orange-spotted cockroach, resides in more humid environments in South America, an area that is objectively less pathogenic than that of the American cockroach. Therefore, the purpose of this study is to observe if these neuropeptides would develop in roaches that live in different environments as well. Additionally, two types of bacteria are used, as another purpose of this study is to determine whether or not the type of bacteria plays a role in how neuropeptides may form for roach immunity. This experiment outlines the processes of housing and injecting B. dubia roaches with either E. coli (gram-negative) or M. luteus (positive), as well as homogenizing their brain tissue followed by antibacterial assays when the tissue is exposed to the two bacteria.

Project Mentor: Angela Dixon, Department of Biology, College of Arts and Sciences, Case Western Reserve University

Short Range Surveillance UAS for Natural Disaster Aid

Ryan Cabrera, Mechanical Engineering major, Department of Mechanical and Aerospace Engineering, Case Western Reserve University; **Aj Dudowski**, Mechanical and Aerospace Engineering major, Department of Mechanical and Aerospace Engineering, Case Western Reserve University

Drones, particularly those certified as Blue UAS, offer a transformative advantage in post-disaster response, providing rapid, secure, and cost-effective solutions for damage assessment and resource allocation. Blue UAS, vetted under stringent security and reliability standards by the U.S. Department of Defense, are specially designed to support operations in sensitive and critical infrastructure environments, ensuring both data integrity and operational security in disaster settings. Their ability to capture high-resolution aerial images and videos provides immediate situational awareness, allowing response teams to quickly assess the scale and specifics of impacted areas.

These drones significantly enhance safety by reducing the need for responders to enter hazardous or unstable zones, instead allowing personnel to analyze damage remotely while reaching difficult or otherwise inaccessible locations. Equipped with advanced technologies such as LiDAR, photogrammetry, and thermal imaging, Blue UAS drones support detailed and accurate 3D mapping, and enable highly effective search-and-rescue (SAR) operations, even in low-visibility and nighttime conditions.

These drones facilitate the rapid and safe delivery of lightweight medical supplies, food, and essential aid to isolated regions cut off by infrastructure damage. In urgent cases, such as delivering blood or time-sensitive medicine, drones reduce delays and enhance survival rates by providing direct access to critical supplies. Cost-effective, secure, and highly versatile, Blue UAS drones have quickly become indispensable tools in modern disaster management, streamlining rescue operations, optimizing resource deployment, and enhancing overall response effectiveness in critical, time-sensitive situations.

Project Mentor: Dr. Roger Quinn, Department of Mechanical and Aerospace Engineering, Director of CWRU Biorobotics, Case Western Reserve University

Speech Recognition Testing for Mandarin/English bilinguals

Linxuan Cai, Communication Sciences, Department of Psychological Sciences, Case Western Reserve University

There is a growing demand for specialized hearing tests in China and among Chinese-speaking people worldwide. There are 3.4 million people in the US that speak Chinese. Currently, in the US, if a Chinese speaker or a bilingual Chinese-English speaker needs audiological healthcare, no clinical testing is readily available in Chinese. There is a need to develop speech recognition test tools that are culturally and linguistically appropriate for Chinese-speaking populations. This project explores the development of a Mandarin version of American English audiological test sentences.

First, the current state of hearing healthcare care and audiological evaluation methods in China is reviewed. Second, linguistic details of the Chinese language, including the complexity due to its tonal characteristics, phonetic structure, vowels, and consonants is reviewed. Linguistic descriptions of Chinese will be compared to English. Third, the English sentences will be translated to Mandarin using AI (ChatGPT and Google Translate) and human translation. English and Mandarin BEL sentences will be produced by synthetic AI generated talkers for use in a speech-in-noise speech recognition experiment.

A speech-in-noise experiment will be designed to evaluate English and Mandarin speech recognition using the aforementioned stimuli. Thirty bilingual Mandarin/English participants with normal hearing will be recruited from university students and staff to participate in the experiment. A linguistic profile will be developed for all participants to understand their language dominance, proficiency, and use patterns of both languages. This work will help us reach our goal of creating linguistically and culturally appropriate Mandarin and English speech stimuli for use in speech-recognition testing for US audiology clinics.

Project Mentor: Dr. Lauren Calandruccio, Department of Psychological Sciences, Case Western Reserve University

Questercise

William Cankar - Computer Science B.S.; **Joonho Son** – Computer Science B.A.; **Eliza Yang** – Computer Science B.A., **William Zhu** – Computer Science B.A., Case Western Reserve University

We developed a gamified workout app titled Questercise that was inspired by RPG releases on the NES and fitness games like Pokémon Go and Ring Fit Adventure. We wanted a way to find a way to get people to be more active while also combining our passion in video games. The goal of the project was to create an app that was both fulfilling to use to exercise with, but also awarded the player like a mobile game so that they would continue to come back every day. Players will complete workouts and receive “gold” which can be used for in game prizes. These prizes include character customization which will add fun touches to the workout visuals. These mechanics will encourage repeat use of the app and retain our player base.

This project was developed with the game engine Unity and is designed for mobile devices, so it is convenient and welcoming towards people of all skill levels. One of the keys to capturing the user's attention is for a visually appealing art style which we accomplished by taking inspiration from early fantasy video games. Our app inspires those who exercise frequently and those who are beginning to improve themselves in a fun and exciting environment.

Faculty Member: Shuai Xu, Department of Computer and Data Sciences, Case Western Reserve University

Cereblon: a novel mediator of tauopathy in traumatic brain injury

Julia Duong, Laurel School; Peter Bambakidis, Chemistry, St. Olaf College; Niklas E. Rietsch, University School; Phoebe K. Templin, Biology, Case Western Reserve University

Misfolded and aggregated proteins are critical components of the pathology underlying various neuropsychiatric diseases. A notable example is found in rare autosomal recessive mutations of the human cereblon gene. The cereblon protein plays a vital role in the cereblon-DNA binding protein 1(DBBP1)-Cullin-4A E3 ubiquitin ligase complex, which is responsible for recruiting and degrading endogenous protein substrates. Disruption of this process due to cereblon depletion or genetic mutation is typically associated with mild intellectual disability. Recent research has revealed that cereblon also independently inhibits the activity of molecular chaperones associated with the phosphorylated form of tau. When tau becomes phosphorylated, it aggregates and forms toxic intraneuronal filaments, which have been implicated in the pathophysiology of traumatic brain injury (TBI). Therefore, we sought to identify the effect of TBI on cereblon's protein levels and activity. To address this question, we employed a mouse model of TBI that exposes animals to globally compressive forces through pressurized air flow along with acceleration-deceleration injury and early blast wave exposure. We quantified cereblon levels in the context of TBI using western blot analysis. Our findings demonstrated that both cereblon and phosphorylated tau levels significantly increased in adult mice post-TBI compared to sham-injury controls. To investigate the causes of increased phosphorylated tau after TBI, we measured the levels of tau kinases, which are the proteins responsible for phosphorylating tau. Notably, we observed a decrease in phosphorylation of the tau kinase known as GSK-3α/β in TBI brains, which indicates increased enzymatic activity. Our data position cereblon as a novel mediator of tauopathy in TBI and suggest that targeting cereblon may hold therapeutic potential for mitigating TBI-induced neurodegeneration.

Project Mentors: Sonny G. Caradonna and Emiko Miller

Faculty Sponsor: Dr. Andrew A. Pieper

Departments of Psychiatry, Pathology, and Neurosciences, Case Western Reserve University

Spatial Resolution of Tumor-Stroma Communication Patterns in Lobular Breast Cancer

Saúl Castillo, Systems Biology and Statistics, Case Western Reserve University

Invasive Lobular Carcinoma (ILC) is the second most common histological subtype of breast cancer and makes up ~10-15% of all breast cancer diagnoses. ILC is typically estrogen receptor-positive (ER+) and low grade, suggesting a favorable prognosis, yet patients often develop multiple tumors and face a high risk of late recurrence. Genomic tests rarely identify high-risk cases, and standard therapies like chemotherapy are usually ineffective long-term. Despite its prevalence, ILC remains understudied. Recent studies revealed unique interactions with ILC and its tumor microenvironment (TME), a ecosystem of cancer cells and non-malignant immune cells within an altered extracellular matrix. The interactions between ILC and its TME highlight a complex interplay that could be involved with the tumor progression of ILC, particularly with the role of the surrounding stroma. This study aims to uncover autocrine and paracrine signaling in tumor and stroma compartments that predict worse outcomes in ILC. We used spatial transcriptomic analysis to identify receptor-ligand pairs expressed in either the tumor or stroma cells or across the tumor and stroma compartments of five ILC tumors. Specifically, we looked for the expression of a receptor in one compartment (tumor or stroma) and its ligand expression in the other compartment or vice versa. Our preliminary analysis found the Hedgehog Signaling pathway enriched in stromal compartments adjacent to tumor cells and the ligand-receptor pair, IHH (Indian hedgehog) and BOC (brother of CDO). IHH is predictive of poor ILC outcomes, meaning targeting this pathway may be a therapeutic option for ILC patients. Future studies involve validating the expression of this ligand-receptor pair in independent ILC samples and in vivo assessment of FDA-approved hedgehog pathway inhibitors in mouse models of ILC.

Faculty Mentor: Yolanda Fortenberry, Department of Biology, Case Western Reserve University

Principal Investigator: Ruth Keri, Department of Molecular Medicine, Cleveland Clinic Lerner College of Medicine

MULTI-MODAL TRANSLATOR WITH SIGN LANGUAGE RECOGNITION

HIEU HOANG, Computer Science, Case School Of Engineering; **ABHI CHADHA,** Computer Science and Data Science, Case School Of Engineering; **OLUGBADEBO ADESINA,** Computer Science , Case School Of Engineering

In today's highly interconnected world the idea of having traditional boundaries, gaps, different people and communities have all faded away with the introduction and easy access to the internet. This interconnection of different backgrounds throughout the whole world highlights the progress of human society, while crucial and significant, comes with its own challenges and surmounting problems, and sitting at the pinnacle of it remains effective seamless communication. Tackling said challenge we took upon the idea of creating an all inclusive translator, bridging the gap between communities who not only speak different languages & dialects but also between the communities who communicate via sign language and don't, hence making sure effective communication is possible between anyone and everyone. Our main goal is to create a multi-modal translator with real time sign language recognition and deploy it on an easy to access web based platform at everyone's disposal. The project would consist of two main components, first, the multi modal translator offering seamless communication between 150 languages & dialects, and the second, involving real time sign language conversion into text laying the foundation of the web based platform. Furthermore, this multi-modal translator would leverage state-of-the-art technology to convert both text and audio from any chosen language or a specific dialect, and deliver the output either as a text or an audio format from one of the 150 languages chosen. The sign language translator on the other hand would be trained on over 200 most spoken words in the American Sign Language offering the possibility of using the application as an everyday companion, enabling communication across linguistic and cultural barriers, and adopting inclusivity around the world.

Project Mentor: Professor Dr Shuai Xu, Computer Science and Data Science, Case School of Engineering

Characterization of Periodic Acid Schiff Positive structures in the C9orf72 murine model of ALS/FTD

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A pathogenic hexanucleotide repeat expansion in Chromosome 9 Open Reading Frame 72 (C9ORF72) is the most common heritable cause of Amyotrophic lateral sclerosis (ALS) and Frontotemporal dementia (FTD). Loss and gain of function mechanisms of the C9ORF72 mutation are thought to contribute to the progressive degeneration observed in ALS/FTD. However, the C9ORF72 mutation acts with incomplete penetrance indicating that additional factors act as necessary drivers of ALS/FTD pathology. Recently, the gut microbiome has emerged as a potential contributor to ALS/FTD. Loss of the murine ortholog, C9orf72, predisposes the host mice to systemic and neural inflammation that models the inflammatory phenotypes associated with C9ORF72-ALS/FTD patients. C9orf72 mutant mice reared in proinflammatory environments characterized by gut microbes with greater myeloid stimulating potential suffer from increased mortality compared to those reared in benign environments. Additionally, the biosynthesis of glycogen is a key metabolomic property that distinguishes inflammatory microbes from benign microbes. Seeing as microbe-host interactions are drivers of disease pathology and ALS/FTD patients exhibit pathologic accumulation of glycogen at sites of motor neuron degeneration, we hypothesized that accumulation of microbial derived glycogen in C9orf72 mutant mouse tissues contributes to systemic and neural inflammation. Here, to examine the role of glycogen in the induction of inflammation, we employed periodic acid Schiff staining to characterize glycogen deposits within the gut, lymphatics, and brains of C9orf72 mutant mice that experienced a natural course of disease or in which glycogen was therapeutically depleted.

Project Mentor: Dr. Aaron Burberry, PhD, Department of Pathology, Case Western Reserve University, Cleveland, OH, USA

Faculty Sponsor: Dr. Jon Niemi, PhD, Department of Neurosciences, Case Western Reserve University, Cleveland, OH, USA

Cell specificity in ECM degradation in the CNS of lysosomal storage disorder, Mucopolysaccharidoses

Kaleb Chassie, Keenan Hope, Dhananjay Yellajoshyula

Fundamental features of brain development and function are regulated by the extracellular matrix (ECM), a three-dimensional milieu composed of fibrous proteins and mucopolysaccharides known as glycosaminoglycans (GAGs). Brain cells have a complex enzyme machinery to balance GAG synthesis and breakdown. Mucopolysaccharidoses are a group of inherited lysosomal storage disorders caused by loss of function mutations in genes coding for GAG catabolic enzymes. MPS VII (or Sly syndrome) developmental disorder results from loss-of-function mutations in GUSB, which codes for the lysosomal GAG catabolism enzyme, β-glucuronidase (GUSB). Prior studies in MPS VII patients and animal models focused on abnormalities in neuronal cells as the principal cause of the MPS associated neuropathology resulting in developmental delay, intellectual disability and motor dysfunction. However, our preliminary analysis has identified that microglia, the brain's resident immune cells, express significantly higher levels of GUSB compared to any other cell type. Microglia are mononuclear phagocytes that play a critical role in the clearance of synapses during developmental pruning. The contributions of microglia in GAG breakdown in MPS has not been previously addressed. In this study, I measured for intracellular GAG accumulation in microglia relative to other neural cell types from control and MPS VII (Gusbmps) mouse models. I stained for GAG accumulation in four major neural cell types - neurons, oligodendrocytes, microglia and astrocytes, in young and adult brain tissue from control and Gusbmps mice. My studies show overt accumulation of peri neuronal net GAGs (a major brain ECM structure) specifically in MPS microglia relative to other neural cell types. Furthermore, the GAG accumulations are associated with striking enlargement of CD68 containing lysosomes. These results newly identify microglia as a cell type of critical importance in MPS VII disease neuropathology and GAG degradation during development.

Evaluating the Efficacy of Semi-Automatic Color Segmentation for Myelinated Fiber Analysis in the Vagus Nerve

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The vagus nerve is pivotal for autonomic functions, playing a key role in enabling efficient neural signaling essential for coordinating physiological activities. Accurate measurement of its myelinated fibers is critical for developing detailed computational models of nerve architecture. Traditional analysis has depended on manual segmentation, a slow and labor-intensive process. This study introduces a semi-automatic technique designed to maintain high accuracy while reducing effort.

We aim to analyze myelinated fibers in the vagus nerve with histological dual staining for brown myelin basic protein (MBP) and pink neurofilament (NF). We aim to employ color segmentation to distinguish between myelinated fibers, axonal filament, and background. This approach specifically identifies myelinated areas by their distinct light and dark brown colorations, corresponding to the density of MBP expression. We trained two annotators to identify color cluster centers in MBP-NF images using ImageJ. The method's parameterization was refined based on a pre-determined standard deviation of manually selected RGB values. We tested nine combinations of standard deviations to optimize MBP color detection and assessed each setting's repeatability by comparing RGB values between annotators. To evaluate segmentation accuracy, we compared our masks to a manually segmented ground truth image. We also compared annotators by calculating the Euclidean and Hausdorff distances between the identified color centers and the MBP masks, respectively. Annotators showed consistent results in identifying dark brown, but variations occurred with other colors due to significant standard deviations inherent in the colors. We predict that using the standard deviation of two for dark brown and four for light brown will be the most accurate segmentation for MBP. This semi-automatic method promises faster and more consistent outcomes, enhancing neurological study efficiency.

Project Mentor: Talya Jeter, Department of Biomedical Engineering, Case School of Engineering, CWRU

Principal Investigator: Andrew Shoffstall, Department of Biomedical Engineering, Case School of Engineering, School of Medicine, CWRU

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

Wei Chen, Bachelor of Science, Major in Biology, Case Western Reserve University

As ectotherms, butterflies rely on environmental temperatures to survive and thrive in their environments, affecting their behavior, movement, and overall role in ecosystems. This study explores how the size and color of butterfly wings relate to their capacity to handle extreme temperatures. Larger insects tend to experience less variation in body temperature than smaller ones, which suggests that their greater size gives them an enhanced ability to buffer against thermal changes. Moreover, Previous research has shown that darker butterflies tend to undergo quicker fluctuations in body temperature compared to lighter-colored butterflie. It may suggest that larger and darker butterflies can tolerate high temperatures. In the research, we examined several butterfly species in Ohio, measuring their wing size and coloration using digital scanning tools, and then determined their tolerance to extreme temperatures. The results showed that butterflies with larger wings had a higher heat tolerance, likely because their large wings could absorb more warmth. Similarly, darker-colored butterflies seemed better equipped to tolerate higher temperatures than lighter ones. This aligns with previous evidence suggesting that darker butterflies heat up and cool down faster than pale butterflies at a given level of solar radiation, and achieve higher body temperatures. Additionally, darker species may be better adapted to cope with the predicted increases in ambient temperatures under climate change because of their higher thermal tolerances. In contrast, while potentially benefiting from rising temperatures in cooler climates, paler butterflies may be at greater risk of overheating in hotter environments due to their slower heat loss capacity and current lower thermal tolerances. These findings reveal the important role of wing size and coloration in helping butterflies manage their body temperature, shedding light on how they adapt to their surroundings. This knowledge could be useful for conservation efforts, especially as climate change transforms butterflies’ thermal landscapes.

Faculty project mentor: Jean Burns, Biology department

Expanding the neurodevelopmental disease spectrum to speech and language disorders

Danny Cho, Department of Biology, Case Western Reserve University;
Yun Sun Eoh, Case Western Reserve University School of Medicine;
Ashleigh Schaffer, Department of Genetics and Genome Sciences, Case Western Reserve University School of Medicine

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, and the most common is 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 severe CAS, a de novo variant was identified in the gene PPP2R5D (protein phosphatase 2, 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. To analyze neurodevelopment, cerebral organoids serve as a model to understand variations in neurogenesis and neural differentiation. Cerebral organoids, derived from human induced pluripotent stem cells (iPSC), self-organize and differentiate into structures that recapitulate the developing mammalian brain. Comparison of cerebral organoids harboring de novo mutations in PPP2R5D and isogenic controls allow for the elucidation of neurodevelopmental differences between CAS and ASD. The outcome of this research study will reveal how speech and language disorders fit into the neurodevelopmental disorders spectrum.

Faculty Sponsor: Dr. Barbara Kuemerle, Department of Biology, Case Western Reserve University

Principal Investigator: Dr. Ashleigh Schaffer, Department of Genetics and Genome Sciences, Case Western Reserve University School of Medicine

Determining the Density of Type I Collagen Fibrils Grafted Perpendicularly to a Surface with Correlative Testing for Improving Soft Tissue Integration Around Dental Implants

Julia Cho,[1] Danny Saliba,[1] Rea Marfatia, [1]Leena Polomo, [2] Steven J. Eppell
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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 of these fibrils. We did this both with direct imaging using scanning electron microscopy (SEM) and by mechanically shearing two parallel surfaces connected to each other via crosslinks between entangled fibrils projecting away from the two surfaces. SEM showed a few fibrils projecting perpendicularly from the surface. The majority of imaged fibrils ran parallel to the plane of the surface. The average density of the fibrils was $7.5x10^6 \pm 4.0x10^6$fibrils/cm^2. Mechanical testing was done ensuring the two surfaces were at least 10 um apart using polystyrene beads as spacers. The average force to shear the coverslips was 2.1± 1.3 N across five different crosslinked pairs. Using previously measured single fibril strength values, we compute an average density of $3.6x10^6$fibrils/cm^2. The results from the two testing methods thus agree with each other indicating our sample preparation method does produce large numbers of fibrils projecting several microns perpendicularly away from the surface to which they are grafted. The SEM images likely fail to show many perpendicularly projecting fibrils due to some sample preparation artifact occurring during the dehydration phase.

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

Development of non-viral cancer gene therapies using in vivo electroporation of TRAIL protein targeting skeletal muscles

Cameron Choi, Department of Biology; Qingzhong Kong, Department of Pathology; CWRU

Tumor necrosis factor-related apoptosis-inducing ligand (TRAIL) is a promising anti-cancer agent because it can kill tumor cells without affecting normal tissues. The anti-cancer efficacy of TRAIL is positively correlated with the levels and duration of its expression. Consequently, sustained expression of adequate TRAIL protein is required for clinical efficacy, but the natural TRAIL protein has a very short half-life in vivo and failed in clinical trials. This research focuses on developing an effective non-viral gene therapy for cancers through enabling continuous expression and secretion of bioactive and stable TRAIL variants from patients' own skeletal muscles, thereby achieving sustained therapeutic levels of TRAIL in the blood to kill cancer cells throughout the body, which has the potential to treat a broad range of non-CNS cancers alone or in combination with certain sensitization treatment and/or traditional cancer treatments. We aim to achieve this through transduction of skeletal muscle tissues with plasmids encoding stable TRAIL variants after in vivo electroporation of skeletal muscles in mice. Different variations of TRAIL have been designed for more stability in vivo, including our novel Z-ABD-hTRAIL variant. Here we report our preliminary results using a GFP reporter plasmid to demonstrate technical feasibility and using the Z-ABD-hTRAIL plasmid to evaluate the blood level of TRAIL that can be achieved with this strategy.

Project Mentor: Dr. Qingzhong Kong, Department of Pathology, CWRU
Faculty Sponsor: Dr. Barbara Kuemerle, Department of Biology, CWRU

ORF-K1 Protein Activation and its Role in the Progression of KSHV-induced Diseases

Joohee Choi, Department of Biology, Case Western Reserve University

Kaposi sarcoma (KS) is a cancer, causing neoplasm of endothelial cells that line blood vessels, lymph nodes, and internal organs. KS lesions are highly angiogenic and often appear red, purple, or brown. It is common among immunosuppressed individuals, such as those who have HIV or AIDS, being the most common tumor in patients with AIDS. However, it was found that another infectious agent other than HIV is involved in the pathogenesis of KS. Kaposi's sarcoma-associated herpesvirus (KSHV), also known as human herpesvirus 8 (HHV-8), was found to be an oncovirus that manifests in all four forms of KS: classic, endemic, AIDS-associated/epidemic, and iatrogenic. Besides KS, KSHV is known to cause diseases called Primary Effusion Lymphoma (PEL) and Multicentric Castleman's Disease (MCD). They are both B-cell lymphoproliferative disorders that also predominantly affect HIV patients. Current treatment methods against KSHV include herpesviral DNA polymerase inhibitors, chemotherapy, and antiviral drugs, but there is yet to be an effective drug specific to KSHV-associated diseases. This paper aims to better understand KSHV-mediated tumor pathogenesis to investigate promising therapeutic targets against these KSHV-induced diseases.

KSHV has latent and lytic viral lifecycles, with respective oncogenes expressed in each state. KSHV is primarily in the latent state and has the potential to be activated for lytic replication. K1 is a lytic oncogene that is manifested in KS, PEL, and MCD. It is known to participate in immune invasion, prevent apoptosis, induce cellular transformation, and contribute to angioproliferative and inflammatory KS lesions. By investigating the role and disease progression of K1, it can be a significant target for understanding KSHV pathogenesis and making advancements for new therapeutic approaches against KSHV.

Project Mentor: Dr. Richard Drushel, Department of Biology, Case Western Reserve University

Opioid-induced modulation of colonic epithelial barrier integrity

Maxine Chou, Chemistry & Music BA Candidate, Case Western Reserve University

Maintaining the integrity of the colonic barrier between the host and external environment is crucial for health. The body regulates this barrier through maintenance of the mucus layer, which protects the single-cell thick epithelium from bacteria and bacterial byproducts. The barrier is also regulated through tight junctions, which seal the paracellular cell-to-cell interface. Tight junctions function to selectively regulate the diffusion of water, ions, and other molecules through the epithelium. Disruption of either mechanism results in decreased barrier integrity, which can trigger inflammation and imbalance in the host.

Our previous studies reported that epithelial monolayer integrity is increased by methadone exposure, as evidenced by an elevated transepithelial electrical resistance. We therefore hypothesized that opioid receptor signaling increases barrier function by either stimulating mucin production or tight junction integrity. We characterized the expression of the mucin proteins MUC2 and MUC5AC and the tight junction protein ZO1 after 12 hours of morphine exposure using an organoid-based Air-Liquid Interface (ALI) model. Microscopic images suggest that morphine increases localization of ZO1 to tight junctions, possibly explaining our earlier observations with methadone regarding barrier integrity. While expression of MUC2 and MUC5AC were not altered by morphine treatment, the distribution of the two mucins is strikingly different. MUC2 appears to be stored in vesicles located in the upper half of the cells, shown by bright fluorescent puncta. MUC5AC expression is more diffuse in the lower half of the cells and is, notably, observed in a 1-2 μm organelle in the nucleus of ~50% of cells. These results signify a possible increase in barrier integrity in the presence of opioids.

Project Mentor: Alan Levine, PhD, Department of Molecular Biology and Microbiology, Case Western Reserve University School of Medicine

Developing a Library of KSHV Viral ORFs to Investigate Interactions with Host Molecules in B Cells and Endothelial Cells.

Yoo Jin Chung, Department of Biology, CWRU

Kaposi's sarcoma-associated herpesvirus (KSHV), also known as Human Herpesvirus 8 (HHV-8), is associated with several human diseases, including Kaposi's sarcoma, primary effusion lymphoma, and multicentric Castleman's disease. KSHV primarily infects B lymphocytes and endothelial cells, where it establishes latency.

To understand KSHV's interactions with host cells, creating a KSHV expression library is essential. Currently, no KSHV expression library is available that applies to multiple cell types. This study focuses on constructing an expression library for KSHV ORF proteins with a lentivirus backbone, enabling a systematic investigation of viral and host protein interactions. To build an expression library for each KSHV ORF protein, cloning and western blot techniques are utilized. The completed expression library will be crucial for examining the interactions between individual KSHV proteins and the host cellular machinery. This approach enables us to uncover cell-type–specific interactions, potentially identifying novel therapeutic targets and advancing our understanding of KSHV pathogenesis in relevant physiological contexts.

Project Mentor: Susan Burden-Gulley, Department of Biology, CWRU
Principal Investigator: Jae Jung, Department of Cancer Biology, Cleveland Clinic

Design of an Active Aerodynamic System for Improved Motorcycle Cornering

Ryan Collier; Mechanical Engineering, Case Western Reserve University

While racing a motorcycle, the lean angles encountered while turning render standard downforce devices useless with respect to cornering speed improvements. Motorcycle manufacturers and designers have proposed various solutions to this problem, including flow redirectors [3] and asymmetrical wings [4], all of which provide a lateral force to help the bike throughout the corner. I have designed an active aerodynamic system which makes use of electronically actuated "wings" to generate this lateral force. The design process involved iterations of testing and refinement to hone in on an optimized wing geometry. The iterative tests consisted of both computational fluid dynamics (CFD) as well as water-tunnel tests to gauge the effectiveness of my design. I compared water tunnel test results with and without my active wing to obtain information on any increase in lateral force (and thus cornering speed) as well as any unwanted increase in drag. The testing is accompanied by design of the electronic and mechanical system for control and actuation. Upon completion of the testing stage, there will be conclusive results on the effectiveness of my design, which will indicate whether pursuit of a functioning prototype is worth exploring.

Project Mentor: DR. Bryan Schmidt; Department of Mechanical and Aerospace Engineering, Case Western Reserve University

Microbe-microbe interactions vary across a genus and alter 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

Most adults are impacted by some form of oral disease, such as caries and periodontitis. Both oral health and disease are influenced by the collection of microorganisms in the mouth and their interactions with each other. For example, the dominant and highly diverse oral genus, Streptococcus, impacts disease through its interactions with oral pathogens. Past research shows that commensal Streptococcus gordonii alters the fitness (growth) and virulence of Aggregatibacter actinomycetemcomitans (Aa), an oral pathogen involved in periodontitis. S. gordonii accomplishes this through its 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 understood, there is little information on how other streptococcal species and strains influence Aa fitness. We hypothesized that Aa fitness varies across interactions with genomically and phenotypically diverse Streptococcus. To test this, we performed in vitro mono-culture and pairwise co-culture biofilm experiments between Aa and 31 diverse streptococcal strains. We found that the Aa abundance varied between mono-culture and co-culture and up to 8-logs between co-culture with different streptococci. The variation in fitness in co-culture was significant across taxonomically-distinct clades of streptococci. Additionally, streptococcal fitness also differed between mono- and co-culture in some strains, with co-culture with Aa often increasing the fitness of the streptococcal strain. From these results, we conclude that strain- and species-level diversity alters commensal-pathogen interactions. Future work in the lab will use bulk RNA-sequencing to explore how diverse streptococci differentially impact Aa. Together, this work will further our understanding on the relationship between microbial diversity, microbe-microbe interactions, and pathogenicity.

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

Metallographic Analysis of DAIDO High Thermal Conductivity HTC40 Steel

John Cotti, Dept. of Materials Science & Engineering, Case Western Reserve University

Erosive wear, including metal loss and thermal fatigue cracking during die-casting of molten aluminum can have a detrimental effect on the accuracy of parts and lifespan of steel die due to which compromises the cast shape and the manufacturing process. There is a need for a steel whose forming process and composition can withstand the thermal and mechanical fatigue presented by aluminum die-casting. In a thermal fatigue cracking test, a rectangular sample of additively manufactured DAIDO HTC40 high alloy steel was cyclically dipped into molten aluminum to simulate rapid heating and cooling, which resulted in almost no metal loss or cracking. This characterization of this sample, drawn from scanning electron microscopy to quantify the microstructural features, offers the possibility to determine what the meaningful parameters are that lead to this steel's performance. This analysis at the different locations on the sample may reveal the secrets to the steel's performance.

Over the last decade, there has been a growing interest in the casting of large, intricate structures, or 'gigacasting' for use in vehicles in order to reduce pieces. However, there is a problem with the slow dissolving of the steel mold as the molten aluminum enters the cast and is cooled. Many industries that implement complicated gigacasting, particularly the automotive industry, would be interested in a steel that could withstand any degradation in this process. An additively manufactured steel with the capabilities to last far longer than common tool steels has high value for a large number of industries, and may provide important technical advantages.

Project Advisor: Matthew Willard

High Speed, High Power, USB C PD Hub

Zach Brown - EE CWRU , **Toby Cowles** - EE CWRU, **Carter Graefnitz** - EE CWRU

This project explores the design and development of a specialized USB-C hub appliance that supports both high-speed data transfer and high-power delivery across multiple ports. While there are various USB-C and USB Power Delivery (PD) devices on the market, ranging from standard hubs to multiport power adapters, none offer a combination of multiple independent high-power PD ports alongside high-speed data transfer. Our hub is designed to bridge that gap, offering USB 3.2 Gen 2 speeds of up to 10 Gbps and delivering up to 100W of power per port in accordance with the USB C PD spec. This is made possible through the use of advanced integrated circuits (ICs) on a custom-built six-layer printed circuit board (PCB). The design aims to be suitable for a wide range of applications, including robotics, by providing reliable connections in a compact and reliable form factor. To achieve this, we leverage the full capabilities of the USB-C, USB PD, and USB 3.2 gen 2 standards, selecting components with care for both the digitally controlled DC/DC converters and the high speed data systems. Additionally, we ensured that the high-speed data transmission would maintain good signal integrity through the use of impedance-controlled, high-speed differential pair traces. This hub is designed to withstand tough conditions, such as those found in Dr. Lee's robotic tractor while maintaining seamless functionality for both power and data needs.

Project Advisor: Dr.Gregory Lee - ECSE Department, CWRU

Bile Acids Species on the Growth Dynamics of a Novel Bacterial Subspecies Isolated from Cavitating Microlesions in Crohn's Disease

Chelsy Kexin Dai, Department of Nutrition, School of Medicine, CWRU; Drishtant Singh, Department of Nutrition, School of Medicine, CWRU

Background: Parabacteroides distasonis, a well-known gut commensal species, is implicated in both maintaining gut homeostasis and causing inflammation. By examining resected bowels from patients that underwent surgery for treatment of Crohn's disease (CD), we isolated bacteria from gut wall cavitating microlesions in the ileum of two individuals, which clustered together within the newly candidatus P. distasonis subspecies cavitamuralis (P. dis). The objective of this study is to quantify the impact of various bile acid (BAs) species on bacterial growth, to define the mechanisms that enable Pdis to thrive in CD-ileal microlesions and serve as a model of other species.

Methods: Pure P. dis (strain CavFT-hAR46) colonies revived on Tryptic soy agar supplemented with 5% defibrinated sheep blood were seeded at McFarland solution 0.5 and cultured in brain heart infusion (BHI) broth without dextrose supplemented with each of 56 single (liver-derived primary, and bacteria-modified secondary) BA species at concentrations of 1, 10, and 100 μM to assess growth over time. Growth was compared to a pool of BA combined individually to emulate the BA composition present in the ileum of C57BL/6J mice affected with TNF-driven ileitis and WT controls (TNF vs WT pools), were used as comparators. Growth was measured via optical density (OD600) for 48 hours of anaerobic incubation at 37°C. The effect of each BA was derived from slope determination derived from the three BA concentrations.

Results To assess and rank the overall effect, we extracted the slope of the effect for each BA across the three concentrations using a linear fit across the OD600s at 48h. Among the concentrations tested, growth promotion was more frequent than inhibition (skewed with R^2 of 0.7953%), which was statistically different from a random effect (expected equal proportion of BA promoting and suppressing growth, gaussian and R^2 of 0.96-0.99). At 100 μM, 36 BA species promoted absolute growth (>20% of BHI alone), with an average increase of 150.3% compared to the control (no bile), while 17 treatments inhibited growth and 6 had negligible effects. At 10 μM, 36 BA treatments promoted growth (average increase of 124.3%), while 8 inhibited and 15 had little effect. At 1 μM, 36 cases showed promotion (average improvement of 89.0%), 12 inhibited growth, and 11 showed no impact. Overall, the strongest growth promoters were taurochenodeoxycholic acid (TCDCA), allocholic acid (allo-CA), and dioxo-lithocholic acid (dioxo-LCA). The strongest inhibitors were β-muricholic acid (bMCA) and deoxycholic acid (DCA). Of interest, the TNF and WT BA pools exerted opposing effects on bacterial growth.

Conclusion: The significant differences in growth promotion and inhibition highlight that the variably dynamics of specific BA in the gut could influence, varying with inflammation and gut microbiome, the growth and permanence of P. dis in the ileum.

Project Mentor: Dr. Alex Rodriguez-Palacios, Department of Nutrition, School of Medicine (CWRU)

Network Analysis of Dense Suspensions

Alessandro d'Amico, Chemical and Biomolecular Engineering Department, Case School of Engineering

Our understanding of soft matter systems is limited due to these system's immense complexity. One such system of great interest to the scientific community is the shear-thickening dense suspension (ST-DS), where viscosity can increase by orders of magnitude with onset stress. ST-DSs have recently been successfully simulated and these simulations have revealed that the interparticle frictional contacts are the cause for the observed increase in viscosity. These frictional contacts form system spanning networks at high stresses. Analysis tools for these networks have historically struggled to find a single network parameter that correlates with viscosity. Using two-dimensional simulations which semi-quantitatively correlate to three dimensional systems, network theory was utilized to characterize the frictional force network and seek the singular network parameter relating to viscosity. Using network theory, the number of edges belonging to third-order loops was found to correlate strongly with viscosity. Network theory also provides the limitations of this relationship. The physics behind our systems provide a theoretical framework behind our limitations.

Project Mentor: Abhinendra Singh, Department of Macromolecular Science and Engineering, Case School of Engineering

Aging is associated with decreased Lactobacillus and increased cervicovaginal inflammation in Canadian women

Ha T. Dang[1], Laura Noel-Romas[1,2], Samantha Knodel[1,2], Kenzie Birse[1] , Alana Lamont[3] , Kateryna Kratzer[3] , Peter McQueen[4] , Michelle Perner[4] , Hossaena Ayele[1,3] , Alicia R. Berard[1,2] , John J. Schellenberg[3] , Stuart McCorrister[4] , Garrett Westmacott[4] , Bonnie Sandberg[5] , Adelicia Yu[2] , Margaret Burnett[2] , Vanessa Poliquin[2] , Adam D. Burgener[1,2,6], Christina Farr Zuend[1]

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Aging is characterized by a general dysregulation of systemic immune responses that increases susceptibility to infections and malignancies. Immune cells in the female genital tract (FGT) are regulated by sex hormones, but little is known about the impact of aging and menopause on immunology in the FGT. This study conducted an age-focused sub-analysis of cervicovaginal samples collected from 47 women enrolled in the Vaginal Mucosal Systems study in Winnipeg, Canada, using a systems immunology approach. The median age of study participants was 38 (range 19-88), with 12 over the age of 50. Increasing age was significantly correlated with increased cervicovaginal inflammation, including inflammatory cytokine MIP-1β (r=0.335, p=0.023), and activated T cells (CD4+HLA-DR+ r=0406, p=0.009; CD8+HLA-DR+ r=0.399, p=0.010; CD8+CD38+HLA-DR+ r=0.386, p=0.013). Proteomic analysis of cervicovaginal mucus identified 925 human proteins, with 108 (11.7%) significantly correlated with age. Pathway analysis indicated biofunctions related to immune response, migration, and myeloid cell phagocytosis increased with age. Interestingly, neutrophil related pathways decreased with age, including G-CSF (r=-0.396, p=0.006) and reactive oxygen species (z-score=-2.607, p=2.31E-4). Vaginal Lactobacillus crispatus, a species associated with mucosal health, significantly decreased with age (r=-0.338, p=0.036), with participants over the age of 50 significantly more likely to have non-Lactobacillus dominant microbiomes (p=0.0097) compared to those under 40. Together, our data suggests that there is an increase in cervicovaginal inflammation and a decrease in L. crispatus that occurs with aging.

Faculty Project Mentor: Dr. Christina Farr, Center for Global Health and Diseases, Department of Pathology.

Metamaterial-Based Gastrointestinal Soft Robot

Joshua Daniel, Department of Mechanical and Aerospace Engineering, CWRU

Colorectal cancer, characterized by abnormal growth of polyps in the colon, is estimated to cause around 53,010 deaths in 2024. Colonoscopies are the primary inspection procedure for colorectal cancer but apply force onto the colon wall during insertion/ removal of the colonoscope, a long flexible tube. This force causes pain, discomfort and, in severe cases, gastrointestinal perforation. Additionally, clinicians, on average, must be trained for four years in order to perform a colonoscopy. However, colonoscopies are needed as they are the only invasive procedure that can screen the colon and remove polyps with the help of a wire. This sparks a need for a colon screening procedure that requires neither human force for insertion/ removal nor extensive training. The main objective of this project will be to create a self-propelled soft robot that will effectively circumnavigate the colon without tearing the colon wall. To do so, we will create a system consisting of two major components. The first is a pneumatically driven, silicone-molded actuator that serves as the movement. The second component is a nodal/ chiral-inspired metamaterial structure developed by Akkus Lab, which helps achieve frictional anisotropy for the soft robot's bidirectional movement. By integrating these components, this project aims to deliver a functional prototype that will circumnavigate bi-directionally in a colon-simulated environment.

Project Mentor: Dr. Yusuf Dikici, Department of Mechanical & Aerospace Engineering, CWRU

Principal investigator: Dr. Ozan Akkus, Department of Mechanical & Aerospace Engineering, CWRU

Faculty Sponsor: Dr. Kathryn Daltorio, Department of Mechanical & Aerospace Engineering, CWRU

Impact of Conditional Inactivation of Adamts6 in Heart Valve Development and Disease

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Congenital heart defects are the leading cause of child morbidity and mortality. Of these, myxomatous (enlarged and disorganized) heart valves account for up to 2.5% of the U.S. population. ADAMTS6 is a protease known to regulate the extracellular matrix (ECM) and is necessary for heart and musculoskeletal development. Adamts6-deficient embryos have congenital heart defects, including myxomatous heart valves, and die at birth. However, its targets in the heart, and specifically in heart valves, remain unknown. In order to determine the role of ADAMTS6 in heart valve development, we generated Adamts6$^{fl/fl}$;Tie2Cre mice. Since premature endocardial cushions become mature heart valves through epithelial to mesenchymal transition, we hypothesized that the conditional inactivation of ADAMTS6 in Tie2Cre positive endothelial cells will result in myxomatous valves without the comorbidities witnessed in global ADAMTS6 deletion. Proteoglycan content, hydrophilic molecules found in the ECM, was assessed by alcian blue staining, which showed significant aortic valve enlargement in Adamts6$^{fl/fl}$;Tie2Cre embryos, as compared to littermate controls. Further testing, including Masson's Trichone staining to investigate collagen content and target antibody staining, will be conducted to distinguish the impact of ADAMTS6 inactivation globally versus in endothelial cells and identify novel valve-specific targets for therapeutic approaches to congenital heart valve disease.

Project Mentor: Timothy Mead, Department of Pediatrics, Case Western Reserve University School of Medicine

Assessing Crime Patterns in Cleveland

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As crime rates in urban areas continue to challenge law enforcement agencies, understanding the influential factors on crime occurrences is critical. Building upon existing research, which includes methods leveraging historical crime data and various machine learning techniques, our project seeks to improve predictive accuracy through innovative data integration and analysis. For this project, we focus on crime in the city of Cleveland. We utilize publicly available crime data from Cleveland's Open Data Portal along with additional datasets such as weather and event information for our analysis. Our methodology involves several key steps, including exploratory data analysis to identify patterns and trends in crime occurrences, the creation of a real-time data pipeline to stream and process incoming data, and the application of machine learning algorithms, such as random forests and neural networks, to predict future crime events. For prediction, we are using census blocks to determine crime locations and are predicting crimes a week in advance. The project will culminate in the generation of interactive heat maps that visualize predicted crime hotspots along with additional visualizations and analysis of different crime patterns. By focusing on influential variables and their correlations with crime rates, we aim to identify patterns that could lead to more effective crime prevention strategies. Our findings will be presented through a user-friendly interface, allowing for continuous updates as new data becomes available, ultimately contributing to the ongoing discourse on crime prevention and resource allocation in urban environments.

Project Mentor: Dr. Shuai Xu, Computer and Data Sciences Department

The Effectiveness of Neurofeedback and Brain-Computer Interface (NFB-BCI) Training on the Treatment of ADHD

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Attention-deficit/hyperactivity disorder (ADHD) is the most commonly diagnosed neurodevelopmental disorder in children with a prevalence of 8.7% (or 5,300,000 children) in the United States (Bozinovic et al.2021). ADHD negatively impacts the lives of individuals and societies, with those diagnosed showing a 12% reduction in employment, 34% reduction in earnings, twice the rate of attempted suicide, and six times the rate of suicide completion compared to typically developing individuals (Faraone et al. 2021). Therefore, conducting systematic research and developing effective treatments for ADHD is of growing importance, and recently, scholars have investigated the possibility of using neurofeedback
(NFB) training through game-based brain-computer interfaces (BCIs) as a non-pharmacological treatment for ADHD. But is NFB-BCI training an effective non-pharmacological treatment for ADHD? If so, how effective is NFB-BCI training at reducing ADHD symptoms, such as inattention? To provide answers to these important questions, we followed PRISMA guidelines and conducted a systematic literature review and meta-analysis on all randomized controlled trials (RCTs) that compared the effectiveness of NFB-BCI training versus different controls (waitlist, placebo) on ADHD symptoms (such as inattention). Using a random effects model, we found a large effect for the use of NFB-BCI training vs waitlisted controls on the reduction of ADHD symptoms ($k = 10$, $SMD = -0.85$, $p = 0.028$). Yet we found no statistically significant effect for the use of NFB-BCI vs placebo controls ($k = 4$, $SMD = 0.15$, $p = 0.344$). We discuss our results on NFB-BCI training for ADHD treatment as well as methodological issues with current placebo-controlled studies (Pigott, Cannon & Trullinger 2018). We also discuss the practical value and limitations of this research along with future work.

Faculty Sponsor: Professor Adam Croom, Department of Cognitive Science, Case Western Reserve University

Applying Kalman Filtering to Model Circadian Rhythms: A Novel Approach to Analyzing Wearable Sensor Data for Predictive Health Insights

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Kalman filtering is a modeling technique typically used in aerospace and defense for hardware-based cyclical processes such as software-defined time series algorithms. It allows for the integration of multiple raw sensor data sources at discrete time intervals that are brought together in an ensemble to produce a more accurate estimate of some system interpreted from the raw data. However, the use of Kalman filtering in biological systems has not yet been thoroughly investigated. Limitations to using this linear sensor data processing algorithm with more nonlinear, biological systems include a lack of relevant control data, a lack of data at discrete time intervals, and few cyclic models that leverage non-differentiable equations. In this project, we create a proof-of-concept filtering mechanism that explores the use of Kalman filtering for modeling various biological rhythms, such as core body temperature, the sleep-wake cycle, and hunger level estimates. These were tracked for 24 consecutive hour intervals, and were generated from per-minute sensor data collected from a 21-year-old male via an Apple Watch. After interpolating the data to have state measurements for consistent, discrete time intervals and normalization, we modeled these circadian rhythms using the previously mentioned Kalman Filtering system that implements a rotational matrix for the state transitions. Subsequently, the three biological rhythms were then combined via a master Kalman filter to produce one signal that was a product of all the denoised inputs in an effort to simulate the ensemble action of the suprachiasmatic nucleus in the human brain. Finding effective ways to predict the state in a circadian rhythm is of interest to the healthcare industry due to its potential for applications in personal health and disease management.

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

Generating GPS-Timed Acoustic and Radiofrequency Costas Array Sounding Signals

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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. The system features a microcontroller for programming arbitrary Costas arrays, a connection to GPS for advanced time synchronization, and a direct digital synthesizer to generate baseband frequencies that are modulated by a carrier frequency for transmission. We were able to transmit signals to a distant receiving radio station successfully and were able to estimate the time-of-flight, quantify the uncertainties due to signal generation errors, and discuss future directions.

Keywords : Ionospheric sounding, Radiofrequency Engineering, Costas arrays

Advisor: David Kazdan
Sponsors: Case Amateur Radio Club W8EDU; Amateur Radio Digital Communications Foundation.

Diabetes Inspired Culinary Education (DICE): An Innovative Approach to Type 1 Diabetes Management Through Culinary Medicine

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ABSTRACT:

Despite the critical role nutrition plays in T1DM management and growth/development, youth with TIDM consistently have poorer diet quality compared with their healthy counterparts. While culinary medicine is an area of research that is still in its infancy, initial studies have demonstrated success in improving youth diet quality and dietary and disease management outcomes in adults with T2DM. Diabetes Inspired Culinary Education is a 10-lesson community-based clinical research intervention seeking to improve T1DM management among at-risk (HgbA1c > 7.0%) youth aged 8-14 through hands-on, experiential culinary, nutrition, and T1DM education. This study aims to assess the feasibility and acceptability of the DICE intervention using a mixed methods approach. Feasibility was assessed through participant attendance and program fidelity. Intervention acceptability was evaluated by post-intervention focus groups with study participants. On average, families attended 8 of the 10 lessons and 82% of families fully completed the program. During focus groups, the majority of families regarded DICE as a positive, informative, and helpful experience that they would recommend. Both kids and caretakers were satisfied with the recipes and cooking skills learned. Overall, these findings indicate DICE is a feasible intervention that is well-received by participants, demonstrating the potential DICE has to positively impact diabetes management and overall health outcomes of at-risk youth with T1DM and their families.

Project Mentor: Dr. Catherine McManus PhD, RDN, LD, Department of Nutrition, CWRU

3D Open-Source Haptic Kit

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Haptic technology sees frequent use in a wide variety of industries. It sees use in simulation applications, particularly in high-risk training cases such as those represented by surgery and heavy machinery. There, the security offered by an initial low-risk, simulated training environment is invaluable. However, the high cost of many of these haptic devices is prohibitive for many developers, making experimentation difficult. Additionally, lower-cost applications may not require the immense precision offered by the current market. As such, an alternative device that is low-cost, sufficiently precise for simpler use cases, and approachable for lower-scope developers is desirable.

Some solutions to this problem already exist. Stanford designed an open-hardware haptic device called Hapkit. It is an economical and easy to assemble kit allowing for one degree of motion free to be programmed. With three of these kits, students at Johns Hopkins University expanded the kit into 3D Hapkit, which has a greater three degrees of translational motion. While the extra dimensions allow for more use cases, their design process compromised some of the accessibility and precision of the kit. Some parts they utilize are unavailable, the design allows for data loss between the boards, and their documentation lacks the detail to allow easy recreation. Our project reworks this device into a far more approachable form, streamlining its documentation, code, and parts list. We also changed and reduced the number of processing boards, this significant rework constituting an immense streamlining of the device's control systems. Beyond this, we refined the device's communication system implementing an I2C protocol, which, alongside the inclusion of more precise Hall effect sensors, allows for both 12-bit precision and increased modularity.

Project Mentor: Zonghe Chua, Department of Electrical, Computer and Systems Engineering, Case Western Reserve University

Duct Master Proposal

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

For the Duct Master project, we aim to design and develop a small lightweight robot capable of navigating and cleaning horizontal HVAC ducts using a left-wall following approach for efficiency. This came after countless trial and error methods, in addition to research done about the path and dynamics of HVAC duct systems. The robot is equipped with ultrasonic sensors for navigation and obstacle avoidance as well as a spinning brush attachment for cleaning dust and debris from duct surfaces. Controlled autonomously using Arduino software, the robot will objectively loosen up dust from the duct walls allowing the softened debris to be captured through the HVAC system's built-in filter, ensuring users maintain clean and efficient HVAC systems. This solution addresses current limitations in HVAC cleaning, such as confined duct spaces, costly alternatives, and availability of HVAC technicians. By using our robot, it will offer a cost effective, automated alternative to manual cleaning or expensive professional services, with a focus on improving safety, efficiency, and accessibility for both residential and commercial application.

Faculty Mentor: Zonghe Chua, Department of ECSE at CWRU

Determination of Epidermal Cell Volume in Drosophila Embryos via FLP-out and Ecad Immunostaining

Vikram Ekambaram; Chemical Biology, Case Western Reserve University.

Investigating the changes that cells undergo during periods of growth is vital to understanding the genetic side of human growth. Drosophila melanogaster is a quick and inexpensive model for genetic research and specifically for this project, research on morphogenesis. Prior research has shown that cell shapes are irregular in developing cor mutant embryos, with the assumption being that cell volume remained constant throughout growth. This project aims to definitively address this assumption and prove it experimentally. To visualize the cells under a confocal microscope, green fluorescent protein (GFP) expression stains the cytoplasm while antibodies staining epithelial cadherin (Ecad) highlight cell junctions. The FLP-out recombination tool (derived from Saccharomyces cerevisiae), which substitutes the highly expressed gene yellow (y) with Gal4 upstream of GFP when exposed to transient heat shocks, is the mechanism for distributing GFP across the cytoplasm. To acquire experimental embryos capable of this procedure, a genetic cross was set up with one line possessing FLP1 and Ecad genes and the other wtih AyGal4 and GFP genes. Ongoing research on this project shows that homozygous crosses for the cor mutation did not undergo FLP-out successfully, so only the FLP1 line has the cor mutation in this cross. The large stocks necessary for performing the FLP-out experiments have been made, and trials testing the timing and intensity of heatshocks to ensure that the FLP-out pathway is expressed adequately are underway. The results of these trials are currently inconclusive, but further experimentation with heatshocks is needed. After achieving cytoplasmic expression of GFP, taking three-dimensional images of the target embryos is the next step, and measuring the cell volumes' growth based on the staining is the final step.

Project Mentor: Robert Ward, Department of Biology, Case Western Reserve University

FlexDDM: A flexible simulation-based Python package for fitting and validating diffusion models

Joy Fan, Alessandra Puccio, Heath A. Demaree, Kyle J. LaFollette, Case Western Reserve University

Diffusion decision models (DDMs) are mathematical models used to explain cognitive processes in decision-making tasks, capturing decision dynamics and response times. Researchers typically fit DDMs to choice and reaction time distributions using available software packages or applications. However, these tools often have limitations: they either lack customizability or require extensive programming knowledge to extend the models, and most rely on likelihood-based routines, which restrict models without closed-form solutions. To address these limitations, we developed FlexDDM, a Python package that uses a simulation-based approach. FlexDDM allows for the easy formulation, validation, and testing of new diffusion models with minimal coding. It includes templates of four leading diffusion models and user-friendly instructions for creating new models in base Python. The package also promotes best practices in model development with automated validation tools for model recovery, parameter recovery, and posterior predictive checks. We demonstrate the utility of FlexDDM through re-analyzing 6 separate experiments of human decision-making. FlexDDM enhances the accessibility of DDMs, enabling researchers to efficiently develop and test new diffusion models, thereby contributing to new theoretical insights to decision dynamics.

Project Mentors: Kyle LaFollette, PhD Candidate, Department of Psychological Sciences; Professor Heath Demaree, PhD, Department of Psychological Sciences

Electrophile Determines Cellular Phenotypes among XPO1-Targeting Small Molecules

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Exportin-1 (XPO1) is a target for many electrophilic small molecules at its Cysteine 528 location, a site of interest for covalent drug discovery. Our work began with an FDA-approved chemotherapy drug, Selinexor, which is part of the established drug class called Selective Inhibitors of Nuclear Export (SINEs). Upon analysis of chemical structure and corresponding biological activity in relation to XPO1 C528-targeting drugs, we reveal a new class of drugs coined Selective Inhibitors of Transcriptional Activation (SITAs). Additionally, while developing our probes, we discovered degrader molecules of XPO1. Through in vitro testing of the various probes, we observed that small changes in electrophilic structure drastically shift cellular responses, including cellular viability. These phenotypic differences in cellular response denote the classification of analogous probes as SINEs, SITAs, and degraders.[AF1] [AF2] Future studies of these molecules will continue to characterize SINEs and SITAs to examine their mechanistic differences. Using the properties of SINEs and SITAs, we will investigate how they may be used to modulate XPO1 to provide therapeutic effects for cancers and T-cell driven autoimmune diseases, respectively.

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

Altered Neural Dynamics and Sleep Patterns in Epilepsy and the Effect of Potassium Buffering

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

This project sought to characterize the neural alterations invoked by epileptogenesis, to further explore the potential of omega fatty acids to rescue these disturbances, and to observe the effects of a novel glial ion channel on epileptiform activity. In order to elucidate the underpinnings of unstable dynamics in epileptic neural circuitry, we cultured hiPSCs and analyzed various electrophysiological properties. As expected, epileptic hiPSC cultures exhibited increasing spiking activity and local variance in spiking patterns. Higher order analysis also revealed changes to metastable brain states and state transition patterns. Previous research utilizing a Drosophila model reported decreased seizure activity in bang-sensisitve mutant flies when their food was supplemented with omega-3 and omega-6 fatty acids, thus provoking our interest in their effects on cell lines. We found that supplementation did not alter firing rates or local variance of spike patterns. However, differences were observed in higher order analysis that revealed changes to transition patterns and state stability, potentially suggesting that the alterations observed in the Drosophila may have been induced by an alternative mechanism. Further delving into the processes underlying seizure activity, we decided to investigate a pH-sensitive chloride channel that serves a role in alkaline taste sensation in Drosophila. The channel (Alka) has been shown to be present in both neurons and astrocytes, as well as in regions of the brain particularly involved in sleep mechanisms. The channel, in the Drosophila brain, serves a role in potassium buffering, an important aspect of mediating hyperexcitability that can invoke seizures. Therefore, we will use Drosophila expressing this channel and mutations to it to analyze their sleep patterns and compare them with those observed in bang-sensitive flies. Through this data collection, we aim to determine a potential relationship between this channel and epileptogenesis.

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

Capstone Mentor: Dr. David Friel, Department of Neurosciences, CWRU School of Medicine

Low-Cost Pediatric Pulse Oximeter

Zachary Fong, Department of Electrical Engineering; Dr. Steve Majerus, Department of Biomedical Engineering, CWRU

Urodynamic studies seek to collect data on lower urinary tract function during filling and emptying of the bladder. However, modern urodynamics testing is largely based on technologies developed over 50 years ago. Currently, urodynamic studies are carried out using catheter-based systems, which have severe limitations. As a result, there is research currently being done on minimally invasive, implantable devices that can improve patient comfort and measurement accuracy. To address these challenges, we have developed a transurethrally implanted bladder pressure sensor, which can be inserted and removed from a patient's body transurethrally which is capable of being powered wirelessly. This device is capable of sending radio transmissions to an external receiver, allowing for real-time monitoring of bladder-pressure data. The device utilizes a tuned-antenna network to receive power from a class-E amplifier; the device also employs a low-power microcontroller and pressure sensor in order to maximize power efficiency. Periodic transmissions of data are made once the device has received sufficient power from the power transmitter. Components were selected to minimize device size, so as to maximize patient comfort during insertion in the final device.

Project Mentor: Dr. Brecken Blackburn, Department of Biomedical Engineering, CWRU
Faculty Sponsor: Dr. Gregory Lee, Department of Electrical, Computer and Systems Engineering, CWRU

Understanding College Student Alcohol Consumption: A Cross-Cultural Review

Vanessa Franco; Psychology, Case Western Reserve University

College alcohol consumption has a multitude of physical health, mental health, and academic consequences. Roughly 80% of college students report consuming alcohol and 50% of those students report engaging in binge drinking[1]. Increasing rates of alcohol consumption leads to an increased tolerance which increases the risk of alcohol use disorder. The purpose of this comprehensive narrative review is to compare the state of college alcohol consumption cross-culturally along with the effectiveness of interventions in these countries to inform American universities [VF1] on focused interventions. The initial search for literature was done using the Web of Science and Google Scholar databases with keywords such as college alcohol consumption, interventions, and cross-culturally. The included papers consisted of European, South American, Asian, and American drinking habits and their comparisons[VF2] [VF3] . They also consisted of interventions in these areas and whether interventions have also previously been used in America. The literature indicated that behavioral interventions and personalized feedback were effective in reducing alcohol consumption and risky drinking behaviors. This further indicated that these interventions would be promising in the diverse American student populations. With American colleges having diverse student populations interventions tailored to their specific cultural needs could be more effective. Having effective interventions could lead to lower rates of risky drinking behaviors which would lead to better physical, mental, and academic outcomes. College students will always engage in alcohol consumption but giving them the tools to engage in healthier drinking behaviors would lessen the risk of falling prey to alcohol use disorder.

Project Mentor: Anastasia Dimitropoulos, Department of Psychological Sciences

Find Your CWRU

Vijay Chattamangu: Computer Science, CWRU, **Adele Fuchs**: Computer Science, CWRU, **Jimmy Gallegos**: Computer Science, CWRU, **Lyris Gordon**: Computer Science, CWRU, **Stephanie Little**: Computer Science, CWRU, **Weston Mansier**: Computer Science, CWRU

CWRU is home to a wide array of campus events, but students often miss out due to social anxiety or difficulty finding events that align with their interests. Our web app addresses this by providing personalized event recommendations and facilitating connections with fellow attendees, making it easier for students to engage in campus life. The app's core feature is a recommendation system powered by content-based and collaborative filtering. Upon registering, users will input personal preferences such as preferred event types, locations, and availability. These preferences, along with user-provided ratings after each event, will be stored in the user's profile. The content-based filtering will analyze event tags and user preferences, while collaborative filtering will compare similar users' ratings to suggest upcoming events. Another feature is group determination, which allows users to indicate attendance by joining events, storing their user ID in the event's participant list within the database. Based on common attendance and event ratings, a friend recommendation system will further enhance the social aspect. Using collaborative filtering and a Tinder-like interface, the system will suggest potential friends with shared event histories, showing mutual events as conversation starters. Through an intuitive interface and algorithms for event and friend recommendations, this app will help create a more connected and engaged campus community. With a focus on both personalization and social connection, this platform will help students easily discover and enjoy new experiences at CWRU.

Faculty Mentor: Shuai Xu, Computer and Data Sciences Department

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

Sreeja Gadepalli, Department of Psychology at Case Western Reserve University

Burnout is a mental health condition characterized by emotional exhaustion, depersonalization, and a loss of personal accomplishment as a result of chronic job stress. The COVID-19 pandemic served as a stark warning about the issue of burnout in the

American healthcare system, with up to 62.8% of physicians reporting symptoms in 2021 (AMA, 2024). Due to its association with lower healthcare quality and clinical mistakes, physician burnout also affects Americans seeking and receiving care (Wu et al., 2024). This comprehensive narrative review takes a structural approach by examining whether physician burnout is still highly prevalent in the aftermath of COVID-19 due to institutional factors such as workplace environment, job demands, and understaffing. Key terms such as organizational support, work-life balance, and work stressors were used to search in databases such as PsychINFO and PubMed. Synthesis of domestic and international literature confirms that burnout is largely a structural issue, rather than a result of deficits in personal coping skills. Emphasis on efficiency, lack of organizational support of work-life balance, and staffing practices emerge as primary factors in physician burnout. These findings indicate the need for re-evaluation of institutional practices in order to minimize current burnout rates and prepare for public health crises in the future.

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

Evaluating Enzymatically Crosslinked in situ Polymeric Hydrogels for Hemostatic Applications.

Maanyav Gangaraj, Department of Biomedical Engineering, Case Western Reserve University

This study evaluates the gelling efficiency and durability of enzymatically crosslinked in situ hydrogels for hemostatic applications triggered by coagulation Factor XIII, a transglutaminase enzyme. Most hydrogel-based wound dressings are pre-formed outside the wound space, thus reducing their efficacy to conform to abnormal wound morphologies. Conversely, hydrogels formed in situ at the wound site are able to conform to the entire wound shape, increasing its hemorrhage-reducing capabilities. Factor XIII is responsible for the crosslinking of fibrin in the coagulation cascade, forming a strong clot and stopping blood loss. Thus, Factor XIII can serve as an endogenous trigger for the in situ crosslinking of polymeric hydrogels in hemostatic applications. Hyaluronic acid (HA), 4-armed Star – Poly(ethylene glycol), and 8-armed Star – Poly(ethylene glycol) polymers were selected because of their documented compatibility efficacy in wound dressings. Each was modified with the crosslinking portion of the fibrinogen γ-chain (a transglutaminase peptide: TGP) to form HA–TGP, 4-armed PEG–TGP, and 8-armed PEG–TGP. Hydrogels were formed in vitro using endogenous concentrations of Factor XIII, thrombin, and calcium with the gelation time recorded. Subsequent gels were then rehydrated to confirm their absorption capabilities, followed by several lyophilization–rehydration cycles to study their durability and swelling capacity. It was found that HA–TGP gels form the quickest, but degraded severely after multiple cycles of rehydration. Meanwhile, StarPEG-TGP gels formed more slowly, but could swell up to 10 times their original weight with water and undergo several dehydration and rehydration cycles with minimal breakdown. Future studies will include rheological characterization of successful hydrogels; specifically quantifying the storage, elastic, and loss moduli to ensure resilience against the skin's dynamic deformations when in vivo.

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

Wearable Monitoring Device for Pediatric Dysphonia

Rachel Barker, Veebha Havaldar, Justin Storn, Nehal Garg, Collin 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 in later life. To help clinicians gather data for pediatric dysphonia patients, a noninvasive monitoring wearable device is being designed. This will help to assess changes in severity over time and analyze vocal patterns. Preliminary work consists of a benchtop testing device which demonstrates its ability to record and store vocal data that is analyzable and useful for diagnosis purposes.The wearable device will eventually sit in custom housing and will be paired with a smartphone application to allow users to assess the progress of their disease and improvements with treatment. The device's collection of quantitative data will allow clinicians to make determinations of severity and plan necessary interventions.

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

The DIVA study: Defining the Microbiome for the Neovagina

Alejandra Gaviria Rozo - Biology; Women's, Gender, and Sexuality Studies; Case Western Reserve University

Transgender women have increased odds of testing positive for sexually transmitted infections, which is maintained after adjusting for high-risk behaviors, suggesting biological factors unique to transgender women may contribute. Limited data exists describing the neovaginal microenvironment in transgender women after gender-affirming vaginoplasty, which is vital for mucosal health and long-term care of transgender women. The purpose of this study is to investigate the neovaginal microenvironment in transgender women after gender-affirming vaginoplasty. Our cohort consists of 41 transgender women who were at least three months post-gender-affirming vaginoplasty and at least 18 years old, with data available for 37 participants. Participants provided biospecimens and completed an extensive questionnaire about their sexual history and behaviors, neovaginal symptoms, diet, surgical satisfaction, and gender dysphoria. Collected biospecimens were analyzed with 16S rRNA sequencing, cytokine array, and metabolomics. The median age of our cohort is 39 (24-68) and the median time since vaginoplasty is 602 days (range 97-2,205). The majority of participants (29, 78%) have had peritoneal pull-through vaginoplasty, with 8 (22%) having penile inversion. The majority of participants (26, 74%) report having vaginal symptoms including discharge, pain, or odor. Cytokine analysis showed that reporting any symptoms or discharge increased the expression of 27 inflammatory cytokines including EGF and IL.10. Over 360 taxa were identified in the neovaginal microbiome, with Prevotella and Peptoniphilus being the most abundant. There were no significant differences in neovaginal microbial composition or cytokine analysis based on the vaginoplasty procedure performed. The results of this study will provide information on the neovaginal microbiome, genital inflammation, and its relationship to gynecological health, which is critical to delivering evidence-based guidelines for post-operative and long-term neovaginal care.

PI: Christina Farr, PhD, Department of Pathology, CWRU SOM

Variation in Flax DNA

Lingshuai Ge, CWRU

Some lines of flax, can change their DNA as they grow under stressful conditions. These changes occur in specific regions of their genomes. They might or might not be inherited to the next generation. When inherited, resulting in new phenotypes, the lines are then designated as genotrophs. These lines are identified as Pl (the original stress-responsive line), L (large) and S (small), with Pl still being responsive to stress-induced changes while L and S are stable, irrespective of the environment in which they are grown. The project will analyze and compare the DNA of various flax genotrophs, specifically Pl, L, S under different inducing conditions, to understand how genetic differences are stabilized across these lines. The primary research objective is to complete the DNA sequencing and genome assembly for each genotroph, and then identify genetic variations among them. By doing so, we can determine the specific genetic changes that occur in response to these environmental growth conditions.Therefore, flax can be used as a model system to determine the extent to which a single variety can adapt to varying growth conditions in short term. This study takes DNA extraction, PCR, electrophoresis, DNA sequencing, and genome assembly. Supplementary online databases and bioinformatics tools will also be utilized to help data analysis. The findings of this study have considerable agricultural and economic significance, both for flax and other important crop species. Understanding the genetic distinctions among flax genotrophs, and identifying genes that control the responses, may provide a pathway for rapidly adapting important crop species to be more resilient to extreme climates.

The Causes and Problems with Echo Chambers on Social Media Sites

Presenter - **David Gentile**

As social media usage increases in the United States, many politicians and people use online forums to discuss and debate hot topic political issues. However, as political social media discourse has increased, there has been a growing sentiment that the discussions are unhelpful and potentially dangerous for society because of the problems of online political discussion. A comprehensive narrative literature review was conducted to examine if social media reduces the amount of cross-party discussion and debate due to the formation of echo chambers and the ease of spreading misinformation. Literature on the topics was found using search engines such as Web of Science and Google Scholar, using search terms such as “Online Echo Chambers, Social Media Politics, and Social Media Policy.” Supporting literature found that there has been a decrease in cross-party collaboration on policies in U.S. legislation. Echo chambers inevitably form due to the effects of homophily and algorithmic learning, and this echo chamber forms both among average citizens and political figures. These echo chambers allow for the creation of strawman arguments, which leads to the spread of misinformation within these social circles, only reinforcing the beliefs of these echo chambers. This literature indicates that social media can lead to political groups who no longer talk across aisles, and that effort needs to be made to reduce the impact and number of echo chambers that are in effect on social media sites.

Characterizing the Rescue of Neurological Deficits in Fascin Overexpression-5xFAD Mice

Pallavi Ghosh, Department of Neuroscience, CWRU; Sabina Bhatta, PhD, Department of Pathology, CWRU School of Medicine

Mitochondria are integral to cellular metabolism and consequently play an important role in function and survival of cells, especially neurons that have a particularly high energetic demand. Mitochondrial dysfunction has been investigated for its role in the progression of Alzheimer's Disease (AD), which is a progressive neurological dementia characterized by a decline in memory, thinking, and behavior. Fascin, an actin-bundling protein, has been shown to promote mitochondrial oxidative phosphorylation and metabolic stress resistance in cancer cells. Furthermore, loss of Fascin has been demonstrated to cause mitochondrial dysfunction via mtDNA leakage into the cytoplasm and ultimately result in deleterious cellular response. Interestingly, previous work in the lab found that levels of Fascin expression was notably reduced in patients with AD, suggesting that the loss of Fascin may play a role in promoting mitochondrial dysfunction in AD. Therefore, this study aims to investigate the brain tissues of mice with genotypes of Fascin overexpression (OE), 5xFAD (Alzheimer's mouse model with five familial AD-linked mutations), Fascin OE crossed with 5xFAD, and wild-type (WT) controls using immunohistochemistry. We aim to determine 1) if Fascin overexpression confers protection from mtDNA disturbance and cytosolic leakage in the brain, and 2) whether Fascin overexpression leads to the rescue of pathological factors present in AD (oxidative stress [4HNE], and neuroinflammation [GFAP for astrocytosis, Iba1 for microgliosis, Caspase-1 p10 for inflammasome]) in AD model neurons.

Project Mentor(s): Dr. Xiongwei Zhu, Department of Pathology, CWRU School of Medicine; Dr. Jon Niemi, Department of Neurosciences, CWRU School of Medicine

Specific root length responses of Rhododendron spp. to water availability and the soil pathogen P. cinnamomi

Nathan Gilbert, CWRU Department of Biology

Soil biotic communities have many effects on plant health, including through soil pathogens. It is known that tolerance to soil pathogen Phytophthora cinnamomi is variable within the genus Rhododendron, even between species in the same clade. However, it is unknown which traits confer tolerance of P. cinnamomi to Rhododendron species, and whether these traits are influenced by water availability. This study will use a factorial greenhouse design across eight species of taxonomically paired Rhododendron grown with and without the pathogen and with high and low watering treatments to elucidate the effects of water availability on plant vulnerability and root responses to root rot. Specific root length (SRL) will be measured due to its indication of resource acquisition strategy. Because high SRL can indicate finer roots, we predict that plants with higher SRL will be less vulnerable to root rot due to partial escape from the pathogen (e.g. finer roots may avoid contact with the pathogen in the soil). Preliminary data has shown that both high water availability and P. cinnamomi absence significantly increased relative growth rates (RGR) of Rhododendron, but we found no significant interaction between watering and pathogen treatments on RGR. This might indicate that SRL will experience non-additive effects of water and pathogen treatments, although this will remain unclear until SRL is measured, because Rhododendron species are known to exhibit various degrees of root-shoot decoupling.

Project Mentor: Dr. Jean Burns, CWRU Department of Biology

Stress and Burnout in High-Performing Student Athletes

Alexandra Gioukaris; Honors in Psychology B.A. and Cognitive Science B.A. minor in Public Policy; Case Western Reserve University

Current research has introduced 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, the current body of research is not conclusive as to why such a correlation exists. Thus, our study focuses on exploring the potential causes of such underdiagnosis in this community. We hypothesize that the internal, external, and environmental stressors athletes face leads to disproportionate underdiagnosis of their mental health issues. This study hopes to utilize a self-report survey including academically-validated measures of depression (BDI), anxiety (GAD-7), disordered eating (EDE-Q), burnout (SMS), internalized stigma of mental illness (ISMI), alongside questions regarding coach and peer pressures that may be seen as a barrier to mental health care. The data will later be analyzed utilizing a MANOVA We expect to see a positive correlation between being a college athlete and increased psychopathology as measured by the above survey. We also expect to see a positive correlation between being a college athlete and pressure as a barrier to mental health care. We include a brief look at future studies looking to expand the population into other divisions of athletics.

Project Mentor: Dr. Jennifer Butler; Department of Psychological Sciences

Synthesis and Characterization of 2-Hydroxy-1-Phosphinoferrocene

Andrew Golden, Department of Chemistry, Case Western Reserve University

The compound 2-phosphinophenol is of interest due to its many unique physical properties. Included in those is the molecule's air stability and capability of forming benzoxaphospholes (BOPs). These BOPs have unique photophysical properties, allowing them to fluoresce in a variety of colors. They also possess unique three-dimensional shapes, such as the "taco" configuration of the benzoxadiphosphole (BDOP) molecule. The air stability of 2-phosphinophenol allowed its physical characteristics to be easily examined. Those of interest included the presence of four distinct conformational isomers in solution and solvent interactions with direct effect on the molecule's 31P NMR chemical shift. Both 2-phosphinophenol and BOPs possess a six-member aromatic ring as their backbone. It is predicted that the base molecule ferrocene can be used to create an analog to 2-phosphinophenol, called 2-hydroxy-1-phosphinoferrocene, that possesses a five-member aromatic ring rather than a six-member one. When 2-hydroxy-1-phosphinoferrocene is successfully synthesized, it can be tested for air stability, unique physical conformations, and as a precursor for a five member BDOP analog. The proposed BDOP analog could possess a similarly unique three-dimensional shape that would be aptly named the "taco bowl." This work details the current progress in the synthesis process for the development of this novel molecule. Several synthesis routes, both successful and unsuccessful, have been taken, each attempting to maximize the efficiency and safety of the reaction sequence. The current body of work does not yet include production of the desired compound; however, progress has been made in understanding the overall synthesis process. This has led to the conceptualization of new synthesis routes, that could lead to successful production of the desired compound in the future.

Faculty Mentor: Dr. John Protasiewicz, Department of Chemistry, Case Western Reserve University

Delineating the mechanism underlying XPC-mediated regulation of CDKN2A expression

Nihit Goli, Department of Biology, Case Western Reserve University; Vipin Shankar Chelakkot, PhD, Department of Cancer Biology, Lerner Research Institute, Cleveland Clinic; Joshua Arbesman, M.D, Department of Cancer Biology, Lerner Research Institute, Cleveland Clinic

Melanoma is a highly aggressive form of skin cancer originating in melanocytes. Despite improvements in early detection and treatment, melanoma continues to be a significant public health concern, underscoring the need for a better understanding of the molecular mechanisms to enhance therapeutic approaches. Loss-of-function of Xeroderma Pigmentosum Complementation Group-C (XPC), a protein required for nucleotide-excision repair (NER), has been implicated in melanoma development. It is suggested that the accumulation of mutations due to a lack of NER function results in melanomagenesis in patients carrying XPC loss-of-function mutations. However, this mechanism does not address melanomagenesis in non-sun-exposed regions. Previously, the Arbesman lab identified melanoma patients with XPC loss who did not show significant NER deficits compared to their unaffected parents. This suggested the existence of NER-independent melanomagenesis pathways. Further studies showed that mice carrying an XPC-loss-of-function variant did not show Cyclin-Dependent Kinase Inhibitor 2A (CDKN2A) expression in their melanocytes. CDKN2A encodes for two tumor suppressors, p16INK4a and p14ARF, critical for preventing melanomagenesis. Based on these, we investigated the relationship between XPC and CDKN2A expression in melanoma cell lines in this study. We modulated XPC levels in WM164 melanoma cells and monitored its effect on CDKN2A levels using western blot and flow cytometry. XPC downregulation decreased CDKN2A expression; however, upregulating XPC did not affect CDKN2A expression. This suggested that a certain threshold XPC level is required for CDKN2A expression. Our results identified a novel mechanism regulating CDKN2A expression in melanoma. Additionally, we identified a novel mechanism by which XPC loss could contribute to melanomagenesis, revealing potential molecular targets for developing therapeutic strategies for melanoma in the clinic.

Project mentor: Joshua Arbesman, M.D, Department of Cancer Biology, Lerner Research Institute, Cleveland Clinic

Faculty Sponsor: Dr. Ronald Oldfield, Department of Biology, Case Western Reserve University

Invisible Second Patients: Revealing Mental Health Disparities Among Informal Caregivers Impacted by COVID-19

Kaitlyn Gorodovich, Psychology, Medical Anthropology

Unpaid, informal caregivers (ICs) are widely known to have poorer mental health than non-caregivers. ICs are individuals who provide unpaid care and support (usually friends, family, relatives) to people who have a disability, mental illness, or those in need of care and assist with daily and medical needs. They are a vulnerable population at risk for increased experiences of high psychological distress, social isolation, and symptoms of depression and anxiety. Globally, the COVID-19 pandemic worsened symptoms due to lockdown, low assistance with care, and financial issues. More mental distress experienced by new ICs that emerged from the outbreak is exemplary of the changes experienced due to low accessibility to resources and adapting to a new norm of intensified caring. The purpose of this review is to highlight the COVID-19 pandemic exacerbating negative mental health effects on informal caregivers of older adults, revealing disparities across dimensions of gender, age, and race/ethnicities. Scholarly search engines such as Google Scholar, Web of Science, PsycINFO, PubMed were used along with key terms such as: informal caregivers, COVID-19, mental health, gender, age, race/ethnicity. Findings suggest that the COVID-19 pandemic has negatively impacted the mental health and wellbeing of ICs through intensified feelings of loneliness, social isolation, and psychological distress. Gender differences of higher distress in women were found. Age differences of older caregivers experiencing higher burdens with aging and younger caregivers experiencing burdens of dual caregiving were highlighted. Racial/ethnic minorities experiencing unique challenges of socioeconomic burdens were noted. Future research is needed to study the longitudinal impact of COVID-19 on informal caregivers and creating targeted support interventions to reduce disparities.

Faculty Mentor: Anastasia Dimitropoulos, Psychological Sciences

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

Filip Goshevski, Biomedical Engineering, Case Western Reserve University

Idiopathic pulmonary fibrosis (IPF) is a progressive and irreversible interstitial lung disease characterized by damage to the lung parenchyma and pulmonary dysfunction. While the disease is of unknown etiology, IPF onset involves abnormal activation of alveolar epithelial cells as a result of recurring epithelial injury. Treatment is limited to anti-inflammatory and immunomodulatory agents, which are unable to reverse the disease. The excessive collagen deposition during IPF is disrupted through TGFβ inhibition by prostaglandin E2. In disease conditions, however, 15-hydroxyprostaglandin dehydrogenase (15-PGDH) metabolizes PGE2, promoting disease progression. Previous studies have demonstrated the efficacy of a novel molecule, (+)SW033291, as a 15-PGDH inhibitor, increasing PGE2 levels. The pharmacological inhibition of 15-PGDH (15-PGDHi) reduces the severity of fibrotic lesions and improves pulmonary function in the bleomycin model. The clinical significance of the bleomycin model, due to the use of bleomycin as a chemotherapeutic drug, highlights the need for validating and expanding the model. Here, I aim to understand the cellular and molecular mediators of 15-PGDH inhibition in the bleomycin model using scRNAseq. I furthermore hope to characterize the hematopoietic niche pre- and post 15-PGDHi in IPF treatment and better define disease kinetics. Consequently, I aim to determine whether 15-PGDH is a negative regulator of pulmonary function following injury, and whether therapeutic targeting of 15-PGDH is a promising strategy to ameliorate lung injury following initiation of fibrotic disease.

Project Mentor: Amar Desai, Case Comprehensive Cancer Center

Implications of Remote Work and Social Isolation on Mental Health and Professional Relationships

Sonia Goya, Department of Psychological Sciences

Remote work was initially considered a privilege as it provided workers with greater autonomy over their work, due to COVID-19 and its lockdown regulations it became a necessity that continued past the end of the pandemic. Before the pandemic, remote work was limited by infrastructure and was only for higher level or specialized roles; but the pandemic accelerated adoption, with companies embracing remote models to get the benefits of flexibility, cost savings, and a broader talent pool (Choudhury, 2020). This narrative review explores how remote working, while offering flexibility and convenience, has intensified social isolation in adults by reducing in-person interactions, negatively impacting mental health and professional relationships. Scholarly databases including the National Institute of Health, American Psychological Association, and Encyclopedia Britannica were searched using keywords like "remote work," "social isolation," "telecommuting," and "workplace loneliness" to locate papers. According to the American Psychological Association, social isolation is when you have a reduction or absence of meaningful social connections which often leads to loneliness, anxiety, and depression (Novotney, 2019). Studies show that reduced social interaction in a remote work setting means employees miss out on informal conversations and are more likely to face mental health challenges (Galanti et al., 2021). Other studies that support this claim explore how remote work gives flexibility and convenience but requires deliberate strategies to maintain mental well-being and social connection (Figueiredo et al., 2024). Findings revealed that remote works intensification of social isolation can undermine mental health and professional relationships, emphasizing the importance of targeted interventions to support employee well-being.

Faculty Mentor: Anastasia Dimitropoulos, Psychological Sciences

Development of Compliant Feet for Bio-inspired Amphibious Robots

Jordan Gray, Engineering Physics BSE Candidate, Mechanical Engineering MS Candidate

This presentation highlights the progress in developing an innovative bio-inspired amphibious robot capable of navigating diverse terrain. The current work focuses on designing an adaptive foot for efficient locomotion on both land and water. Inspired by the biomechanics of a duck, we designed an adaptive foot for swimming in water capable of adjusting the force difference between the forward and backwards strokes. The proposed design utilizes a passive mechanism similar to an umbrella check valve, allowing water to flow through the foot during the forward stroke while providing resistance during the backward stroke. This concept design was evaluated using simulation models developed with ANSYS, and laboratory water tank testing with force sensors. Both the simulations and experiments confirmed the effectiveness in swimming locomotion for amphibious robots.

Project Mentor: Changyong (Chase) Cao, Mechanical Engineering

Devices for the Control of Airflow in Reedless Wind Instruments

Tyler Griffith, Aerospace Engineering, Case Western Reserve University

The objective of this project is to provide a design, prototype and comparison of the effectiveness of devices which can be used to supply controllable airflow to reedless wind instruments to be used in future studies for the mapping of the flow variables and the musical variables of the instrument. To this end, two designs have been prototyped: A pulse width modulation fan and funnel system with flow straightener, and aperture - and a lung/tongue inspired piston/cylinder, funnel, and aperture device with a linear actuator, and one way valve.

To prototype these devices, this project makes use of SolidWorks, a 3D printer, bought parts, and miscellaneous resources provided by Dr Taylor. These devices will both be capable of creating musical notes on a recorder or ocarina with some level of defined variation. The fan/funnel device implements variable fan speed at full torque, and the piston/cylinder device implements variable flow rate through the motion of the piston. Both devices will have variable flow acceleration with a simple aperture.

Audio recordings taken with the set up described in this report were used to obtain volume versus time and frequency content data for sounds produced by these devices which will be the basis for further research into the empirical mapping of input flow to sound output for reedless wind instruments. Based on these initial data and how each device allows the operator to traverse the space of audio outputs, this report provides a detailed comparison of the efficacy and limitations of each design for the intended purpose of creating a repeatable, controllable, and quantifiable airflow input to reedless wind instruments.

Project Mentor: Dr Brian Taylor, Department of Mechanical and Aerospace Engineering Case Western Reserve University

Machine Learning Quantification of EEG Data from Rat Models of Focal Cortical Dysplasia.

Palki Gupta, Case Western Reserve University; Ashley Nemes, Department of Neuroscience, School of Medicine; Imad Najm, Epilepsy Center, Cleveland Clinic; Balu Krishnan, Epilepsy Center, Cleveland Clinic

Analysis of electroencephalography (EEG) is vital when studying epilepsy and recent developments in machine learning algorithms have paved the way for efficient, automatic analysis of mass amounts of EEG data. The analysis of human EEG has proved incredibly fruitful, yet there is a gap of knowledge for rodent EEG despite their widespread use in research. The movement artifact and difference in ictal patterns require a program that is more specific to rodent EEG. A common model of Focal Cortical Dysplasia, a type of medically refractory epilepsy, is the irradiated rat model where seizures are induced using Pentylenetetrazole (PTZ). This research aims to design a machine learning algorithm to analyze EEG data with patterns associated with the PTZ/ irradiated rat model. This program will automatically mark spike and seizure patterns to be reviewed by an epileptologist. The machine learning model is based upon previously collected data that has been reviewed by epileptologists. This data includes true ictal patterns as well as artifact and allows the model to learn how to distinguish between them. This algorithm will help move away from manual analysis of EEG towards more automated methods promoting research with these models. In the future, this program may be expanded to include other models of epilepsy to help contribute to analysis.

Project Mentor: Dr. Ashley Nemes, Department of Neuroscience, Case School of Medicine

Faculty Sponsor: Dr. Ashley Nemes, Department of Neuroscience, Case School of Medicine

Intraoperative EEG and Postoperative Delirium in Cardiac Surgery Patients

Rishya Gutti, Biology, Case Western Reserve University; Sana Sheikh, Dalhousie University; Pryce Panchur, Biology, Case Western Reserve University; Alexander Yin, Biology, Case Western Reserve University

Anecdotal data suggest that the use of electroencephalogram (EEG) may be a useful technique in the prediction of postoperative delirium (POD) in patients undergoing general surgery. We systematically reviewed the literature to evaluate whether intraoperative EEG may be useful in the prediction of postoperative delirium in those undergoing cardiac surgery. A systematic search was conducted using MEDLINE (via ovid), PsycInfo, CENTRAL, Embase, and Google scholar. Search terms consisted of keywords including cardiac surgery, electroencephalography and delirium. Four independent reviewers assessed studies based on eligibility criteria and extracted data on the efficacy of intraoperative EEG, the outcomes and study characteristics relevant to the demographics, length of hospital stay, days spent in the ICU, and type of cardiac procedure. A total of 1448 articles were reviewed, of which 21 fulfilled the inclusion criteria. Of those, 18 had found that intraoperative EEG was useful in predicting POD while 3 studies determined its inefficacy to predict and/or reduce the incidence of POD in patients undergoing cardiac surgery. Given the number of studies reviewed, it is suggested that intraoperative EEG modalities may be useful in early detection of postoperative delirium in patients undergoing cardiac surgery. In terms of future directions of research, these modalities may be used to more accurately predict POD based upon EEG patterns observed. Furthermore, POD incidence could be studied in not only cardiac surgery, but in other surgeries of various systems and how EEG patterns change or remain the same in predicting POD incidence. Some limitations of this study were that there was not a large amount of literature found surrounding the topic due to the novel nature of the research.

PI: Dr. Mohammed El Diasty, Medicine, UH Hospitals

A Multi-Sample Prostate Core Needle Biopsy System

Esmeralda Qiang[1], Octavio Guzman[1], Jube Augustino[1], Jennifer D'Silva[1]

[1]Department of Biomedical Engineering, Case Western Reserve University

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. Currently, there are several types of prostate cancer biopsies such as Fusion-Guided biopsy, Transperineal biopsy, etc. Existing systems, however, only collect one sample per insertion, making the overall procedure inefficient and causing great discomfort, bleeding, and risk of infection to the patient. None of these existing systems allow for taking more than 1 sample per insertion. Hence the urologist makes minimum 24 insertions to get the required samples causing discomfort to the patient and bleeding at the biopsy site, urine, and semen. To address this issue, we are designing a multi-sample needle biopsy system. This system entails a shuttle-like mechanism with two needles, outer and inner needles, and a storage cartridge. 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 diagnostic efficiency, and minimizing post-procedural pain & discomfort.

Project Mentors: Dr Colin Drummond[1], Dr. Jonathan Shoag[2] , 1- Department of Biomedical Engineering, Case Western Reserve University, 2- University Hospitals, Case Comprehensive Cancer Center

English Band Importance Functions for Spanish second-language learners of English

Sofia Hall[1], Emily Buss[2], Lauren Calandruccio[1]

[1]Department of Psychological Sciences, Case Western Reserve University

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Listening to and recognizing speech can be a natural and easy process. However, it can be much more challenging if the listener has hearing loss or if there is background noise. These listening challenges become more exaggerated if the person is listening to speech spoken in their second language. When people listen to degraded speech signals, certain spectral regions of the speech stimuli are more important than others for recognition. We can measure the importance of the regions through "spectral weights" where a higher weight indicates that the loss of the spectral information within that region is more detrimental to speech recognition than spectral content with a lower weight. Spectral weights for native English speakers is well researched whereas little is known about spectral weights for people listening in their second language. The purpose of this study is to determine how spectral weights for Spanish speaking second-language learners of English compare to spectral weights measured for monolingual English speakers for a speech-in-speech recognition task. Data from this experiment for a group of Spanish/English bilinguals and a group of monolingual English speakers will be presented. Preliminary analyses indicate similar spectral weighting functions between groups of listeners.

Project Mentor: Lauren Calandruccio, Department of Psychological Sciences, Case Western Reserve University

Vetero

Jenny Guerrero[1], Ethan Hansen[1], Mariam Hassan[1], Nabaa Khan[2], Valentina Nova[1]

1. B.S. Computer Science, Case Western Reserve University
2. B.A. Computer Science, Case Western Reserve University

Vetero is a weather-based clothing recommendation web app. In order to achieve outfit recommendations that are individually tailored to each user's preferences, a myriad of customization options are provided. These include daily start time, daily end time, location, and threshold for precipitation tolerance. Each item of clothing the user adds tracks that item's "heat points", number of clothes available currently, total number of that type of clothing in their wardrobe, whether that item of clothing is waterproof, and whether that item of clothing must be washed each time it is used. The "heat points" are combined with the day's average temperature and the user's comfort temperature to suggest an outfit to wear each day, also taking into account precipitation on days when it's relevant. Each day, the user is prompted to provide feedback on the previous day's recommendation, and that feedback is fed into the learning algorithm for improved future recommendations. Vetero's backend is written in V using the built-in "veb" web framework and no external libraries. The frontend is written in JavaScript, utilizing the Vue framework. In order to connect the frontend and backend, we created our own REST api. We use V's built-in ORM to set up and manage an SQLite database, allowing for simpler interfacing between our V structs and the data stored in the database. Weather information is provided by the National Weather Service. All of our work is open source and licensed under the MIT license, freely available on GitLab.

Faculty Mentor: Dr. Shuai Xu; Department of Computer and Data Science

Observing The Variation in Propagation of 10-Meter RF Signals

Jared Hausman, Department of Electrical, Computer, and Systems Engineering; David Kazdan, Department of Electrical, Computer, and Systems Engineering; CWRU Amateur Radio Club, Case Western Reserve University

Radio Frequency Signals on the 10-meter frequency band are high-frequency signals used for long range communication in amateur radio. The 10-meter band spans from 28.0 MHz to 29.7 MHz. These signals propagate long distances by reflecting off of the ionosphere. This causes the propagation of 10-meter signals to be affected by the time of day. The ionosphere is energized by the high-energy ultraviolet radiation from the sun. This means that the charge density of the ionosphere varies throughout the day as the sun rises and sets, thus affecting the distance RF signals' ability to travel during the day. The sun also goes through a solar cycle, which affects the intensity of the radiation emitted. The purpose of this project is to observe the variations in propagation of these high-frequency signals, and present visual displays to showcase these variations. A beaconing system broadcasted using WSPR protocol on the 10-meter band with a transmit power of 5 watts. The receptions of this system are collected over six weeks, along with distance, direction, and time of day. This data will be presented geographically, through time, and analyzed using different statistical methods to thoroughly showcase the variations influenced by variables such as the solar cycle and time of day.

Project Mentor: Professor Greg Lee, ECSE Department

Predictive Factors for Treatment Engagement in Individuals with Psychosis

Jolie Held, double major in psychology and cognitive science, CWRU

Rates of treatment engagement for individuals with psychotic disorders has proven to be alarmingly low, considering the seriousness and persistence of symptoms (Fontanella et al., 2013). Prior research has shown that low cognitive functioning, often measured by IQ, is a good predictor of treatment engagement, while also impacting an individual's global functioning (Leeson et al., 2009). Additionally, certain at-risk, disadvantaged populations are less likely to engage in treatment because of an increase of barriers in accessing quality treatment (Fontanella et al., 2013). Thus, it is imperative to understand what variables impact treatment engagement.

Using previously collected data from Case Western Reserve University's Clinical Neuroscience Lab, this study tested three key hypotheses: 1) Higher IQ will correlate with higher rates of treatment engagement in patients with psychotic disorders (higher number of appointments scheduled and higher rates of adherence), but this relationship will be negatively mediated by treatment barriers such as internet access, stigma, affordability, fear of hospitalization, etc.; 2) Psychosis symptom severity will serve as a moderating variable in the positive correlation between IQ and treatment engagement; 3) Demographic variables such as income level, race, education, and employment status, which may label someone as disadvantaged, will correlate with more treatment barriers. While preliminary results did not show a significant correlation between IQ and treatment engagement, and there were no mediating or moderating effects, being diagnosed with an affective psychotic disorder increased the occurrence of treatment barriers ($p = .012$). In a further exploratory hypothesis to look across symptom profiles, we find a significant positive correlation between appointments scheduled and symptoms of anxiety and depression ($p = .038$), and a significant negative relationship of hostility and treatment adherence ($p = .025$).

Project Mentor: Sarah Hope Linkcoln (CWRU Department of Psychology), Madeline Ward (CWRU Department of Psychology)

Vein Finding Device using Infrared Imaging and Processing

Kyle Heston, Electrical Engineering, Case Western Reserve University
Siddharth Balakrishnan, Computer Engineering, Case Western Reserve University **Jarvis Chen**, Electrical Engineering, Case Western Reserve University

This project presents a system design for a vein visualization device that uses infrared imaging, processing, and projection to enhance venous access in clinical settings. The system leverages a Raspberry Pi, an infrared (IR) camera, and an IR flashlight to capture real-time images of a patient's hand or arm, targeting areas where veins are typically accessed. The IR camera, connected to the Raspberry Pi, acquires high-contrast images of subcutaneous veins illuminated by the IR flashlight. Image processing is carried out on the Raspberry Pi using Python's OpenCV libraries to filter the IR light in veins, enhance vein contrast, and create a clear vein map. Once processed, this map is sent to a Texas Instruments DLPDLCR230NPEVM projector board, connected via the Raspberry Pi's GPIO pins. The projector then overlays the vein map back onto the patient's skin, providing a live, precise guide for clinicians. This approach demonstrates a cost-effective, portable solution for improving accuracy in venous access, reducing patient discomfort, and potentially lowering failure rates in procedures requiring vein localization.

Advisor: Xin Yu, Department of Biomedical Engineering, Case Western Reserve University

Autonomous Exploration and 3D Mapping System in Enclosed Environments

Tiancheng Pu, Electrical Engineering, Case Western Reserve University

Zifei Hong, Electrical Engineering, Case Western Reserve University

Xiaorong Wang, Electrical Engineering, Case Western Reserve University

This project aims to develop an autonomous robotic platform for exploration and 3D mapping in enclosed environments. Equipped with a 2D laser scan sensor and controlled by an Arduino microcontroller, the robot will independently navigate and gather spatial data. The main objectives for this semester are to construct a fully operational hardware platform, establish stable communication between components, achieve automatic obstacle avoidance, implement basic data processing, and ensure the platform functions consistently under real-world conditions. Achieving these goals will lay the groundwork for future enhancements, including advanced SLAM (Simultaneous Localization and Mapping) algorithms and complex data management.

Project Mentor: Peng (Edward) Wang, Associate Professor, Mechanical and Aerospace Engineering

Medication Management for Polypharmacy Patients

Siddharth Balakrishnan[1], **Keren Hu**[1], **Atreya Sridharan**[1], **Angela Tsang**[1]

[1] 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.

Project Mentor: Professor Matthew Williams, Department of Biomedical Engineering

MOHRA: Machined Open-source Humanoid Robot Architecture

Ian Dyke, Mechanical Engineering, CWRU, and **Joshua Huang**, Mechanical Engineering, CWRU

Humanoid robots are emerging from R&D labs and early-stage companies with the hope of one day assisting us in the home or on the manufacturing floor. These developments have largely occurred behind closed doors, keeping advancement internal to specialized labs and the private sector. To gain insight into the utility of humanoids, these research teams and companies are evaluating their particular designs' capabilities in various applications. However, the limited options, lack of customization, and high upfront costs of these products hinders such exploration. Opening up development to the growing ecosystem of accessible manufacturing and cooperative engineering ("makers") allows more individuals to participate in humanoid design and implementation. Enabling broader input will deepen understanding of the mechanical and control requirements of humanoids, raising technical awareness of the challenges associated with designing humanoids and supporting new solutions that advance the field.

We are working with K-Scale Labs to accelerate and open-source a novel humanoid robot design that anyone can build and iterate upon. Our project explores the feasibility of designing a Machined Open-Source Humanoid Robot Architecture (MOHRA) with a focus on efficient weight distribution, machinability, cost, and performance. Our design is assessed in a physics simulation environment where the humanoid demonstrates stable standing postures and walking gaits and is trained with proximal policy optimization (PPO). MOHRA is a step toward making progress in humanoids more transparent, accessible, and customizable.

Faculty Sponsor: Dr. Stephen Hostler, Mechanical and Aerospace Engineering, CWRU

Project Sponsor: Ben Bolte, Founder, K-Scale Labs

TouchGrass: Social Media App to Connect Friends via Photos

Abhimanyu Bangaru[1], Ethan Fang[1], Jacob Huber[1], Vinay Kancharla[1], Rithvik Kasarla[1], Jackson Schuetzle[1], Jesse Silverberg[1]
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TouchGrass is a mobile application designed to route photos to the appropriate people, leveraging software engineering, machine learning and facial recognition techniques. Suppose one goes on a group trip with many friends, and during the trip they take a large quantity of photos together. After the trip, everyone would likely send their photos in a group chat. However, this introduces an issue for the friends: the chat can be flooded with hundreds of photos, forcing them to sift through each one, many of which they may not be. TouchGrass aims to alleviate this problem. Instead of wasting time going through each photo in the sea of group texts, TouchGrass ensures that each person gets only the photos they need. When a user uploads photos into the application, TouchGrass routes each photo to the appropriate people in the photo using facial recognition technology. Users in the photos are able to accept or decline the photos from within the application. Accepting a photo downloads it to the user's camera roll. This process ensures that people only have to sift through the photos that they are in. In addition, the mobile application contains gamifying features that encourages users to go outside and connect with their friends and colleagues. Each user has a public score that increases whenever they upload photos to the application or are featured in a photo uploaded by another user. The application also features a leaderboard of each user's friends with the highest scores. TouchGrass is intended for use on iOS mobile devices.

Project Mentor: Shuai Xu, Assistant Professor, Computer and Data Sciences Department

Age-dependent methionine sulfoxide speciation in actin and calmodulin reveal dynamic conformation changes in mouse brain proteins

Jiwoo Hwang, Applied Mathematics, BS & minors in Biology, Chemistry, and Computer Science, College of Arts and Sciences

Reactive oxygen species (ROS) have traditionally been viewed as toxic byproducts of metabolism, leading to non-specific cellular damage. Proteins, particularly through their methionine residues, are susceptible to ROS-induced oxidation, reflecting the biology of oxidative stress. However, recent evidence suggests that a select subset of methionine oxidation(MSox) may function as targeted regulatory mechanisms to modulate protein activity in response to redox changes. Methionine oxidation can be enzymatically reversed by the methionine sulfoxide reductase (Msr) enzyme family. For instance, in calmodulin, Met 77 oxidation by MsrA occurs selectively in a calcium-bound state, while actin is oxidized at Met44 by the enzyme MICAL and reduced by SelR.

This study investigates actin and calmodulin in the context of methionine oxidation within the mouse hippocampus as a function of age (at 3, 6, and 9 months) and Alzheimer's disease(AD), which are known to be linked to ROS pathology. Results indicate age-dependent variability in MSox at specific methionine sites. In actin, MSox at Met 44 and Met 47 in the D-loop decreased from 3 to 6 months, then increased at 9 months, whereas Met 269 in the H-loop remained stable. In calmodulin, MSox at Met 77 in the linker region consistently increased with age, while Met 145 and Met 146 demonstrated a continuous decline. These findings highlight dynamic, age-related methionine oxidation patterns in actin and calmodulin within the mouse hippocampus, revealing conformational adjustments in response to aging rather than AD progression.

Project Mentor: Dr. Mark Chance, Case Center for Proteomics and Bioinformatics, Department of Nutrition, School of Medicine

Identifying scFv Targeting LANA Using Phage Display Screening

Taehyeong I, Biology, Case Western Reserve University

Kaposi sarcoma-associated herpesvirus (KSHV) is a gamma herpesvirus essential to the pathogenesis of Kaposi sarcoma (KS) and other associated diseases such as, primary effusion lymphoma (PEL), and multicentric Castleman disease (MCD). Understanding the mechanisms of KSHV is important due to its prevalence as a major health burden in regions of Africa. The latency-associated nuclear antigen (LANA) protein plays a crucial role in KSHV latency by tethering viral episomes to host chromatin, thereby sustaining viral persistence and contributing to oncogenesis. Recent research has identified specific immunogenic peptides within the LANA middle region, near the C-terminal domain, as promising targets for immune detection. For the immune detection, this study utilizes a single-chain variable fragment (scFv) phage display library derived from the RNA of KS patient's blood. The scFv is the small derivative of the antibody or immunoglobulin on the tip of the protein that is responsible for specific binding to the target antigen. The scFv has been utilized in antibody-based therapy due to its relatively low immunogenicity and more effective tissue penetration while maintaining high binding affinity to the antigen. Therefore, this study aims to single-chain variable fragment (scFv) phage display library to identify antibodies that can selectively bind these LANA peptides potentially impairing KSHV's ability to maintain latency. 4 rounds of biopanning process on the scFv-displayed phage library is performed followed by the polyclonal and monoclonal Enzyme-linked Immunosorbent Assay (ELISA).

Project Mentor: Jae Jung, Cleveland Clinic, Cancer Biology; Valerie Haywood, Biology

Effects of Fuel Vibration on Limiting Oxygen Concentration at Low Pressures

Kuper Imrem, Mick Bastuga, Mechanical and Aerospace Engineering

This study investigates the impact of linear oscillations on the Limiting Oxygen Concentration (LOC) required for flame spread in cellulosic fuels under low-pressure conditions. The objective is to determine the LOC threshold, below which flame propagation ceases, for samples at two pressure levels and two vibration frequencies. Experiments will be conducted using a Hitchhiker apparatus at the NASA Glenn Research Center's Zero Gravity Facility in Cleveland, Ohio. The apparatus, originally designed for a Blue Origin suborbital flight, was adapted for 1g conditions to study the effects of vibration on combustion. It has since been modified to be dropped and operate in a microgravity environment. The experimental setup employs a Raspberry Pi Zero W and a Raspberry Pi Camera module for real-time data collection and imaging, capturing the combustion process. Subsequent data and image analysis to assess flame spread characteristics, offering valuable insights into the behavior of flames in microgravity, low-pressure environments. The findings are expected to enhance understanding of material flammability in space settings, contributing to improved fire safety protocols for future missions.

Advisors: Dr. Steven Hostler (CWRU), Dr. Vedha Nayagam (CWRU/NASA), Dr. Daniel L. Dietrich (NASA), Timothy Krause (NASA)

Substance Use and Loneliness Over the Course of the COVID-19 Pandemic

Anna Isberg, Psychology, Biology

Many theories have been proposed in an attempt to identify the motivations underlying substance use. Two such theories posit that substance use functions as a maladaptive coping mechanism and that substance use is utilized as a means to catalyze social interactions. In the context of loneliness, these theories may result in opposing outcomes, as some individuals may use substances in a solitary manner to cope with loneliness, while others may engage in substance use to increase social interactions and feel less lonely as a result. The COVID-19 pandemic resulted in drastic increases in chronic loneliness. The purpose of this comprehensive narrative review was to examine studies conducted both during and since the acute phase of the pandemic to examine whether loneliness differentially impacts substance use trends depending on whether use functions as a maladaptive coping mechanism or as a means of facilitating social interactions. Literature was identified using the Web of Science and Google Scholar databases with keywords such as substance use, loneliness, COVID-19, and lockdown. Collectively, while many studies elucidated direct relationships between substance use and loneliness, others found more complex patterns, such that the use of certain substances that are more commonly used in a social manner decreased as pandemic-related loneliness increased. Additionally, several articles reported increases in substance use throughout the pandemic and the maintenance of increased levels of use after the acute stage of lockdown irrespective of loneliness levels, which poses a significant public health burden. These findings provide crucial insight into the effects of the pandemic on the substance use crisis, and necessitate consideration in the development of post-pandemic interventions.

Faculty Mentor: Anastasia Dimitropoulos, Psychological Sciences

Exploring Pacemaker Incidence and Dependency Long-term in Patients post-TAVR Procedure

Aliza Jalani, Department of Biology, CWRU

Aortic stenosis (AS) is a progressive disease of the heart's aortic valve, which pumps blood throughout the whole body. Narrowing of the valve due to calcium buildup or scarring restricts blood flow. Transcatheter aortic valve replacement (TAVR) is a minimally invasive catheter-based procedure designed to treat severe or critical AS. The TAVR implantation procedure minimizes invasiveness and reduces recovery time, however, some risks are still present. New onset heart conduction abnormalities can result in permanent pacemaker implantation post-TAVR. A pacemaker dependent patient cannot function without a pacemaker, so it is important to assess the long-term effects TAVR has on pacemaker dependency. This retrospective analysis study aims to determine pre-procedure patient characteristics that may predict post-TAVR pacemaker dependency, incidence of pacemaker dependency at 6 months and 1-year post-procedure, and whether valve type plays a role in pacemaker dependency. By collecting clinical data from University Hospitals on patient demographics and medical history (heart rate/rhythm, COPD, diabetes mellitus, hypertension, concomitant mitral valve disease, coronary artery disease, prior cardiac surgery, BMI, and valve prosthesis implanted), descriptive statistics will be utilized to evaluate pacemaker dependency at 6 months and 1 year using a 1 year Kaplan-Meier curve. Logistic regression analysis will be used to determine if patient characteristics or type of valve implanted affects dependency on pacemaker. Statistical analysis will include percentages of individuals requiring pacemaker post-operation and subsequent dependency at 6 months and 1 year. This study will offer valuable insight into long-term clinical outcomes resulting from the TAVR procedure.

Project Mentor: Dr. Nicole Crown, Department of Biology, CWRU

Principal Investigator: Dr. Gregory Rushing, Department of Cardiac Surgery, UH

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

The central jugular vein is located in the neck beneath the sternocleidomastoid muscle and has a direct connection to the heart via the superior vena cava. In a clinical environment, the pressure measurement from the internal jugular vein can be used to predict cardiac distress. The most prevalent current noninvasive method for measuring jugular venous pressure includes a visual examination performed using two rulers. The placement of these rulers allows clinicians to determine the vertical height of the venous column, providing the mean jugular venous pressure in cm of H_2O. The main challenges with this method are time sensitivity and accuracy. It takes time to properly position the patient, but is also subjective, as the physician determines the angle of the rulers and the location of the vein, which can be inaccurate in a time-sensitive situation. 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. The horizontal component incorporates an LED vein finder and rod to properly locate the top of the jugular vein, and an electronic level to hold this component parallel to the ground. 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, 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; Dr. Jayakumar Sahadevan, Department of Medicine, CWRU

Continuing stigma towards people suffering from HIV/AIDS and the governmental implementation of unbiased healthcare policies in China.

Haozheng Jiang, Anthropology, college of arts and sciences

This research explores the ongoing stigmatization and discriminatory attitudes toward individuals living with HIV/AIDS in China, assessing the effectiveness of government healthcare policies. The researcher employed a secondary research methodology, utilizing data from previous literature, including governmental reports, academic journal articles, official government websites, and WHO reports. The qualitative data collected revealed significant gaps in prior research regarding the intersectionality of the issue and its disproportionate impact on vulnerable communities.

The findings are presented thematically, focusing on four major areas: the factors contributing to cultural stigma and misconceptions, the role of healthcare institutions, an evaluation of the effectiveness of Chinese governmental policies, and potential recommendations for improvement. The study indicates that government policies should promote uniformity to eliminate the differential treatment of HIV-positive individuals.

Given the diversity within Chinese society, the analysis suggests that varying perspectives have contributed to the rise of discrimination and stigmatization related to HIV/AIDS. The research has some limitations; for example, it relied solely on secondary data and evaluated the situation at a national level rather than examining specific regions within China. Future researchers could address these limitations by utilizing primary data collection methods and focusing on particular areas of China to gain a more in-depth understanding of the issue.n be stopped. Given the wide diversity of Chinese society, it is analyzed that diverse viewpoints have contributed to the rise of HIV/AIDS-related discrimination and stigmatization. The present research has some limitations; for example, it did not use primary data and focused only on the national level rather than on different Chinese regions. Future research scholars can address these limitations by choosing primary data collection methods over secondary ones and choosing specific areas from China to understand the situation closely.

Mentor: Lihong Shi ,Anthropology, college of arts and sciences

Comparison of C8, C18, and HILIC stationary phase coverage of metabolites for vaginal mucosal metabolome profiling and biomarker discovery

Ariele Jinich[1, 2], Sausan Azzam, PhD[2], Riley Eckert[2], Adam Burgener, PhD[2]

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Mucosal specimens collected from the female genital tract is a 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. The primary approach to metabolome mapping is through untargeted metabolomics approaches, using high performance liquid chromatography (HPLC) coupled to mass spectrometry (MS). Metabolite identification by LC-MS is influenced by the type of chromatographic separation approach. This project aims to evaluate three different chromatographic column types including reversed-phase (RP), hydrophilic (HILIC) and RP (C8) to separate metabolites and then compare their coverage.

A representative pooled vaginal mucosal sample collected from 90 women was selected for this analysis, with 6 technical replicates. Comparison between columns was based on net metabolite output via LC-MS/MS from columns. Data was processed using Compound Discoverer, and functions were annotated using KEGG and PubChem databases.

We identified a number of significant metabolites (C8: 166; C18: 163; HILIC: 93). Upon comparison, metabolites unique to each column were identified (131; C8: 55, 21.40%; C18: 44, 17.12%; HILIC: 32, 12.45%). Several metabolites identified through the C8 and HILIC columns are characterized as lipids (8, 6%), and are involved in biological processes associated with cancer, including ABC transport and tumor formation. Other identified metabolites showed involvement in immune and inflammation pathways, including central carbon metabolism and the mTOR signaling pathway.

Given the identified fatty acid and lipid metabolites with C8 and HILIC were not seen on C18, this approach may allow for increased coverage of the metabolome in mucosal samples for biomarker discovery. Further validation of this observation is warranted with a larger sample size.

Project Mentor: Dr. Sausan Azzam, Center for Global Health and Disease, CWRU
PI: Dr. Adam Burgener, Center for Global Health and Disease, CWRU

The effect of deletion of one subunit of RNA polymerase 1 on nucleolar structure in Saccharomyces cerevisiae

Anna Johnson, Department of Biology; **Isabella Torres,** Department of Biochemistry; Alyson Yuen, Department of Biology

The nucleolus plays a crucial role in ribosomal RNA (rRNA) production and ribosome assembly, but the details of its organization are still not fully understood. This study aimed to examine changes in the integrity of the nucleolus when rRNA synthesis is halted. We examined Saccharomyces cerevisiae cells lacking Rpa12, a subunit of RNA Polymerase I. When Rpa12 is absent, these cells grow normally at room temperature, but when exposed to 35°C, they stop producing rRNA and halt growth. This temperature-sensitive response allows us to explore the organization of nucleolar proteins when rRNA is not being synthesized. We focused on three groups of nucleolar proteins: proteins directly linked to rDNA (e.g., Hmo1 and Rrn proteins), snoRNPs (Nop1, Gar1, Sik1), and several assembly factors (Utp15, Mak11). By tagging these proteins with GFP, we track their localization at higher temperatures to see which proteins stay in place or get released. To help with this, we used cells expressing Sik1-mRFP, which forms MNBs (mini nucleolar bodies) when released. We also tested whether MNBs intermix fully with chromatin by studying cells in which the nucleolar proteins are tagged with GFP and histones are tagged with a red fluorophore. Our observations suggest that the nucleolar proteins do not intermix with chromatin. This study may offer new insights into nucleolar dynamics, helping us understand how the nucleolus stays intact.

Project Mentor: Dr. Sarah Bagby, Department of Biology

Principal Investigator: Dr. Alan Tartakoff, Department of Pathology

Race, Gender, And Intersectionality: Unpacking How Identities Influence Mental Health Inequities And Outcomes

Arielle Johnson, Psychology, Medical Anthropology, Case Western Reserve University

Research has consistently shown disparities in mental health care access, treatment, diagnosis, and psychological outcomes for marginalized communities. Still, much less focus has been dedicated to examining the compounding effect multiple marginalized identities have on how individuals interact with our medical system. This literature review examined how intersectionality lends itself to exploring how social factors, such as race and gender, impact these disparities. Databases such as Google Scholar, Web of Science, and PsychINFO were searched using key terms such as “psychiatric diagnosis,” “disparity, “disparity in mental health outcomes," intersectionality,” and “the black-white mental health paradox.” Studies included in this study had to be done within the US or on US participants due to our specific cultural context of race and gender views. Research reviewed has demonstrated that Black people were more likely to be diagnosed with schizophrenia instead of other mood disorders compared to white people presenting with similar symptoms. Gender further complicates this symptom presentation with a diagnosis and treatment gap, with women being about 2 times more likely to receive an anxiety dialogis. However, men are steered toward medication over other interventions, potentially due to biased decision-making on behalf of our medical system. When combined, the intersectionality of both race and gender further exacerbates these biases and uniquely disadvantages individuals with multiple marginalized identities. These results demonstrated that people with multiple marginalized identities face lower disparities in diagnosis treatment and increased adverse psychological outcomes than their counterparts.

Project Mentor: Dr. Dimitropoulos, PhD, Department of Psychological Sciences

Comparative Analysis of Sepsis in Neonatal and Pediatric Intensive Care Units

Nikhila Juluri, Department of Computer Science, Case Western Reserve University; Department of Neuroscience, Case Western Reserve University

Sepsis remains a leading cause of morbidity and mortality in neonatal and pediatric intensive care units (NICU and PICU), driven by dysregulated immune responses to infection resulting in 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, age-specific management strategies. This study aimed to address critical knowledge gaps by examining and comparing the epidemiology, pathophysiology, clinical manifestations, and treatment responses of sepsis in NICU and PICU populations.

A retrospective review of electronic health records from University Hospitals spanning January 1, 2015, to September 30, 2023, was conducted to identify patients with microbiologically confirmed sepsis. Inclusion criteria were admission to the NICU or PICU with a gestational age ≥32 weeks and age ≤6 months. Patients born at gestational ages <32 weeks were excluded. De-identified data were stored in a REDCap database, with variables including patient demographics, comorbidities, clinical presentations, microbiological profiles, therapeutic interventions, and outcomes such as length of hospital stay, morbidity, and mortality.

This study aims to delineate age-specific differences and shared characteristics in sepsis management between neonatal and pediatric cohorts to inform the development of more precise diagnostic and therapeutic strategies. Insights from this analysis have the potential to refine intensive care protocols, addressing critical areas for improvement and optimizing outcomes for critically ill neonates and pediatric patients. Findings will contribute to the advancement of evidence-based sepsis care tailored to the unique needs of NICU and PICU populations.

Project Mentor: Dr. Kenneth Remy, MD, FCCM, Division of Pediatric Critical Care Medicine (Case Western Reserve University School of Medicine, and University Hospitals)

Differential Gene Expression Profiling of HIV-infected CD4 + T Cell subtypes

Nairith Kalale, Department of Biology, CWRU; Saba Valadkhan, Department of Molecular Biology, CWRU School of Medicine

HIV infection leads to complex and persistent alterations in immune function, particularly affecting the gene expression landscape in T cells, which play a crucial role in coordinating adaptive immune responses. Understanding these molecular disruptions is essential for uncovering how HIV contributes to immune dysfunction and compromises the body's ability to fight infections. This study aims to identify specific gene expression changes induced by HIV infection in T cells through RNA sequencing, allowing for a detailed profile of gene expression differences that may highlight disrupted pathways. In this ongoing project, RNA is extracted from HIV-infected and uninfected CD4+ T cells. Using the SeqMonk platform, statistical analyses are conducted to identify genes with significant differential expression, followed by identification of pathways affected. Specifically, the goal of this study is to determine whether the main CD4 T cell subtypes show differences in the way they react to HIV infection. The findings from this study are expected to highlight potential molecular targets for therapeutic intervention. Analyses are underway to compare differences in gene expression pattern among CD4+ T cells subtypes at different timepoints in the life cycle of these cells. This project will define the importance of subtypespecific molecular profiling in HIV research.

Project Mentor: Saba Valadkhan, Department of Molecular Biology, CWRU School of Medicine

Investigating the Efficiency of Fraction Strategies by College Students: Visual vs. Numeric Strategies

Anna Kan, B.S. in Systems Biology, Case Western Reserve University

Clara Todd, B.S. in Nutrition, B.A. in Psychology, Case Western Reserve University

Understanding the concepts of fractions and how they relate to each other has a correlation with overall success in future math classes. When originally learning how to solve fraction problems there are a multitude of strategies that can be utilized, some leading to greater success compared to others. Previous research shows that the main strategies used to analyze and solve complex fraction problems fall under two broad categories: converting the fraction to a decimal form and looking at the fraction more visually. When converting fractions to other number forms there tends to be a higher success rate with complex fractions compared to using visualization strategies. To analyze the success rate of different strategies our study provides a list of fractions with numerators and denominators ranging from 0-100. Research participants are then asked to order the fractions, split into groups of five, from least to greatest without the use of a calculator. The strategies used were recorded and will be compared with the accuracy of their rankings. Additionally, the study analyzes which specific rankings are correct compared to others; meaning understanding when participants can correctly rank the outliers, the smallest and largest numbers, compared to being able to differentiate between the middle numbers. These results will be compared with previous math experience, college majors, and overall confidence in math to conclude an ideal strategy to approach fractions, therefore improving overall math comprehension in younger students.

Project Mentor: Dr. Lee Thompson, Department of Psychology Sciences, Case Western Reserve University

Characterizing strain diversity of Lactobacillus crispatus in the vaginal microbiome

Kaitlyn Kao, Department of Biology, CWRU; Alyssa Hamm, MS; Gina Lewin, PhD, Department of Global Health and Diseases, CWRU School of Medicine

The vaginal microbiome supports women's health through the bacteria's ability to maintain an acidic environment and line the epithelial wall to act as a barrier to pathogens. Lactobacillus crispatus is one of the bacteria that can support vaginal health, and its presence is inversely associated with Bacterial Vaginosis (BV), an extremely 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. I hypothesize that there is strain diversity both between and within vaginal microbiomes, and this contributes to vaginal health. Therefore, my goal is to broadly characterize the phenotypic and genomic diversity of lactobacilli across the genus and to specifically characterize the intrapersonal diversity of lactobacilli within a single vaginal swab. First, I tested six strains of Lactobacillus from different women and found phenotypic variation across L. crispatus strains in their maximum specific growth rates, doubling times, and lag phases of growth curves. To investigate the genomic diversity of these lactobacillus, I also assembled their genomes. Next, to further understand if intrapersonal strain diversity of L. crispatus is a factor that supports women's health, I isolated eighteen bacteria from a single clinical sample from a healthy woman without BV using the selective medium, De Man-Rogosa-Sharpe (MRS). I then used MALDI-TOF to determine the identity these isolates as Lactobacillus species. Future work will include sequencing and assembling genomes from these strains to compare the genomic diversity of lactobacilli within a single woman and characterizing the strains phenotypically. By investigating Lactobacillus diversity, we are deepening the 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

Cell Specific Proteomic Analysis of Intracortical Microelectrode Implant Site

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Intracortical microelectrode arrays (MEAs) are devices that are implanted into the brain's cortex to record neuronal activity. MEAs can send recorded signals to an external device, allowing individuals with motor impairments to independently control brain-computer interfaces (BCI) such as prosthetics and wheelchairs. However, MEA recording quality declines over time, leading to failure, largely due to the chronic neuroinflammatory response that occurs following implantation. Currently, no treatments for MEA-driven neuroinflammation have been widely accepted, possibly because this response is yet to be fully characterized on a molecular level. Building upon previous studies from our lab, we have conducted the first large-scale cell-specific proteomic study of MEA-implanted tissue. In this study, we measured the expression of 62 proteins in neurons and astrocytes, a type of neural support cell, over time to understand specific cellular responses to chronic MEA implantation. Our results demonstrate the interplay between immune cells and neurons. With prolonged infiltration into the brain, immune cells have a neurotoxic effect, and our results illuminate molecular pathways involved in this neurodegenerative cascade. Therapeutically targeting the identified activated pathways to promote neuronal survival or decrease immune cell infiltration into the brain may help improve long-term recording quality.

Faculty mentor: Jeffrey Capadona (Department of Biomedical Engineering)

The Nucleolar Response upon Mechanical Stress: A Model for Neuronal Injury

Risha Kaur, Department of Neurosciences; Dr. Alan Tartakoff, Department of Molecular Biology and Microbiology

The nucleolus is a central site for ribosomal RNA (rRNA) transcription, pre-rRNA processing, and ribosomal subunit assembly, playing a vital role in cellular protein synthesis. Disruptions in nucleolar function can induce nucleolar stress, impacting cell viability and overall ribosome biogenesis. We developed a fibroblast-based model of nucleolar stress by mechanically scraping cells from a substratum, enabling selective examination of damaged cells identified by an extracellular fluorescent tracer. These cells demonstrate unique recovery behaviors, including reattachment, spreading, and mitotic activity near the wound edges. We hypothesize a biphasic response, beginning with a temporary reduction in rRNA synthesis, followed by a potential increase in ribosome production as the nucleolus recovers from damage. To assess this, we utilize fluorescent tracers to monitor gap closure dynamics, changes in nucleolar appearance, and a click chemistry-based assay with 5-ethynyl uridine (EU) to measure rRNA synthesis rates, particularly lateral to the scrape. Additionally, we use hydroxyurea (HU) to inhibit DNA synthesis and cycloheximide (CX) to inhibit RNA synthesis, providing a framework to evaluate cellular responses to nucleolar stress. This model also offers a basis for future immunostaining and transcriptomic studies to elucidate molecular changes during cellular recovery from mechanical injury. Together, these approaches provide insights into nucleolar dynamics under stress conditions and the potential compensatory mechanisms cells utilize to restore ribosomal activity.

Project Mentor: Dr. Alan Tartakoff, Department of Molecular Biology and Microbiology

Integration of a Force and Torque Sensor into a Surgical Robot

Connor Kiernan, Department of Mechanical and Aerospace Engineering; **Grant Boone**, Department of Mechanical and Aerospace Engineering, CWRU

Robotic surgery systems allow for surgery to be performed with finer control, minimal invasiveness, and even remotely. However, these systems are still limited in the feedback they provide. Presently, the majority of telesurgical systems provide only visual feedback with a few newer versions having the option for limited axial force measurement. To address this, the project focused on implementing a small diameter, six-axis force and torque sensor into an existing laparoscopic manipulator for a robotic surgery system. To enable the sensation of axial and torque forces in the instrument's shaft, an interface between the sensor and the laparoscopic manipulator, as well as a minimally destructive method of modifying the manipulator to install the sensor were designed. This modification will allow surgeons to receive a wider range of information on the actions they perform in vivo. This includes but is not limited to the tension force they apply when tying sutures, the force with which they manipulate tissue directly, and sensation feedback if the instruments contact an object outside the surgeon's view. This technology can also allow the collection of data to monitor the impact of instrument-tissue interactions on tissue trauma and recovery. Loading and function tests were performed to ensure that the manipulator retained its structural integrity and end effector functions after modification. The device was then integrated into a da Vinci Research Kit for further testing and confirmation of its functionality. In continuing work, the installation method developed in this project will be further improved along with signal processing methods to enable accurate force sensation.

Project Mentor: Dr. Zonghe Chua, Department of Mechanical and Aerospace Engineering

Analyzing Molecular Interactions of ATE1 Using EMSA

Abigail Kim, Department of Biology; Dr. Yi Zhang, Department of Biochemistry; Dr. Thilini Abeywansha, Department of Biochemistry, CWRU

Arginyl tRNA protein transferase 1 (ATE1) is an enzyme that catalyzes the conjugation of an arginine residue to N-terminal or mid-chain Asp, Glu, or Cys residues of its substrates using $tRNA^{Arg}$. Protein arginylation is a global biological regulator and essential for many physiological processes such as angiogenesis, embryogenesis, aging, and cell migration. Mutations and dysregulation of ATE1 have been found in various cancers, such as those affecting the breast, prostate, liver and skin. However, the precise mechanisms through which ATE1 regulates tumorigenesis are not well understood, largely due to the limited understanding of the catalytic mechanism and substrate specificity. Therefore, Yi Zhang Lab's research project is dedicated to understanding how ATE1 functions through identifying the specific components of ATE1 and other key factors necessary for its function. Quantitative analysis was used to analyze the interactions between ATE1 and its substrates. Techniques such as Electrophoretic Mobility Shift Assay (EMSA) were used as a part of broader structural and functional study conducted by the Yi Zhang Lab. PCR and cloning were performed to create fusion substrate-ATE1 protein to increase affinity. This protein was expressed in E. coli and then purified. Nonhydrolyzable arginylated tRNA was used to conduct EMSA experiments. The results were analyzed to calculate the binding affinity. The experiments will contribute to the Yi Zhang Lab's effort to uncover detailed insights into the molecular interactions of the catalytic complex of ATE1.

Project Mentor: Dr. Yi Zhang, Department of Biochemistry, CWRU

Faculty Sponsor: Dr. Fritz Petersen, Department of Biology, CWRU

Assessing the Quality of Provider-Patient Communication and Clinical Trial Representation Among Different Ethnic Groups

Brandon Kim, Biology B.A., Case Western Reserve University

Effective communication between healthcare providers and patients is critical for improving patient outcomes, enhancing satisfaction, and making health-related decisions. Additionally, clinical trials are very important in making advancements, whether through medications, therapies, or surgical procedures. In the current healthcare system, certain ethnic groups are not well represented in clinical trials, leading to certain populations feeling anxious and uncertain towards the quality of their healthcare. Therefore, it is important to study and improve the diversity of clinical trials to help improve diagnoses and other outcomes for specific individuals. This study investigates the quality of conversations between oncology providers and patients of different ethnicity, while also focusing on key dimensions such as clinical trial representation and equality. To help aid in this study, we worked with the New York Mount Sinai Health System and Duke Cancer Institute, who provided us with audio recordings of conversations to help assess the communication quality. These recordings were analyzed with our codebook that identified the quality of provider-patient interactions, which included some patients reporting difficulties in understanding complex medical jargon and feeling insufficiently supported emotionally. Additionally, reviews of other studies were used to study the ethnicity representation of clinical trials across the healthcare system. These analyses highlighted the need for more personalized communication strategies that considered individual patient preferences and more diverse clinical trials. This study also underscores the importance of training healthcare providers in effective communication techniques, while also aiming to enhance the overall quality of care in health settings. Therefore, improved conversation quality and diversified clinical trials may lead to better treatment plans, reduced anxiety, and increased patient satisfaction, resulting in an improved healthcare system.

Project Mentors: Dr. Siobhan Aaron, Frances Payne Bolton School of Nursing; Dr. Michael Benard, Department of Biology

mRNA Vaccine for PIV3 through Codon Optimization

Daniel Kim, Biology, Case Western University, Cleveland

Parainfluenza virus type 3 (PIV3) is a major cause of respiratory infections in children and immunocompromised individuals, yet no licensed vaccines or antiviral therapies exist for its prevention or treatment. Although an mRNA vaccine for PIV3 has been developed experimentally, this study aims to enhance its efficacy through codon optimization to increase protein expression and immunogenic potential, targeting the prefusion conformation of the PIV3 fusion (F) glycoprotein. mRNA vaccines offer significant advantages, including the ability to produce candidate vaccines swiftly, lower production costs compared to traditional vaccines, and applicability to a wide range of infectious diseases, such as influenza, hepatitis C, HIV, and tuberculosis. By stabilizing the F protein in its prefusion state through strategic disulfide bond and proline modifications, we aim to enhance immunogenicity and achieve a more robust neutralizing antibody response. Preliminary results indicate that the prefusion-stabilized F proteins elicit markedly higher neutralizing titers in preclinical models, positioning this approach as a promising avenue for effective PIV3 vaccination. We began by obtaining the PIV3 gene from our collaborators, which we inserted into the PZMV vector alongside a Lucia signal peptide for comparative analysis. Through a structured procedure—including PCR and Gibson assembly, transformation for higher concentration, zeocin plating, miniprep, sequencing, and DNA transfection into 293T cells—we aim to produce optimized mRNA. Following initial plasmid preparation and sequencing, DNA was linearized for in vitro transcription (IVT), and poly-A tail was added to produce mRNA, which was then transfected for protein harvesting and western blot analysis. Our findings will provide details into the potential of codon-optimized mRNA vaccines to generate enhanced immune responses against PIV3 and highlight a pathway for the improved production of mRNA-based immunogens.

Project Mentors: Inho Cha, Project Mentor, Department of Cancer Biology, Cleveland Clinic

Jae Jung, Principal Investigator, Department of Cancer Biology, Cleveland Clinic

Robert Ward, Capstone Faculty Sponsor, Department of Biology, Case Western Reserve University

Tremor Suppression 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 an estimated 8.5-million people worldwide. Research has shown that hand tremors impact 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 total elimination of PD tremors. Surgical interventions, such as deep brain stimulation 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. 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

Identifying the Lyso-Lipoprotein Form and Characterizing the Lipoproteins in Lactobacillus rhamnosus

Michelle Kim, Biology BA Major, CWRU Undergraduate Student

Bacterial lipoproteins are important components of both Gram-positive and Gram-negative bacteria, having roles in cell adhesion, signal transduction, and the overall maintenance of the cell envelope. This study aims to verify whether the lyso-form lipoprotein structure is present on Lactobacillus rhamnosus, thus confirming the existence of a homologous Lit enzyme in these species. The significance in the lyso-form lipoprotein stems from its ability to modulate the immune response by weakly activating the TLR2/TLR1 heterodimer. The study also hopes to characterize the most common lipoproteins produced and whether the lipoproteins dictate the host immune system's ability to recognize the bacteria. Using click chemistry to label lipoproteins with 16-carbon alkyne-palmitate, followed by SDS-PAGE and fluorescence detection, two distinct lipoproteins were identified at approximately 70 kDa and 43 kDa. This process was repeated to include 14-carbon and 18-carbon fatty acid chains, alkyne-myristic and alkyne-stearic respectively. Additionally, lysate of the tagged L. rhamnosus bacteria will be reacted with biotin and streptavidin to isolate the alkyl-lipidated products and purify all lipoproteins in the sample. Future research is needed to achieve these results.

Faculty Project Mentor: Dr. Mahmoud Ghannoum, Case Western Reserve University School of Medicine, Department of Dermatology

Capstone Faculty Sponsor: Dr. Emmitt Jolly, Case Western Reserve University College of Arts and Sciences, Department of Biology

Screening FDA approved drugs for SSH1 inhibition Using PNPP Assay and Cell Culture Models

Suhee Kim, Department of Biology at Case Western Reserve University

Slingshot Protein 1 (SSH1) is a critical phosphatase that regulates the actin cytoskeleton, impacting processes such as cell movement, shape, and migration, particularly in neuronal tissues. In the brain, SSH1 functions by interacting with P-cofilin and F-actin, promoting the dynamic regulation of actin filaments, which is essential for normal neuronal function and cell migration. Dysregulation of SSH1 activity can disrupt these processes, leading to abnormal accumulation of actin filaments, impaired cell migration, and neuronal dysfunction, all of which are characteristic features in the pathology of neurodegenerative diseases. Given its role in actin regulation, SSH1 is a promising target for therapeutic intervention.

SSH1 catalyzes the hydrolysis of para-nitrophenyl phosphate (PNPP) to generate para-nitrophenol and inorganic phosphate, a reaction that can be measured to assess SSH1 phosphatase activity. In this study, we aim to investigate whether FDA-approved drugs can inhibit SSH1 phosphatase activity, potentially offering new therapeutic strategies for neurodegenerative diseases. We hypothesize that certain drugs may reduce SSH1 activity, thus restoring normal actin dynamics and improving neuronal health. The effect of each drug will be tested in a PNPP assay, where inhibition of SSH1 will be indicated by a reduced production of para-nitrophenol, observable as a decrease in absorbance at 405 nm.

To test this hypothesis, we will screen over 200 FDA-approved drugs for their ability to inhibit SSH1 activity. Each drug will be tested at multiple concentrations to quantify its inhibitory effect. The expected results will identify specific drugs that inhibit SSH1, providing insights into their mechanisms of action and potential repurposing for neurodegenerative diseases. This research could lead to novel therapeutic approaches by modulating actin dynamics and improving neuronal health in diseases associated with SSH1 dysregulation.

Project Mentor: Ashwini Shivalinga, PhD, Department of Pathology, School of Medicine at Case Western Reserve University**,** JungA ‘Alexa’ Woo, PhD, Department of Pathology, School of Medicine at Case Western Reserve University

Faculty Sponsor: Dr. Ronald Oldfield, Department of Biology, Case Western Reserve University

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]

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Syncope is a common condition characterized by transient and spontaneous loss of consciousness. It can result from cardiac arrhythmias, the vasovagal relex, orthostatic hypotension, and many other conditions. Of these, cardiac abnormalities are the most life-threatening and can be dificult to diagnose in the clinic. Electrocardiogram (ECG) signals are vital in the screening and diagnosing cardiac etiologies of syncope but can only detect abnormalities when they occur, generally only during activities of daily living. 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. Despite its eficacy, current implementations of Holter monitors can record ECG signals either continuously or during a short window around a syncopal event; however, capacity is generally limited, and current monitors 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 capacity for up to a week. Users are alerted to potential arrhythmias and potential syncopal episodes, as detected by an artiicial intelligence algorithm, to help patients avoid falls. This extended recording capability is designed to increase the likelihood of detecting cardiac rhythms associated with syncopal events, allowing healthcare providers to better assess the need for further diagnostic evaluation. By enhancing at-home screening methods, our device aims to support early identiication 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

Comparative Analysis of Inflammatory Responses in T-lymphocytes: Examining the Impact of Pre-exposure to Heme in IFN-y Levels

Sara Kong, Bachelor of Science in Biology, CWRU and Dr. Kenneth Remy, Cardiovascular Research Institute, CWRU and University Hospitals

Hemolysis, the breakdown of red blood cells (RBCs), is increasingly recognized as a central mechanism in the pathogenesis of sepsis. During hemolysis, the lysis of RBCs releases free hemoglobin, which further degrades into free heme. Free heme acts as a catalyst for the production of intracellular reactive oxygen species (ROS), driving oxidative stress and contributing to endothelial dysfunction. In sepsis, the resultant immunosuppression places patients at heightened risk for secondary complications, including nosocomial infections, dysregulated hemostasis, and thromboembolic events.

We hypothesized that immune suppression in sepsis may be partially mediated by heme tolerance, a phenomenon where repeated exposure to free heme attenuates immune responsiveness to subsequent pathogenic stimuli. To investigate this, we conducted an in vitro study utilizing healthy blood donor samples pre-exposed to varying doses and concentrations of free heme prior to stimulation with T cell receptor (TCR) agonists.

T cell activation was assessed via the production of interferon-gamma (IFN-γ), a key cytokine released upon TCR engagement by CD3+/CD28+ stimulation. Blood samples pre-exposed to heme and those without heme pre-treatment were compared. IFN-γ levels were quantified using ELISpot and ELISA assays, with each experimental condition replicated three times and performed in duplicate.

Results demonstrated that samples pre-treated with higher concentrations of free heme exhibited a significantly attenuated IFN-γ response following CD3+/CD28+ stimulation, compared to samples without heme pre-exposure. These findings support the hypothesis that repeated exposure to free heme induces a state of immune tolerance, suppressing the activation of T cells and potentially contributing to the immunosuppressive phenotype observed in sepsis.

Faculty Sponsor: Dr. Abdel Halloway, Department of Biology, CWRU

Principle Investigator: Dr. Kenneth Remy, Cardiovascular Research Institute, CWRU and University Hospitals

Spatial Transcriptomics Learned Non-negative Matrix Factorization (STL NMF)

Grant Konkel - Computer Science and Mathematics, Case Western Reserve University

Within the field of biology, being able to locate cell types within the body is a task that can be critical for saving lives and making discoveries. Ståhl et. al.'s discovery of using spatial transcriptomics data to aid us in this task proved to be a particularly useful tool. This idea of using spatial transcriptomics is based on the understanding that the functions of cells and genes are both tied to location and this allows us to find a spatial mapping of cells. Our goal is to "deconvolve" this spatial transcriptomics data through a mix of a mathematical model and implementation with computer science.

Through this deconvolution, we estimate cell type proportion versus locational data and identify regions with larger proportions of any certain cell type. We propose a method of deconvolving this spatial transcriptomics data using an unrolled non-negative matrix factorization neural network named Spatial Transcriptomics Learned Non-negative Matrix Factorization (STL NMF). However, this task is non-convex, so it requires additional updating constraints so solutions approach the truth. To do this, STL NMF utilizes histology information through a membership matrix within a graph laplacian, group sparsity regularization, and a summation to one term, all factored into its objective function. Once we have this objective function, we can derive the multiplicative update rule and we can unroll the iterative algorithm to create our neural network. This network learns the parameters of our objective function and creates a robust solution to our problem. STL NMF gives promising results and even beats some competitive methods.

Project Mentor: Ph.D. Weihong Guo, Department of Mathematics, Applied Mathematics and Statistics

Investigating Harmful Algal Blooms in Ohio Inland Lakes: Correlating Environmental Factors and Microcystin Production

Laerke Kristensen, Civil Engineering, CWRU

Harmful algal blooms (HABs) pose significant environmental and health risks, particularly in freshwater systems. In Ohio, HABs impact tourism and local economies and have been linked to health issues for nearby communities. This project investigates the factors influencing HAB occurrence across 20 Ohio inland lakes, with a specific focus on correlations between water quality parameters and microcystin gene expression. Microcystin is important due to its toxicity, which poses serious risks to both human and animal health. Water samples were collected at 4 points throughout bloom season (March September) and analyzed for both biotic and abiotic factors. Following sample processing, DNA extraction and preparation of quantitative PCR (qPCR) plates were performed to track the abundance of all bacteria, all cyanobacteria, all Microcystis, and microcystin-producing Microcystis. Data were analyzed using R to assess relationships between water quality indicators, such as nutrient levels, and cyanobacterial gene markers, including those specific to microcystin production. Preliminary analysis highlights potential correlations between nutrient concentrations and cyanobacterial bloom intensity. By understanding the links between environmental factors and toxicity levels, this project will offer insights into bloom dynamics, which is crucial for predicting and managing future blooms. This study provides evidence-based insights into the factors that influence HAB occurrence and severity, contributing to better lake management practices and public health safeguards in Ohio.

Faculty: Bridget Hegartuy, Civil and Environmental Engineering

Characterization and Analysis of Aerosol Jet Printed Circuits

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

Aerosol jet printing (AJP) is a form of additive manufacturing that can be used to fabricate flexible electronics with micron-scale resolution. This novel technology consists of many different parameters, including gas flow rates, atomizer voltage, stage speed, and platen temperature. Printing parameters may be optimized using a Bayesian approach, which can be time and material efficient. Three iterations, each with five printing parameter sets, were printed on polyimide thin film with diluted silver nanoparticle ink and thermally cured after printing. Optical microscopy was used to image the AJP circuits, specifically a set of dumbbells and individual pads for each dumbbell. Each pad was imaged under specific parameters to prepare them for image analysis. A custom MATLAB script was utilized to obtain values for five parameters: trace width, rectangularity, line edge roughness, overspray density, and average distance of overspray clusters or pixels from the trace edge. Visual Conformity Grade (VCG) then utilized the outputs from image analysis to calculate how accurately the print conformed to the intended G-Code. Prints' overspray distance and density, edge roughness, and rectangularity were standardized through Z scores, and were multiplied by subjective weights based on their perceived importance. Edge roughness, overspray density and overspray distance, multiplied by their respective weights, were then taken from the rectangularity value times its weight to output a final VCG value. Resistance measurements were taken using a four-point probe system and used to calculate conductance. The characterization results from each iteration were used to determine the following iteration's parameter sets. Results from this study will be used to evaluate the effectiveness of a Bayesian approach in comparison to other optimization methods.

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

Two Possible Triggering Mechanisms of pch2-dependent Pachytene Checkpoint That Induce Interchromosomal Effect

Ayah Lababede, Department of Biology, CWRU; Nicole Crown, Department of Biology, CWRU; Bowen Man, Department of Biology, CWRU

Crossover formation enables the reciprocal exchange of genetic information during prophase 1 of meiosis, which leads to the formation of genetically unique haploid gametes. An interesting phenomenon is observed when there is a heterozygous inversion on a chromosome in Drosophila melanogaster. This phenomenon, the interchromosomal effect (IC), occurs when an inversion on one chromosome suppresses its own crossover formation while increasing crossover formation on other freely recombining chromosomes. Previous research studies have attributed the IC effect to defects in the chromosome axis, which trigger a pch2-dependent pachytene checkpoint activity that delays the progression of prophase 1. However, the type of chromosome axis defect that triggers the checkpoint has not been directly determined. This ongoing experiment will address the gap by testing two hypotheses behind the mechanism, which are (1) the checkpoint may be activated by the detection of disrupted axial organization within the chromosome or (2) the checkpoint may be triggered by the absence of a crossover on the inverted chromosome. The inversion selected for this study is inversion AB because it is a medium-sized, single inversion in the middle of the long arm of the X chromosome, which allows us to recover crossovers that occur outside of it. The freely recombining chromosome chosen to observe crossover frequency is chromosome 2. If the detection of disrupted axial organization activates the checkpoint, we would observe significantly increased frequencies of crossovers on chromosome 2 regardless of crossover formation on the X chromosome. If the absence of a crossover on the inverted chromosome activates the checkpoint, we would observe significantly increased frequencies of crossover formation in chromosome 2 when the X chromosome does not have a crossover as compared to when it does have a crossover.

Project Mentor: Dr. Nicole Crown, Department of Biology, CWRU

How Does Azotobacter Phage Infection Physiology Depend on Host Nitrogen Availability?

Mariana Labat, Systems Biology B.S., Case Western Reserve University

Bacteria are of great significance to soil ecology due to their role in the biogeochemical cycling of carbon (C) and nitrogen (N) (Lladó et al., 2017). Some of this activity is thought to be indirectly modulated by bacterial interactions with bacteriophages—the viruses of bacteria (Sun et al., 2023). This project investigates how bacteriophage infection dynamics are impacted by varying nitrogen availability, focusing on Azotobacter vinelandii, a nitrogen-fixing soil bacterium. We hypothesized that A. vinelandii would exhibit altered susceptibility to phage infection depending on nitrogen availability, with reduced susceptibility in nitrogen-deficient conditions compared to nitrogen-rich ones. We predicted that differences in infection physiology would be observable in phage adsorption, burst size and timing, and gene expression during expression. To explore this hypothesis, we conducted adsorption experiments to assess phage binding efficiency under different nitrogen conditions. In ongoing work, we will conduct a one-step growth experiment under varying nitrogen conditions to assess how phage infection dynamics are affected, sampling RNA at multiple time points during the one-step experiment. In preparation, this semester has focused on establishing a reliable RNA extraction protocol and methods for assessing RNA quality and quantity. Sequencing the isolated RNA, along with transcriptomic analysis, will enable the assessment of differential gene expression during the phage infection cycle across nitrogen conditions. The results of this research aim to enhance our understanding of how complex, nutrient-variable environments influence phage infection physiology.

Project Mentor: Dr. Sarah Bagby, Department of Biology

The Reliability of Hand-Crafting Implantable Vagus Nerve Stimulation Devices For Rats

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The use of vagus nerve stimulation (VNS) as a neuromodulation therapy to increase neuroplasticity in patients following neurological injury is a growing area of study with clinical and preclinical applications. For preclinical studies, stimulation devices need to be fitted for small rodents, such as rats. These miniature specialized devices – namely swivels, headcaps, and cuffs – are meticulously hand-crafted in the laboratory using mainly components such as Omnetics connectors, wires of varying sizes, acrylic powder and monomer, and are assembled with the aid of lab and precision tools, including forceps and soldering irons. Additionally, they are assembled under microscopes due to their size. The construction of such miniscule devices requires a careful training pathway and sharp attention to detail, as well as the development of important skills, such as soldering, basic metallurgy, microscopy, and wiring. These competencies are heavily emphasized when learning to assemble these devices, and are essential foundations for microengineering, which refers to the construction and engineering of such miniscule objects. Ensuring that the microdevices created are consistent with one another is important for the collection of data as it decreases the variability of measurements due to the implanted devices and improves reliability when running experiments using VNS, as well as reducing the risks of harm or other complications regarding the animals by ensuring that the devices are not too fragile and can deliver precise stimulation to the target spot (vagus nerve) only. The training rigor and extensive assembly practice eventually leads to the successful manufacturing of durable and consistent devices, showing that hand-building is a reliable and reproducible method to use.

Project Mentor: Dr. Ana Guadalupe Hernandez-Reynoso, Department of Biomedical Engineering, Case Western Reserve University

Power Output Measurement of Miniature Stirling Engine

Bao Le, Department of Mechanical Engineering, Case School of Engineering.

Daniel Orozco, Department of Mechanical Engineering, Case School of Engineering.

The Stirling engine is an external closed-cycle type heat engine that has been attracting the growing attention of many researchers lately because of its high theoretical efficiency and encouraging applications to the renewable energy industry. This project studies on the configurations of the Stirling engine and experimentally measures the power output on a gamma-type base model. The primary objective of this work is to measure and conduct analysis of the mechanical and electrical power output of a base commercially available gamma-type Stirling engine. The experimental setup for measuring mechanical power output consists of a base model of Stirling engine, a simple light load dynamometer for torque measurement that is connected to the shaft of the base engine. Thermocouples will be placed to record the temperature difference data. Mechanical power output will be calculated using torque data and angular velocity which can be obtained from the engine's rpm and load displacement. The experimental set up to measure the electrical output of the engine will require the same temperature difference data with readings from a DC motor that is mounted to the shaft of the engine. The findings are used for performing comparison and analysis of the obtained power output through different measurement methods. This project aims to explore the power output, identify optimization opportunities for the gamma configuration of the Stirling engine and explore future integration with renewable energy sources for engine operation.

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

Experimental investigation of the effect of streamwise curvature on the BL on a rotating cone

Justin Le, Mechanical Engineering, Case Western Reserve University

The boundary layer flow over a rotating cone remains a topic of significant interest in fluid dynamics due to its complex nature and broad applicability in aerospace and marine engineering. While much of the existing research has concentrated on the laminar and transitional phases of flow, this study aims to extend the focus to the turbulent phase of flow over a rotating slender cone with an apex angle of 60 degrees. To capture and analyze the flow dynamics, the stereo Particle Image Velocimetry (PIV) technique will be employed. PIV involves seeding the flow with tracer particles, illuminating the flow field with a laser sheet, and capturing successive high-resolution images using synchronized cameras. The displacement of the particles between images allows for the calculation of the velocity field across the illuminated plane. The velocity field is crucial for understanding key flow characteristics, as it allows for the subsequent calculation of the pressure field, vorticity, shear stress, and strain. Through this investigation, we expect to deliver a comprehensive experimental setup, stereo PIV data, and a detailed report that explores the behavior of turbulent boundary layers over rotating conical surfaces, providing further insight into this complex flow regime.

Faculty Project Mentor: Bryan Schmidt, Mechanical & Aerospace Engineering, Case Western Reserve University

Electronic relaxation mechanism of 4-dimethylaminophthalimide and thio-4-dimethylaminophthalimide: a photophysical insight for heavy-atom-free photosensitizer development for cancer cells

Eric Lee, Department of Chemistry, Case Western Reserve University

Modifying heavy-atom-free photosensitizers (HAF-PSs) through thionation presents a promising approach to enhancing their photophysical properties without the drawbacks of incorporating heavy atoms like metals, iodine, or bromine. Traditionally, heavy atoms are incorporated to facilitate intersystem crossing (ISC) pathways to triplet excited states. However, these atoms often result in high synthesis costs, dark cytotoxicity, limited biocompatibility and short triplet decay lifetimes. Thionation, which is achieved by substituting oxygen with sulfur, introduces spin-orbit coupling effects comparable to heavy atoms, thereby improving ISC, while preserving the favorable traits of HAF-PSs, such as low cost, dark cytotoxicity and high biocompatibility. This study explores naphthalimides, p-deficient compounds with potent photochemical and biological activities, which are a promising class of photosensitizers due to their high molar absorptivity, photostability, and low toxicity. Specifically, we examine 4-dimethylaminophthalimide (DMAP) and its thionated derivative, thio-4-dimethylaminophthalimide (SDMAP). Although both DMAP and SDMAP exhibit favorable properties, its electronic relaxation mechanisms remain underexplored. Here, steady-state absorption, emission spectroscopy, femtosecond transient absorption, nanosecond laser flash photolysis, and quantum calculations will be employed to analyze and compare the excited-state dynamics and electronic relaxation pathways of DMAP and SDMAP in acetonitrile, advancing the understanding of thionated HAF-PSs as next-generation photosensitizers for photodynamic therapy and other biomedical applications.

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Project Mentor: Chris Acquah, Department of Chemistry, Case Western Reserve University

Principal Investigator: Dr. Carlos E. Crespo-Hernández, Department of Chemistry, Case Western Reserve University

Exploring the Use of Biosynthetic Drug to mitigate Amyloid Pathology in Alzheimer's Disease

Esther Lee, Department of Biology, Case Western Reserve University (CWRU)

Alzheimer's disease (AD) is a chronic neurodegenerative disorder associated with progressive cognitive decline. The accumulation of neurotoxic Aβ is hypothesized to initiate a cascade of neurodegenerative events, impairing synaptic integrity and triggering widespread neuronal dysfunction. This neuronal loss and synaptic degeneration underlie the hallmark cognitive and memory impairments observed in AD. In response to the hypothesized role of neurotoxic Aβ in AD pathophysiology, current therapeutic research is intensively focused on strategies that target Aβ formation, aggregation, or clearance. These approaches are aimed at mitigating or halting AD progression by intervening in Aβ plaque accumulation, which is considered a critical driver of neurodegeneration in AD. Our research focuses on evaluating FDA-approved biosynthetic compounds for their potential effect in modulating Aβ pathology via dose-dependent analyses. Utilizing both APP wild-type (WT) and APP 293T mutant cell lines, we investigate the inhibitory effects of these compounds on Aβ aggregation. Our goal is to determine optimal concentrations for minimizing Aβ aggregation, leveraging a combination of in vitro cell culture assays and in vivo murine models to validate findings and assess therapeutic efficacy. By concentrating on naturally derived bioactive compounds, our study aims to broaden the scope of Alzheimer's disease (AD) therapies that target amyloidogenic pathways. Our findings have the potential to lay the groundwork for future clinical applications, providing promising alternative treatment options that specifically address Aβ pathology. This research contributes to the expanding evidence supporting novel, targeted approaches in AD therapy, intending to advance more precise and effective interventions.

Project Mentor: Pramoda Nagaraju, Department of Pathology, Case Western Reserve University School of Medicine; JungA 'Alexa' Woo, Department of Pathology, Case Western Reserve University

Faculty Sponsor: Dr. Abdel Halloway, Department of Biology, Case Western Reserve University

Adolescent Screen Usage and Its Impact and Implications on Adolescent Memory Development

Jonathan Lee, Psychology

In the advent of the digital age, screen use has become more prevalent. In particular, adolescents have become far more reliant on screen usage, both recreationally and in the classroom, with post-pandemic bringing around 60% usage of screens in children. This comprehensive literature review attempts to see how excessive screen usage affects adolescents in higher executive functions, particularly when it comes to memory processes such as encoding. Scholarly search engines such as Psychiatry Online, PsycArticles, PsycINFO, and the OhioLINK Electronic Book Center, with the use of key search terms like Adolescents, Screen Time, Memory, Short-Term, Long-Term, Addiction, School Children, Education, Brain Development, Smartphone, Cognitive Development were used to identify the literature. Findings show that adolescents with some type of screen addiction performed worse in memory performance tests and possessed a lower academic ability in the classroom in conjunction with poorer memory performance. Furthermore, adolescents exposed early to screens were found to be negatively affected in brain development, with key areas and factors in brain matter such as the sulcal depth, cortical thickness, and neural connectivity being far weaker in these adolescents than those without some type of screen addiction. The limitations of the review come from the various correlational data presented and the lack of clear accounting for external factors, such as sleep or depression affecting academic performance rather than memory. Findings tell that sharp intervention methods should be placed early in adolescent development to prevent the effects of screen addiction in not only attention, but memory as well

Faculty Mentor: Anastasia Dimitropoulos, Psychological Sciences

Investigating the Mechanism of Quaternary Compound Selective Cytotoxicity to Oligodendrocytes

Kristin Lee. Department of Genetics and Genome Sciences; Dr. Paul Tesar

In contemporary societies, humans are routinely exposed to an immense variety of chemicals through their daily interactions with the environment. Toxicity assessments conducted by the Environmental Protection Agency utilize a standard approach to evaluate the safety of chemicals in terms of their toxicological impacts on the human body. However, most of these studies are typically conducted at a macro-level, failing to adequately account for the intricate effects that chemicals can have on individual cell types. Currently, there is a dearth of research conducted on the relationship between chemical exposure and neurodevelopment, which has hindered the development of our knowledge in this field.

We have undertaken an extensive toxicity screen of oligodendrocytes, consisting of 1823 chemical compounds, aimed at identifying those that are cytotoxic versus non-toxic to oligodendrocytes. Subsequently, a secondary assay was conducted to confirm the viability of the cells and to assess whether oligodendrocyte development was impaired. We compared the results of this screen with the same toxicity assay performed on astrocytes, along with data from an EPA database, and found that 49 out of 292 chemicals identified as cytotoxic were specifically cytotoxic to oligodendrocytes. Dose-response experiments on these 49 chemicals led to the identification of an enriched class of quaternary compounds, consisting of a nitrogen cation surrounded by four alkyl groups, which were shown to lead to apoptosis in oligodendrocyte progenitor cells before they develop to oligodendrocytes. Notably, these compounds are commonly found in widely used antimicrobial agents and hair conditioners. The body of the work focuses on determining a mechanism underlying this cytotoxicity and observing how behavioral phenotypes are affected longitudinally to hint toward the chemicals and their involvement in neurological diseases.

Project Mentor: Dr. Paul Tesar
Graduate Student Mentor: Erin Cohn, Rania Ziar

Voiced: Text-to-Speech for the International Phonetic Alphabet

Kyle Kaufman[1], **Shea Leech**[1], **Noah Mollerstuen**[1], **Benjamin Poulin**[1], **Simon Schwartz** [1], **Kasey Wei** [1], **Wendy Wu** [1]

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Voiced is a browser-based text-to-speech application capable of pronouncing the international phonetic alphabet (IPA). The IPA is a system of readable phonetic notation designed to represent all human linguistic utterances, and is standard across speech fields, from lexicography and linguistics to speech-language pathology. Due to the ubiquity of IPA transcriptions, Voiced is a useful tool for learning to pronounce foreign languages, acquiring novel vocabulary, and studying speech. Unlike other IPA pronouncers, Voiced interprets its input as unambiguous narrow transcription, prioritizing accuracy over following language-specific shorthands (like the omission of aspiration on final unvoiced stops in English). Voiced therefore does not have an "accent," and can be relied upon to correctly pronounce any correctly entered input. Speech synthesis in Voiced is performed by a JavaScript synthesis engine which implements the parametric formant synthesizer described by "Software for a cascade/parallel formant synthesizer" (Dennis Klatt, 1980). The 1980 "Klatt synthesizer" accepts a matrix of parameter values varying over time, and uses these parameters to produce an utterance by subtractive synthesis from Gaussian noise and a glottal impulse train. With Voiced, we determine Klatt parameterizations for IPA phones by spectrogram analysis, and propose a rules-based method for handling coarticulatory effects when combining phones. We develop a demonstration of Voiced, written in HTML, CSS, and JavaScript, and compatible with all modern web browsers. Users of the demo may enter target IPA either by copying and pasting from another source, using a built-in word-to-IPA dictionary lookup, or by typing with an on-screen IPA keyboard. They can then adjust speed and pitch before playing the generated speech and viewing the time variant frequency spectrum of that speech.

Project Mentor and Faculty Sponsor: Professor Shuai Xu, Computer and Data Sciences Department, CWRU

Hormones Regulating Asprosin's Secretion in 3T3-L1 cells

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1. Department of Neurosciences, Case Western Reserve University
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Asprosin is a protein hormone secreted by white adipose tissue and plays an influential role in regulating appetite and blood glucose levels. Its secretion is notably elevated during physiological states such as fasting and anxiety, where metabolic demands and stress responses are heightened. However, the regulatory landscape of asprosin's secretion (activators or inhibitors) remains poorly understood. This study aims to investigate potential factors that might govern asprosin's secretion. Considering the complex environment associated with both fasting and anxiety, we sought to look at the effect of hormones such as insulin, epinephrine, norepinephrine, and glucagon on the secretion of asprosin. Insulin levels rise in the fed state, while glucagon, epinephrine, and norepinephrine increase during fasting; notably, epinephrine and norepinephrine also elevate in response to anxiety.

Asprosin is the c-terminal cleavage product of the protein profibrillin which is encoded by the Fbn1 gene. The Fbn1 gene is highly expressed in white adipose tissue, making this tissue a primary source of plasma asprosin. Therefore, we chose to use the 3T3-L1 cell line, which can be differentiated into mature adipocytes that produce and secrete asprosin. To determine if any of the above factors influence asprosin secretion, differentiated 3T3-L1 cells were exposed to the previously mentioned hormones at various concentrations. After, cell media was collected and used to assess asprosin secretion. RNA was also harvested and used to look for the relative expression of the Fbn1 gene. Preliminary results indicate that insulin, a hormone elevated in fed states, has an inhibitory effect on asprosin secretion where higher levels of insulin are correlated with lower levels of asprosin in media. Also, epinephrine and norepinephrine resulted in elevation of asprosin.

Project Mentor: Hiba Obeid, Department of Genetics and Genome Sciences, Case Western Reserve University

Faculty Sponsor: Dr. Atul Chopra, Harrington Discovery Institute, Case Western Reserve University

The Role of Explicit and Implicit Learning in Second Language Acquisition and its Applications on Language Teaching

Chih-Cheng Lin; Cognitive Science, Case Western Reserve University

This paper summarizes important research in the topic of implicit and explicit learning regarding second language acquisition (SLA). Starting from Krashen's (1981) noticing hypothesis, the debate on the role of consciousness in language learning remains an important topic even today. Early research suggested that the "noticing" level of consciousness is an essential component in handling linguistic knowledge, while more recent studies tend to argue that implicit knowledge is the key component for language acquisition that explicit knowledge of grammatical structure and form can only serve as a supplementary method of learning due to the complexity of languages. Despite robust findings about the importance of implicit learning, most of the current language instruction in classroom settings still maintain large proportions of explicit knowledge training, such as repetition, memorizing patterns and rules. Most language classes have little or no instructional design to train learners' implicit knowledge. However, it is also important to note that implicit learning is not necessarily best encouraged through implicit instruction. There are also findings which suggest that explicit instruction is beneficial to learners' both implicit and explicit knowledge. Finally, although most research suggests that the influence of implicit instruction on learners is limited, there are some studies showing that implicit instruction can increase the effectiveness of explicit instruction when the two are used in combination. Due to the gap between implicit-explicit instruction theories and real-life classroom settings, it is necessary to develop a new type of language classroom which applies explicit instruction alongside additional implicit instruction. This kind of language classroom can benefit learners' by creating a balanced learning environment where learners gain intuitive knowledge and have opportunities to apply rules consciously.

Project Mentor: Dr. Vera Tobin; Department of Cognitive Science

Volume Electron Microscopy Study to Investigate Neuroplasticity After Spinal Cord Injury in Rat

Jason Lin, Case Western Reserve University, Department of Neuroscience

Spinal cord injury (SCI) has long been an area of research due to its debilitating effects and complexity of injury. However, it is known that synaptic plasticity permits some recovery of the spinal cord especially after incomplete transected SCI. In this study, we used an IH impactor set at 250kDyn to cause a contusion at the T8 region of the rat. The plasticity was compared between the injured and sham group at the L3/L4 region, which is below the site of injury, using volume electron microscopy. Based on the results, it was found that in the injured rat, the injured group has higher glial process occupation, decrease in bouton occupation, and increase in unoccupied space. The data were not significant when three neurons for each animal are grouped together and analyzed, but when individually analyzed, it shows significant differences. Due to huge variability in the data, the method to measure occupations of glia and boutons should be refined and a larger sample size is needed. Although there is large variability, the general trend of the data is consistent with an increase in glial process occupation, decrease in bouton occupation, and increase in unoccupied space as predicted.

Principal Investigator and Mentor: Dr. Yu-Shang Lee, Assistant Professor, Medicine, CCLCM-CWRU

Rate CWRU Courses: Centralized Peer Course Review Platform

Cameron Dewberry (Department of Data Science and Analytics)[1]; **Ethan Ho** (Department of Computer and Data Sciences)[2]; **Emmanuel Makoye** (Department of Computer and Data Sciences)[3]; **Alice Liu** (Department of Computer and Data Sciences)[4]

Case Western Reserve University[1,2,3,4]

Many students at Case Western Reserve University struggle to find reliable, up-to-date information to make informed course choices, often relying primarily on peers for insights. This lack of centralized, student-driven resources limits their ability to effectively assess course difficulty, content, and its usefulness. To address this, we developed a comprehensive platform that provides authentic course insights directly from students. Our platform will enhance the course selection process by centralizing peer reviews, ratings, and advice, creating a reliable hub of current course information.

Key benefits of this platform include streamlined access to a broad range of student evaluations, allowing users to evaluate courses based on firsthand experiences in areas such as difficulty, relevance to career goals, and overall utility. This peer-to-peer network is especially valuable for students without extensive social connections on campus, providing insights and fostering connections that might otherwise be inaccessible. Additionally, our platform includes a data science component that analyzes review trends, offering interactive dashboards that present insights on course difficulty, perceived value, and major-specific trends. These features support both students and university decision-makers in optimizing the course selection process.

Technically, the platform integrates a ReactJS front end for an engaging user experience, an ExpressJS backend for streamlined data processing, MongoDB for flexible data storage, and Python for data analysis. This structure enables us to deliver a sustainable, user-centered platform to enhance informed course selection and the academic experience at Case Western Reserve University.

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

Identifying TET2 effect on compensatory injury induced sprouting of the corticospinal tract rostral to the injury site using mouse models

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Spinal cord injury is a permanent disease leaving patients disabled and with lifelong paralysis. Currently, there are no treatments that effectively recover injured nerve fibers to engage in voluntary motor function. However, our current research has identified how grafting neural progenitor cells (NPC) into the spinal cord injury site of a mouse model facilitates cortical spinal cord axon regeneration. The NPC graft has shown that immature neurons display a greater capability to regenerate post-injury compared to mature neurons. An explanation for this difference lies in the chromatin structure, specifically DNA methylation- an epigenetic modification associated with gene silencing, found to increase with maturity, and restrict genetic availability for the regenerative processes. Therefore, if we are able to revert the mature and injured neurons back into immature neurons through inhibiting DNA methylation and reorganizing the chromatin structure to mimic the chromatin state of an immature neuron, it could induce neuroregeneration.

Ten-eleven translocation (TET) proteins are enzymes involved in DNA demethylation and axon regeneration. In our previous research, we have identified how a TET2 knockout (KO) mouse shows less neural growth through their NPC graft compared to a wild type mouse. It is unknown whether the compensatory induced sprouting of the corticospinal tract after injury is affected by the TET2 similarly as its mechanism is independent of the NPC graft. Thus, I will be assessing the compensatory injury induced sprouting of the corticospinal tract rostral to the injury site by transverse sectioning, staining, and quantifying regenerating axons in TET2 KO and wild type mice. Based on our previous research, I hypothesize that TET2 KO mice will show less compensatory induced sprouting compared to wild type mice.

Project Mentor: Gunnar Poplawski, Lerner Research Institute, Center for Immunotherapy & Precision Immuno-Oncology, Cleveland Clinic

Literature Review: How RNA and Ferroptosis Findings Lead to Potential DLBCL Treatments

Yijuan Lu, Bachelor of Arts in Biology, Case Western Reserve University

Diffuse large B-cell lymphoma (DLBCL) is the most common type of non-Hodgkin lymphoma (NHL). It contributes of 30% of all the new NHL diagnosed in the United States each year (Susanibar-Adaniya and Barta, 617). Due to DLBCL's asymptomatic nature, it is often difficult to diagnosis patients in the early stages. In addition, the current R-CHOP treatment is not very effective. Around 50% of the patients who received this treatment do not have a positive response or relapse later (Liu and Berta, 604). Previous studies indicated that men have higher chances of having DLBCL compared to women (Cerhan, et al., 16). Elders are also more likely to have DLBCL. Other risk factors, such as immune function problems and higher young adult BMI, also affects one's possibility of having DLBCL.

Recent studies have indicated PIWI-interacting RNA (piRNA)-30473 may have a positive role in supporting the development of DLBCL. It is also related to patients' survival rate. Suppression of piRNA-30473 has an impact in the inhibition of tumor growth (Han, et al., 25). Additionally, Micro-RNAs (miRNAs) is associated with tumor prognosis. Patients with miRNA-199a and/or miRNA-497 usually have better overall survival rate since they have higher chemosensitivity (Troppan, et al., 18077). In some DLBCL patients, mutations of BCL10 are presented and can be used as potential biomarkers for future treatment (Xia, et al., 1923). Another new possible target for DLBCL treatment is ferroptosis, as it is presented in many carcinogenic and anticancer pathways. There is also a correlation between ferroptosis-associated genes and DLBCL prognosis (Bian, et al., 1). These recent studies bring up new discoveries of DLBCL, suggesting various possible future diagnostic methods and potential treatment methods.

Faculty project Mentor: Dr. Yolanda Fortenberry, Department of Biology, CWRU

Holy Ships!: A Competitive and Cooperative Space Adventure

Pranav Balabhadra[1], **Timothy Cronin**[1], **Benjamin Luo**[1], **Anthony Wang**[1],

[1]Department of Computer Science, Case School of Engineering

Holy Ships! is an engaging peer-to-peer multiplayer mobile game designed for collaborative and fast-paced play. In this dynamic survival game, a team of two must work closely together to pilot and protect their spaceship during a thrilling journey across the universe. Players collaborate to keep their ship operational by addressing various unexpected malfunctions that arise along the way through the completion of interactive minigames. For example, if the ship starts losing oxygen due to a hole caused by an asteroid collision, players will need to work together to drag materials to cover that hole. If there is a fire on board, teammates will have to quickly fill a water bucket and bring it to the flames to extinguish them before they engulf the ship. Teammates may get locked into a room and must coordinate to put in a special combination through pressure plates to unlock the door and escape. As the game progresses, the challenges become increasingly frequent and difficult, testing players' ability to think quickly, coordinate timing, and communicate effectively. If malfunctions accumulate, causing severe damage, the spaceship will explode causing the journey to end. On the contrary, a team that successfully overcomes adversity will go on to uncover deep secrets of the cosmos, forever cementing themselves in space travel history. Holy Ships! offers an immersive space-themed adventure that focuses on teamwork, quick thinking, and problem-solving skills. The game’s art and music takes inspiration from classic sidescrollers and retro sci-fi themes. The top-down two-dimensional gameplay hopes to inspire nostalgia and adrenaline. Our aim is to provide an experience centered on cooperation, strategy, and fast-paced crisis management. Keep your cool and happy exploring!

Project Mentor: Shuai Xu[1], Department of Computer Science

Exploring Mental Health Experiences Among East Asian Minorities

Mulan Ma, Cognitive Science, Case Western Reserve University

This study explores the cultural, societal, and generational factors shaping the mental health experiences of East Asian American youth within Generation Z. Through a comprehensive review of existing literature, this research reveals that family expectations, racial identity, societal pressures, and stigma surrounding mental health services significantly impact mental health outcomes for this demographic. East Asian American Gen Z individuals frequently encounter complex, intersecting challenges related to academic performance, cultural assimilation, and self-identity, which can adversely affect their mental health. The model minority stereotype—a longstanding label applied to Asian Americans—has further exacerbated disparities by fostering silence around mental health issues. This study draws on anthropology, sociology, psychology, and cultural studies to examine the distinct challenges faced by this group and advocates for culturally responsive mental health support approaches that consider these contextual factors. The findings underscore the need for tailored resources that genuinely address the experiences of East Asian American youth and critique the inadequacies of current mental health services, which often fail to meet the unique needs of minority groups.

Project Mentor: Professor Fey Parrill, Department of Cognitive Science

Risk of CHIP: An Approach on Guidelines for Clonal Hematopoiesis of Indeterminate Potential (CHIP) Treatments and Prevention

Shreya Maanavi[1], Dr. Jean H. Burns[1], Dr. Robert S. Ohgami[2]

[1]Department of Biology, Case Western Reserve University, Cleveland, OH; [2]Department of Pathology, Univeristy of Utah

Clonal Hematopoiesis of Indeterminate Potential (CHIP) occurs when hematopoietic stem and progenitor cell clones (HSPCs) with a somatic mutation slowly form in the blood or bone marrow of an individual. The somatic mutations found within these cell clones are commonly DNMT3A, TET2, and ASXL1, but there are other mutations that can cause this pre-malignant state. Clonal hematopoiesis occurs when a normal stem blood cell experiences an oncogenic event and turns into a premalignant or preleukemia neoplastic stem cell. The cell or its daughter cells acquire somatic mutations and expand into clones over time, but the mutation is not detectable because they are slowly cycling and only have low oncogenic potential. Clonal Hematopoiesis can also increase the risk of heart conditions and blood cancers. The prevalence of CHIP increases with age, but research currently lacks laboratory findings to treat or stop CHIP cell clones from growing, despite the danger the expansion of the HSPCs could cause. We searched through databases for cases with CHIP from 2018-2024 and analyzed the capability of different treatments used for blood cancers that could eliminate HSPCs . Our findings determined that there are inadequate treatment and prevention protocols for CHIP cases. Other research link clonal hematopoiesis to various cardiovascular diseases and focus on monitoring somatic CHIP mutations in patients. Based on our analysis, there are a few treatments could dispose CHIP clones, including stem cell therapy and bone marrow transplant. However, other possible protocols, such as chemotherapy, radiation and holistic therapy, are not as effective on HSPCs. This analysis demonstrates a shortage of laboratory findings on treatments and prevention of CHIP and suggest more research into viable practices to remove HSPCs.

Project Mentor: Dr. Jean H. Burns, Department of Biology, Case Western Reserve University

Automated Optimization of Crab Gait Parameters for Simulated Climbing

Will MacCormack, Department of Mechanical and Aerospace Engineering, Case Western Reserve University

CrabLine Robotics aims to provide underwater pipe-navigating robots to construct and tear down pipelines, oil rigs, and offshore wind installations. Proper maintenance and construction protect critical infrastructure and the environment; however, underwater human inspection, burning, and welding are both costly and dangerous. This project examined the ability of a digital twin of the CrabLine Robotics robot to navigate vertical pipes in a MuJoCo simulation environment. Initially, the simulation was slow to run, lacked runtime flexibility in gait generation, and failed to take any steps without falling off the pipe. This work rearchitected the simulation, introduced a tetrahedral contact gait, and numerically optimized gait parameters to successfully climb a vertical pipe in the MuJoCo simulation. The Scikit Optimize library was used in conjunction with the parallelization framework Dask to enable CPU parallelized, gradient free, model-based optimization of gait parameters for stable navigation of a vertical, uniform pipe. In conclusion, the optimized tetrahedral feedforward control of robotic limbs successfully enabled prolonged vertical pipe navigation; although, feedback-based control would likely enable more robust navigation of uncertain environments.

Project Mentor: Ryan Brown, Department of Mechanical and Aerospace Engineering, School of Engineering, Case Western Reserve

PI: Kathryn Daltorio, Ph.D., Department of Mechanical and Aerospace Engineering, School of Engineering, Case Western Reserve

Losing Our Minds: The Dancing Plague, The Salem Witch Trials, and the Problem with Mob Mentality

Meera MacMullen, B. A. in Medical Anthropology, College of Arts & Sciences, CWRU

Throughout history, societies have experienced mass events where people come together and exhibit the same behavior. In some of these events, people exhibit the same behaviors with seemingly no logical reason. To outsiders, it seems as if the people exhibiting these behaviors are blindly following a person or behavior. In cases like this, a crowd's behavior is explained by a concept called mob mentality. The Dancing Plague of 1518 is one of these cases. In medieval Austria, a woman named Frau Troffea took to the streets and danced. She danced for the entire day until she collapsed from exhaustion. However weeks passed and Frau Troffea did not stop dancing, and more people began to join her. The event lasted for a month and claimed over 400 people. The Salem Witch Trials are another one of these cases, where people were driven to accuse women of witchcraft and subsequently executed. With no logical medical explanation for either of these events, scholars have analyzed this event through the lens of mob mentality. This view was able to show how multiple people may have fallen in line with the same behavior, however the category of mob mentality leaves out a lot of important information about these events that may have contributed to the behavior that was exhibited. This paper looks at the society, religion, and medicine at the time of the Dancing Plague and the Salem Witch Trials to show how outside factors may have prompted these mass events, and how mob mentality may not be able to fully explain these behaviors.

Project Mentor: Dr. Lihong Shi, Department of Anthropology

Designing Artificial Intelligence to Identify Wood Frogs and Monitor their Activity

Maddie Maduzia, Department of Biology, CWRU

As the effects of climate change on woodland environments increase, it is crucial that we are able to observe how indicator species are impacted. A sample of wood frogs (Lithobates sylvaticus), an example of an indicator species, have been raised and monitored for the past year at the University Farm. Wood frog activity was monitored through photography, and it is hypothesized that the amount of movement and activity will increase as the climate increases. To determine if there is a relationship between climate change and wood frog activity, we designed and trained artificial intelligence (AI) to accurately identify wood frogs in photographs. A small, annotated set was used as a baseline for training and testing, while a larger, annotated set was used for full training of the system. Once the AI is fully trained, a new set will be introduced to both the AI and a trained student in the lab to compare the detection of the system to human detection. Once the AI is able to identify frogs at a rate higher than 90%, photographs can be fed into the system with ease and accuracy. The number of frogs present in each image will be calculated. This will save scientists hours of time that would have been spent analyzing hundreds of images. Frog activity trends will be easily calculated from the data created, as well. The AI system could also be extended to work efficiently with other frog species with the proper training.

Project Mentor: Dr. Mike Benard, Department of Biology

MiMo: A CWRU Subletting Service

Jakob Danninger (Computer Science, Case Western Reserve University),

Vibha Mandayam (Data Science and Analytics, Case Western Reserve University),

Neha Panduri (Computer Science, Case Western Reserve University),

Sydney Winner (Computer Science, Case Western Reserve University)

Many upperclassmen at Case Western Reserve University choose to rent off-campus apartments due to the limited availability and high cost of university housing. Subleasing between students fosters a sense of trust and community and is often the easiest way to deal with rental leases that do not align with the academic calendar. Our website MiMo aims to provide Case Western Reserve University students with a platform to advertise subleasing opportunities to other students. Unlike the existing off-campus housing website, MiMo is built for students to interact with one another in a trusted environment. With the central slogan “Moving in and Moving on,” MiMo will allow students to easily find sublets and connect with the sublessor. This web-based application will allow students to create profiles, post advertisements for subletting, post advertisements for potential sublease roommates, comment on posts, and message one another. The sublet advertisements will also indicate to other users whether or not the sublease’s advertised rent is a reasonable price utilizing data science methods based on market trends. MiMo will also allow users to filter posts based on their desired number of bedrooms, number of bathrooms, distance to campus, and other such factors. Built with an Angular Web frontend and a FastAPI backend, MiMo aims to simplify the process of finding and managing off-campus housing subleases for Case Western Reserve University students while also allowing students to understand the fairness of the listed rental prices. This goal is achieved by creating this trusted website and forming a stronger sense of community among the student population.

Project Mentor: Shuai Xu (Department of Computer and Data Sciences)

Long Term Adjustable Compression Sleeve for POTS Management

Rea Marfatia, Jake Stahl, Thomas Gaither, Benjamin Danielson

Academic Major: Biomedical Engineering (all)

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) and are unsatisfied with the current products' performance.

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

Stroke Rehabilitation Biometrics Tracking

Cole Judson, Department of Biomedical Engineering, CWRU; **Anna Mathis**, Department of Biomedical Engineering, CWRU; **Abdul Melaiye**, Department of Biomedical Engineering, CWRU; **Mohit Patel**, Department of Biomedical Engineering, CWRU

Stroke is a leading cause of long-term disability in patients, of which one notable aspect being reduced hand and arm function and mobility. It is noted that 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 in order 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 general overview of hand function without tracking 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 doing targeted therapy. To address this issue, our aim is to design a wearable device that measures force output exerted by individual fingers 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 silicone 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 wearable device will be designed with comfort and ease of use in mind, allowing full range of motion and ability to wear while performing daily activities. 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

Evaluation of Prediction Models for Kidney Transplant Failure

Misaki Matsuura, Data Science and Analytics, Case Western Reserve University

My research focuses on optimizing kidney transplant outcomes by evaluating and simulating policy adjustments in donor-recipient matching. Current allocation policies primarily use blood type; however, research suggests that other factors—such as donor and recipient age, race, and human leukocyte antigen (HLA) compatibility—significantly impact transplant success. Leveraging data from the Scientific Registry of Transplant Recipients (SRTR), I developed machine learning models to predict and rank recipient matches that would yield longer-lasting grafts and fewer re-transplants. Through simulations, I examined the potential benefits of adjusting current policies to incorporate these factors. The models, including Multi-Task Logistic Regression (MTLR) and DeepSurv, achieved significant accuracy improvements, indicating that incorporating factors like age, race, and HLA mismatches into the matching process could significantly reduce the number of re-transplants and increase graft longevity. However, integrating variables like race raises fairness concerns; for instance, prioritizing racial factors alone might exacerbate existing health disparities. This research balances the need for effective matching with ethical considerations, offering evidence-based insights for more informed policy changes in organ allocation to improve the quality of life for end-stage renal disease patients on the transplant waitlist, as well as for the healthcare systems managing these critical resources.

Project Mentor: Dr. Kevin Xu, Department of Computer and Data Sciences

Wash Table Fabrication for Paper and Textile Conservation

Jonathan Mazin, Mechanical Engineering, CWRU

Will Allen, Mechanical Engineering, CWRU

Noah Weiss, Mechanical Engineering, CWRU

Textiles and paper are common and fragile forms of art media. Preserving this media type requires large wash areas with mechanical and chemical specifications to increase longevity while preventing damage to the art. Our team was tasked by the Intermuseum Conservation Association (ICA) of Cleveland Ohio to design more accessible alternatives to current large-scale wash tables on the market. The design follows requirements provided by ICA and the conceptual design conducted in a previous student's 398 Capstone Final Report. The ultimate wash table design is achieved through iterative computer-aided design (CAD) on Dassault System's SOLIDWORKS software and collaborative revision with ICA conservators.

The table stayed under the $10,000 budget provided by the ICA while being more versatile than market competitors. The design incorporates pre-existing components reducing cost, fabrication complexity, and a more reproducible design. Some features include variable water capacity, multi-degree tilt on two axes, casters for maneuverability, adjustable height for a comfortable work experience, and multiple table compatibility.

Faculty Mentor: Dr. Sunniva Collins, Engineering

Capstone Instructor: Katheryn Daltorio, Engineering

Barriers to Diagnosing Autism Spectrum Disorder in Females

Caroline McAdam, Psychology, Case Western Reserve University

Autism spectrum disorder (ASD) is a neurodevelopmental disability that affects approximately 1 in 36 children in the United States. The ratio of males to females that are diagnosed with ASD by a qualified clinician was previously estimated to be 8:1, but as more research has come out in the last decade or so on how ASD symptoms manifest differently in females, the ratio has changed to roughly 4:1. The purpose of my narrative literature review is to evaluate and outline the specific barriers that keep women and girls from receiving an ASD diagnosis. I used the databases PsycINFO and Web of Science for finding relevant literature, and my outside disciplines include the British Journal of Special Education and Child: Care, Health and Development. According to my research, the most common barriers to acquiring an ASD diagnosis for women and girls are gender stereotypes, camouflaging (also known as "masking") behaviors, the Female Phenotype Theory (FPT) of ASD, and improper training for diagnosticians. This narrative review is limited by the overarching gender disparity in ASD research and diagnosis, and by a lack of quantitative data. It is imperative that systems are put in place that educate diagnosticians and families on how ASD symptoms can manifest differently in females, as well as how to look out for masking behaviors.

Faculty Mentor: Anastasia Dimitropoulos, Department of Psychological Sciences

Investigating the Localization and Function of Chromatin Remodeling Proteins in Yeast and Their Relevance to Neuronal Cells

Helena McHugh, Department of Neuroscience, Case Western Reserve University

The nucleolus plays a fundamental role in ribosome biogenesis, housing a network of proteins involved in transcription regulation. Among these are chromatin-remodeling proteins that facilitate nucleosome disassembly and transcriptional control. This study investigates the nucleolar localization and behavior of the chromatin remodeling proteins Arp4, Pob3, and Spt16 in Saccharomyces cerevisiae. By employing fluorescent imaging, we identified which proteins localize to the nucleolus and created fluorescent, arrestable strains for further analysis against known nucleolar markers. We analyzed the distribution of these proteins under conditions of transcriptional inhibition induced by thiolutin treatment.

Our analysis demonstrated notable changes in the spatial distribution after thiolutin exposure, suggesting a relationship between chromatin remodeling protein positioning and transcriptional activity. This research not only enhances the understanding of chromatin remodeling in eukaryotic cells but also lays the groundwork for studying the human homologs of Arp4, Pob3, and Spt16. Future work will use bioinformatics to explore their expression in various brain regions and cell types, potentially linking their roles to neuronal function. This integrative approach bridges the knowledge gap between yeast cell biology and complex neuronal processes, offering new perspectives on transcription regulation and chromatin dynamics in neural circuits.

Project Mentor: Dr. Alan Tartakoff, Department of Molecular Biology & Microbiology

Activation of PI3K/Akt and MAPK Pathways Through CysLTR1/2 Upon Exposure to Lipid Oxidation-derived Products in a Macrophage Model

Ian McIntyre, Biochemistry Major, Department of Chemistry, Case Western Reserve University

Cysteinyl leukotrienes (CysLTs) are potent inflammatory lipid mediators derived from the enzymatic oxidation of arachidonic acid and are implicated in cancer progression through the promotion of a supportive tumor microenvironment. CysLTs promote chronic inflammation and oxidative stress (OS) by increasing levels of reactive oxygen species (ROS). Our lab found that OS can also induce the radical-induced oxidation of AA, which leads to products that resemble CysLTs. We termed these radical-induced products pseudo leukotrienes (øLTs). Elevated levels of ROS can also activate leukocytes (e.g. monocytes, macrophages, etc.) which are involved in cancer by suppressing the immune response. Specifically, tumor-associated macrophages (TAMs) are involved in the reinforcement of this pro-tumorigenic loop, making CysLT pathways attractive targets for cancer therapy. We hypothesized that øLTs may mimic the activity of CysLTs, which further exacerbates this pro-tumorigenic loop. This lab has discovered two previously unreported pathways induced by LTD_4 and øLTD in a macrophage-like cell line, that activate inflammatory and stress responses through PI3K/Akt and MAPK pathways. To conduct this research, we used macrophages derived from Tohoku Hospital Pediatrics-1 cells (THP-1), a human monocytic leukemia cell line. We found that upon exposure to øLTD, upregulated both PI3K/Akt and MEK/ERK phosphorylation by 2.5-fold and 6-fold, respectively. Further research will aim to elucidate the role of øLTs by identifying and assessing the consequences of these pathways, such as the secretion of cytokines and chemokines (e.g. MCP-1, VEGF, TNF-alpha, IL-6). It is anticipated that this research will identify potential targets for the treatment of hematological cancers.

Project Mentor: Abby Hite (PhD Project Mentor), Department of Chemistry, Case Western Reserve University; Robert G. Salomon (PI), Department of Chemistry, Case Western Reserve University

Sciatic Nerve Branching and Anatomical Variation: Implications for Neuromodulation Strategies in Spinal Cord Injury Recovery

Alex McKnight, Department of Neuroscience, School of Arts and Science
Ashley Nemes-Baran, Department of Neuroscience
Andrew Crofton, Department of Anatomy

The sciatic nerve is the longest and widest nerve of the human body, originating from the ventral rami of the lumbosacral plexus before exiting inferiorly to the piriformis muscle via the greater sciatic foramen. The nerve typically runs posteriorly down the thigh before bifurcating into the tibial and common fibular nerves at the apex of the popliteal fossa. Typical motor branches include innervation of the posterior muscles of the thigh, the hamstring portion of the adductor magnus, and indirect innervation of the muscles of the leg and foot via its terminal branches, whereas typical sensory branching is limited to indirect innervation of the skin of the lateral leg, heel, and dorsal/plantar surfaces of the foot via its terminal branches. Thus, the sciatic nerve plays a critical role in the motor and sensory functions of the lower extremities. Current research lacks clarity regarding the normal anatomical variations of the sciatic nerve and its branches. Due to the use of the sciatic nerve in neuromodulation strategies for spinal cord injury patients, understanding these normal variations is crucial for optimizing neuromodulation strategies aimed at enhancing functional recovery after spinal cord injury. Previous research has shown that sex differences exist in the context of neurodevelopment, behavioral phenotypes, endocrinology, genetics, and epidemiology, suggesting that common anatomical variations may be distinct in males versus females. By comparing the branch numbers and relative sizes of the right and left lower extremities in both male and female cadavers, this study aims to enhance sciatic nerve stimulation models and support more informed surgical approaches for electrode implantation, ultimately improving treatments for spinal cord injury-related conditions such as neuropathic pain and motor impairments.

Robo-Advisor

James Telzrow, Computer Science, Case School of Engineering; **Jackson Dong**, Computer Science, Case School of Engineering; **My Le**, Computer Science, Case School of Engineering; **Sam King**, Computer Science, Case School of Engineering; **Max Zhang**, Computer Science, Case School of Engineering; **Saurav Giri**, Computer Science, Case College of Arts & Sciences; **Jonah Medina**, Computer Science, Case College of Arts & Sciences;

A robo-advisor is a system that provides automated, algorithmically-managed investment services with minimal human supervision. This system typically asks new users simple questions about their current financial situation and future goals in order to determine their risk tolerance. They have low fees, low initial investment, and are accessible via a web or mobile application; being an attractive prospect for those who prefer a simple, non-active approach to investing and financial management, delivering safe returns. Reflecting on the failure of Goldman Sachs's Marcus Invest product, we are developing a business-to-business Robo-Advising-As-A-Service platform that allows existing fintech platforms to offer access to simple algorithmically managed portfolios to: appeal to a users' individual risk tolerances, allow near-instant withdrawals, and have near-zero initial deposits.

Like most algorithmically managed portfolios, we will employ Nobel-Prize-winning Professor Harry Markowitz's Modern Portfolio Theory for asset selection and position sizing. Embracing diversification (holding a wide variety of uncorrelated assets) to protect against loss based on the idea that an asset's risk / reward should be considered in the context of its contribution to the portfolio overall; it provides an algorithm for constructing from a large set of assets and a portfolio that maximizes potential return given a fixed-risk threshold. Our system has an event-driven, service-oriented architecture, composed of a set of strongly-encapsulated service classes which adjusts holdings within a portfolio when: (1) new market data becomes available, (2) a user wishes to buy into the portfolio or (3) a user wishes to redeem their investment. We define and optimize our model using the Python library Cvxportfolio; and store data using a Postgres and Psycopg based data-store service through a simple in-memory approach based on pandas.

Project Mentor: Shuai Xu, Case School of Engineering

TrashScan: Gamifying Recycling through Computer Vision Detection

Lauren Eterno[1], Data Science & Analytics; **Joy Fan**[2], Computer Science & Psychology; **Zoe Goldberg**[1], Computer Science; **Arohi Mehta**[1], Computer Science; **Alessandra Puccio**[2], Computer Science & Psychology, Shuai Xu[1], Department of Computer & Data Sciences

[1]Case School of Engineering, [2]CWRU College of Arts & Sciences

Recycling is vital for reducing waste, conserving resources, and preventing pollution. While many people recognize recycling's value, consumer confusion regarding what is recyclable hinders the success of recycling, leading to the contamination of existing recycling or recyclable items being sent to landfill. However, a study performed by professors at the University of Utah [1] shows that through gamifying recycling, individuals become more engaged with, educated on the correct practices of, and informed on the impacts of recycling. To implement an engaging solution,, we introduce TrashScan, a mobile device application that allows users to scan items with their phone cameras to determine if they are recyclable using computer vision. Additionally, TrashScan promotes recycling habit tracking through goal dashboards, streaks, badges, and other rewards to keep users motivated. Users can also map and bookmark their recycling locations, making it easier to track where they have recycled and revisit those spots in the future. Users can gain progress towards their goals through growing the number of recycling locations they have visited. Weekly summaries, such as a "Recycling Wrapped," will highlight achievements, with the ability to share progress with friends. The app will also provide personalized notifications based on user goals and LLM suggestions to ensure continuous engagement. By leveraging advanced artificial intelligence technology and gamification, TrashScan empowers individuals to make informed recycling choices, fostering a culture of sustainability and increasing community recycling efforts.

[1] C. M. Werner and E. Makela, "MOTIVATIONS AND BEHAVIORS THAT SUPPORT RECYCLING," Journal of Environmental Psychology, vol. 18, no. 4, pp. 373–386, Dec. 1998, doi: https://doi.org/10.1006/jevp.1998.0114.

Effects of neuroprotective P7C3-A20 compound in a Type 1 diabetes mouse model.

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Diabetic retinopathy (DR) is a major microvascular complication of diabetes and one of the leading causes of vision impairment and blindness. It is characterized by retinal hyperglycemia, oxidative stress, inflammation, ischemia, and detachment but there are currently few known therapies that prevent or treat DR.

Neuroprotective compound, P7C3-A20 has been shown to reduce neuroinflammation, oxidative stress, and neurodegeneration while improving motor and cognitive control in mouse models of neurodegenerative diseases and disorders (i.e. traumatic brain injury, amyotrophic lateral sclerosis, Parkinson's disease). Here, we explore the effects of P7C3-A20 on early markers of DR.

The experiment consists of a control group (n=3) receiving the STZ vehicle (0.01M Sodium Citrate) and P7C3-A20 vehicle, STZ control group (n=4) receiving STZ and P7C3-A20 vehicle, and an STZ experimental group (n=5) receiving STZ (30mg/kg/day) and P7C3-A20 (10 mg/kg/day). A 3-day STZ/vehicle intraperitoneal (IP) injection period was followed by a 2-week P7C3-A20/vehicle IP injection period. Mice weights and blood sugars were obtained at the start of each week and IP doses were calculated and administered daily.

Blood and retinal P7C3-A20 levels are to be measured. Electroretinography (ERG) activity will be obtained and analyzed using a, b, and c-waves as well as light-adapted response amplitudes in response to a range of stimulus light intensities. ERGs serve as indicators for function and response to light stimuli. Immunohistochemistry techniques will also be used to investigate changes in inflammation by glial fibrillary acidic protein (GFAP) immunoreactivity and retinal cell death morphology. We hypothesize that P7C3-A20 will reduce retinal oxidative stress, inflammation, and degeneration. The outcomes of this experiment will determine if P7C3-A20 has preventative or therapeutic effects on DR and should be further investigated.

Project Mentor: Ivy Samuels, Ophthalmic Research, Cleveland Clinic Cole Eye Institute and Research Service, Louis Stokes VA Medical Center Medical Research Service

Faculty Advisor: Radhika Atit, Department of Biology, Case Western Reserve University

Advanced Testing of Printed Flexible Sensors: Contact Angle and Bending Fatigue Analyses

Emilio Blythe, Department of Biomedical Engineering, Department of Materials Science and Engineering, CWRU; **Oliver Meisel**, Department of Mechanical and Aerospace Engineering, CWRU; Janet L. Gbur, Department of Materials Science and Engineering, CWRU

Printed flexible sensors designed for nerve stimulation devices implanted in the upper arm are fabricated using aerosol jet printing, a novel technique for creating flexible electronics. Previous work has determined an optimal ink and substrate combination of a silver nanoparticle ink and amorphous silicon carbide (a:SiC) as well as developed an optimized set of printing and curing parameters. To support ongoing improvements, contact angle goniometry and mechanical testing are being investigated. Contact angle goniometry is employed to evaluate interactions between three silver inks and the a:SiC substrate by measuring the angle at which each ink meets the surface. This measurement provides essential data on adhesion and coating uniformity, key factors in selecting the ink that best interacts with the substrate. We expect that the ink with the lowest contact angle indicates enhanced surface wettability. These findings will support advancements in selecting inks for improved performance on non-metallic substrates. Additionally, a customized testing fixture and protocol were developed to evaluate the electrical and mechanical integrity of flexible sensors under bending fatigue. The fixture is compatible with a rotational actuator and was developed to test up to 4 sensors across 2 rods of customizable diameter. Samples are held in tension by a small counterweight at a stress far below the yield strength. Bending stress is applied to each sensor by rotating the arm 180° (0°±90) with a 1 Hz frequency. Data is collected continuously to monitor the electrical performance of the sensors. Bending fatigue data will provide chronic reliability information as it relates to the in vivo strains applied to the sensors. These two methodologies will further guide the design and properties of the printed flexible sensors.

Project Mentor: Dr. Janet L. Gbur, Department of Materials Science and Engineering

Hand Weakness Assistance Device

Eamon Kraft[1], **Lily McCloskey**[1], **Kate Menzer**[1], **Alexandria Miskey**[1], **Shaoqian Xiang**[1], Jordan Smith[1], Colin K. Drummond[1], Matthew Williams[1]

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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, fear of injury, lack of confidence, and social challenges. Consequently, improved HGS could increase the quality of life for geriatric patients. This work has sought to prototype a system that provides external support and strength for a geriatric user. Current devices on the market tend to perform well with stability support but can be inconvenient during donning and doffing. Our innovation aimed to resolve and improve these issues as well as address the overarching goal of increasing HGS. The solution concept we generated was a string faux-tendon glove that pulls the user's fingers into a fist, thus allowing for assisted gripping. This proposed device is more lightweight, easier to don and doff, more simplistic, and less expensive than current devices on the market. The mechanical design included materials and mechanisms meant to simulate hand and wrist tendon movement to assist with the completion of ADLs. Our ultimate goal for this device was to improve HGS in the geriatric population and allow them to complete ADLs independently which they previously struggled with.

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

Hydraulic Brake Master Cylinder

Simon Merenstein, Mechanical and Aerospace Engineering Major at CWRU School of Engineering;

The hydraulic brake master cylinder is a vital component of the braking system of an off-road vehicle, such as the one designed and built each year by the CWRU Motorsports Baja team. Currently, the team purchases Tilton master cylinders which are expensive and are not available in the optimal size for maximum braking efficiency on the vehicle. The objective of this project is to design a more compact, reliable, and cost-effective solution to enhance the vehicle's braking performance and decrease the overall cost of the vehicle. The design will be a ½ inch diameter master cylinder capable of stopping the car by producing high pressure. The project will start with a detailed CAD model of the entire assembly and finite element analysis (FEA) to ensure mechanical integrity. Upon completion, the master cylinder will be manufactured, assembled, and tested to validate its performance under high pressure, over 1000 psi. Further testing will demonstrate that the pressure generated in the master cylinder is proportional to the force applied to the brake pedal.

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

Clock Domain Crossing Data Synchronizer

Alessandro Meucci, Computer Engineering and Electrical Engineering, CWRU;

Andrew Cedar, Computer Engineering and Electrical Engineering, CWRU;

Viet Nguyen, Computer Engineering, CWRU; Department of Electrical, Computer, and Systems Engineering

High-level processing in modern technology relies on multi-core processor systems. Multi-core processing is essential in today's computing because it leverages parallel processing to boost performance and efficiency. To achieve optimal efficiency, multi-core systems operate at varying clock frequencies, which introduces the challenge of clock domain crossing. Clock domain crossing occurs when data moves between different clock domains, potentially causing timing issues such as setup or hold time violations. These issues can lead to metastability and data errors. An effective solution for managing clock domain crossing is to synchronize data through an asynchronous first-in, first-out (FIFO) component. In this design, the multi-core processor will include pipelined and unpipelined cores running at a slower clock speed, while memory operates at a faster clock. Since there are two different processors accessing the same memory, the issue of contention is also apparent. To handle the clock domain crossing, the asynchronous FIFO will synchronize data transfer between memory and CPU cores, while an arbiter will address the issue of memory contention by managing which core accesses the memory to fetch instructions. Every module will be developed in VSCode at the gate level in SystemVerilog, before its functionality is then verified through ModelSim, drawing on concepts from digital design, computer architecture, RTL design, and ASIC design. By constructing this project at the gate level, the group aims to not only gain a more thorough understanding of computer architecture fundamentals but also gain insight into the intricacies of hardware coordination, timing management, and efficient data transfer techniques, as well as practical experience in tackling the challenges involved in connecting and optimizing these elements within a cohesive system.

Project Mentor: Dr. Daniel Saab, Department of Electrical, Computer, and Systems Engineering, CWRU

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

Efficacy of Compound 18 in Inhibiting the SWELL1 Channel

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Platelet shape and volume changes are early mechanical events contributing to platelet activation and thrombosis. Volume regulated anion channels (VRAC) are mechanoresponsive anion channels which are expressed in many cell types and are activated in response to cell swelling and shape change. LRRC8A (leucine-rich repeat-containing protein 8A, also known as SWELL1) is the essential subunit of the heterohexameric LRRC8 VRAC and is required for functional VRAC in megakaryocytes and regulates platelet volume, adhesion to collagen-coated surfaces and agonist-stimulated activation, aggregation, ATP secretion and cytosolic calcium. Compound 18 is an analog of DCPIB, which inhibits SWELL1 by binding to a constriction point in the pore of the SWELL1 channel. Small molecule inhibitors of VRACs hold the therapeutic potential for the treatment of VRAC related diseases. This study examines the potential of Compound 18 to act as a small molecule inhibitor using whole cell patch clamp electrophysiology of MEG-01 megakaryocyte cells. Compound 18 showed negligible inhibition of SWELL1 at 20 μM, 66% inhibition at 10 μM, 73% inhibition at 5 μM, and 81% inhibition at 1 μM. A reverse dosing effect of Compound 18 on inhibiting the SWELL1 channel was observed, likely due to the precipitation of Compound 18 in hypotonic solution. The final effective concentration of Compound 18 was determined to be <1 μM, and we determined the IC50 of Compound 18 to be 7.920 μM. Compound 18 has the potential to act as a small molecule inhibitor for the therapeutic treatment of VRAC related diseases.

Project Mentor: Rajan Sah, MD, PhD, Department of Internal Medicine, Cardiovascular Division, Washington University School of Medicine, St. Louis, Missouri, USA

Beyond the Bad Kid Label: Unpacking the Link Between Conduct Problems and Suicidality in African American Youth

Malcolm Miller, Department of Psychological Sciences and Department of Sociology, CWRU

The rates of completed suicides among African American youth has skyrocketed in the past two decades to new highs. With particularly high rates among African American boys and men, LGBTQ+ African American youth, and youth ages 11-17 years old these rates sit high above that of suicide rates for other racial groups. This population is also overpoliced, over-incarcerated and more involved in their schools' disciplinary systems then youth of other races. Strikingly, Black youth are disproportionately redirected to care for behavioral symptoms of mental health disorders and receive poor quality care when they do see mental health providers. This research aims to perform a quantifiable exploration of the association between conduct behavior problems and suicidality. Statistical analysis was completed using data from two longitudinal studies: Project Alliance 1 and Project Alliance 2 that surveyed 500+ youth as they grew from age 11 to their mid-twenties. Conduct behavior was measured using youth self reports of actions such as stealing, truancy, and hitting others. Suicidality was measured as a dichotomous variable that indicated that a young person had experienced frequent thoughts of dying, participated in self-harm behavior, wanted to take their life and/or other endorced other characteristics of suicidality. The results indicate that African American youth experience a significant positive correlation between high rates of self-reported conduct behavior and suicidality. The research also suggests that this relationship was unique to African American youth and was not present in other racial groups represented in the study. Further research should explore possible mechanisms of this relationship such as experiencing carceral punishment or lacking mental health care.

Project Mentor: Dr. Arin Connell, Department of Psychological Sciences, CWRU

Bioinspired Magnetic Navigation: Modeling the Performance of Different Navigation Strategies in a Time-Dependent Magnetic Field

Nathan Mitchell, Department of Mechanical Engineering, Case Western Reserve University

Many animals are theorized to use magnetoreception to navigate across vast distances; these animals are theorized to be able to sense and use the Earth's magnetic field as an internal compass to aid in long-distance migration and navigation. Loggerhead sea turtles are one of many such animals. Understanding how these animals use the magnetic field can facilitate the design of navigation technologies utilizing the Earth's magnetic field, which is more reliable and robust than traditional satellite-based technologies. The goal of this project is to use a simulation, created by Dr. Brian Taylor et. all, to determine how an agent, or sea turtle, can continue to navigate to the same location as the Earth's magnetic field shifts over time. This simulation models how a loggerhead sea turtle could follow lines of constant magnetic field intensity and inclination to navigate to different goal locations. The simulated agent used adaptive remembrance strategies to reach its assigned goals over time. The performance of these strategies was evaluated over both short and long time scales. It was found that over short time scales, where the simulated magnetic field-coordinate space was modeled to rotate and translate by a small amount, linearly across time, the agent was, for the most part, able to make it to its assigned goals. Over long time scales and when the field rotated and translated by varying large amounts, the strategies, for the most part, failed to allow the agent to navigate to its goals. Future efforts should focus on developing navigation algorithms that investigate and account for non-linear movements of the magnetic field over time.

Project Mentor: Dr. Brian Taylor, Department of Mechanical and Aerospace Engineering

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

Mosquito Takeoff and Flight Dynamics in Response to Aversive Low-Frequency Sounds

Skylar Monjure, Biology, Case Western Reserve University; **Lauren Roskuszka**, Biology, Case Western Reserve University

Mosquitoes are the primary contributors to vector-borne disease cases in humans, which 80% of the population is vulnerable to, and understanding their behavior is crucial for potential control efforts. Preliminary evidence shows that flying mosquitos respond with a negative phonotaxis to sound stimuli within the 140-200Hz range. Preliminary evidence shows that flying mosquitos respond with a negative phonotaxis to sound stimuli within the 140-200Hz range. In this project, we asked if Aedes aegypti mosquitoes respond to auditory stimuli in both quiescent and flying animals. Another fly, Drosophila melanogaster is known to use rapid steering mechanisms to alter their flight paths when presented with aversive stimuli mid-flight. Similar escape takeoffs to visual stimuli have been documented in mosquitoes. However, as with flying mosquitoes, their behavioral reactions to auditory stimuli also remain understudied in this behavioral state. Our research examines whether Aedes aegypti exhibits comparable behaviors. To test this, we presented mosquitoes with auditory tones of 180 Hz (putatively aversive), 300 Hz (neutral), and 450 Hz (attractive). We used high-speed cameras to record mosquitoes which were either freely flying in an enclosed space or standing stationary on a platform. We collected recordings of stimulus-evoked mosquito trajectories and body orientation changes. These and other measurements including wing-beat frequencies and leg raises were then digitized and analyzed using custom MATLAB programs. So far our findings suggest that females display a stronger escape response to sounds played at 180Hz and males respond to both 180Hz and 450Hz. This apparent sexual dimorphism may reflect neural activity recordings from neck connectives which revealed sex-specific differences in sensitivity to low-frequency stimuli. This behavior may be exploited as a new method of mosquito control.

Project Mentor: Gabriella Wolff Dept. of Biology, Case Western Reserve University

Evaluating Bilingual Speech Perception Using a Japanese Speech Recognition Test

Minami Moriuchi, Department of Psychological Sciences, Communication Sciences, CAS - College of Arts & Sciences

Background: The increasing population of non-native English speakers in the United States highlights the need for effective speech perception assessments in multiple languages. Research indicates that non-native listeners encounter significant challenges in understanding speech, especially in noisy environments. This issue is pronounced for individuals with communication disorders, and there is a lack of appropriate assessment tools and evidence-based interventions that can be used to serve these populations.

Purpose & Objectives: The purpose of this study is to create inclusive testing materials for second-language learners of English to be used within US audiology clinics. Specifically, the primary objective is to develop Japanese sentence test materials adapted from the Basic English Lexicon (BEL) sentences, which were developed to assess speech recognition for second-language learners of English (BEL; Calandruccio & Smiljanić, 2012).

Methods: 500 BEL sentences have been translated into Japanese using AI technologies (ChatGPT and Google Translate). The translated sentences are being analyzed by a native-Japanese speaker for correctness and accuracy. Two sentence forms have been created: polite and plain, catering to different social contexts. Synthetic voices are being used to produce all Japanese sentences. Japanese/English bilinguals will be recruited to listen to the sentences in the presence of speech-shaped noise. Each listener's speech recognition thresholds (SRT) will be evaluated for both Japanese and English. Participants will also complete a Bilingual Linguistic Profile so that we can understand their linguistic background (BLP; Birdsong et al., 2012).

Expected Outcomes: We hypothesize that native Japanese speakers will exhibit better (more negative) SRTs for Japanese sentences than English sentences. Furthermore, we anticipate that BLP data will predict SRT outcomes across both languages.

Key Words: sentence testing, non-native listeners, Japanese speech recognition test

PI: Dr. Lauren Calandruccio, Department of Psychological Sciences, Communication Sciences

WWVB Monitor Display System

Jeremiah Mubiru, Bachelor of Science in Electrical Engineering

Several timekeeping systems and clocks in North America rely on a broadcast WWVB (60 KHz) time signal to determine time. It is therefore of the utmost importance that the signal's integrity is viable for ensuring accuracy of the time set for such systems. A WWVB monitor display system would provide a way to evaluate the signal's quality at a location to determine its accuracy and reliability for timekeeping purposes. The information from the system would be used to give accurate diagnostics on the signal integrity allowing for accurate system optimizations to be done in order to deliver accurate time data to timekeeping systems. The system contains a Raspberry Pi computer connected with a microcontroller processor that is responsible for data collection and processing of information from the time signal. The information is then passed to a User-interface to display the signal's diagnostics. The development of the system's firmware is implemented using C++ in order to leverage the language's fast computation capabilities which is crucial to ensure accuracy of the displayed time signal data. The display system is intended to be distributed to third parties with elaborate documentation for usage.

Project Mentor: Professor. John Gibbons, Department of Electrical, Computer, and Systems Engineering.

The Benefits of "Sharenting" to Parents and the Psychological Harm to Children: a Review of the Literature

Sadie Mueller, Psychology, Cognitive Science, Case Western Reserve University

Sharenting– the practice of parents or primary caregivers posting content of their children on social media including images, videos, and sensitive information– is an emerging phenomenon that is being facilitated by the increased presence of social media in our daily lives. The existence of influencers and family vloggers whose primary genre of content is child-focused draws attention to the scale of sharenting and provides a more extreme example. Sharenting of the average parent more often consists of images and updates on facebook or instagram detailing daily occurrences, special achievements, or asking for advice. The purpose of this comprehensive narrative literature review is to examine the psychosocial benefit provided to parents through the practice of sharenting as well as the potential for psychological harm inflicted on children who are the subjects of sharenting. Relevant research was identified through the APA PsycInfo database using the search terms “sharenting, risks, children or kids or youth or child, influencers, and parent posting”. Concurrently, evidence indicates that parents are motivated to participate in sharenting due to a variety of positive and reinforcing impacts including community building, parenting advice, positive engagement on posts by followers, and the creation of a digital “diary” of the child. Simultaneously, older children and adolescents who have been made the focus of their parent’s social media content may face psychological distress during crucial years of development due to the feeling of limited autonomy over how they are presented online. It is important to draw attention to sharenting practices to strike a balance between support and benefit to the parent and limited risk to the child.

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

Exploration of Cannabis-Induced Executive Function Impairments on Academic Performance in College Students

Abigail Mukete, Psychology, Case Western Reserve University

The use of cannabis in the college setting has increased in prevalence over the past years, especially after the recent changes in state policies and the effects of the COVID-19 pandemic. Executive function, an array of skills used by the brain that allow individuals to complete everyday tasks, plays an important role in a college student's academic performance. However, using cannabis runs the risk of executive function impairments that can negatively impact the academic performance of college students who use it. While research highlights the effects of cannabis-induced executive function on adolescents, research on its effects on college students is limited. This paper is a comprehensive narrative literature review that explores the associations between college student cannabis use with executive function and lowered academic performance. PsycInfo, SCOPUS, Science Direct, and Web of Science were databases used to find literature; and keywords such as executive function, college students, and cannabis were used. Overall, literature has been found to support the idea that cannabis use can negatively affect executive function, however only memory, attention, and inhibition are significantly impacted. This can contribute to the decreased academic performance that is associated with cannabis in college students. Limitations of the present research are addressed, and further investigations are needed to examine the causality between cannabis-induced executive function impairments and academic performance. However, this characterizes a potential need for more awareness of the cannabis effect in the classroom.

Faculty Project Mentor: Anastasia Dimitropoulos, Psychological Sciences

Characterizing CG1907 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. We can investigate allometric growth using Drosophila melanogaster; during larval stages, tracheal cells stop dividing and instead grow and extend lengthwise as the organism continues developing. We know from previous work that tracheal specific cell growth is under genetic control. This project characterizes a novel mutation (l(3)12265) located in the third chromosome of Drosophila melanogaster that results in an overgrown, highly convoluted trachea phenotype. Genetic mapping of the mutation suggested that the gene CG1907 may be responsible for the l(3)12265 phenotype. We tested whether CG1907 is the gene behind this mutant phenotype, and if so, what role other tracheal regulatory genes such as Uninflatable play in the phenotype. 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. Ubiquitous expression of CG1907 interference caused the mean trachea length to be statistically larger than wildtype trachea. Next, antibody staining was conducted to view the relative levels of Uninflatable and coracle, a gene involved in apical-basal cell polarity, in both wildtype and in l(3)12265 flies. This stain revealed that Uninflatable levels are increased in the l(3)12265 mutants. PCR testing will be conducted to further elucidate if increased expression of Uninflatable is responsible for creating the phenotype. Lastly, a P-element excision will be conducted to generate a mutant allele of CG1907 to examine how the loss of this gene impacts tracheal growth. This data will be compared with previous data to confirm if CG1907 is the gene causing the mutant phenotype.

Project Mentor: Dr. Robert Ward, Department of Biology, CWRU

Determination of notoungulate dietary preferences using enamel growth rates

Grant Mussemann, Department of Biology; Dr. Scott Simpson, Department of Anatomy; and Dr. Darin Croft, Department of Biology, CWRU

Between ~53 and 3 million years ago, South America was separated from the other continents. This facilitated the evolution of unique mammals such as notoungulates: extinct, ungulate-like herbivores, many of which had ever-growing (a.k.a. hypselodont) teeth. While modern rabbits and some rodents are hypselodont, no living, hooved mammals are. The goal of our study is to investigate whether all hypselodont notoungulates were grazers, as traditionally assumed based on their teeth. As a first step, we investigated enamel secretion and extension rates for two Middle Miocene (16-12 million-year-old) notoungulates from Bolivia – a toxodontid and a mesotheriid. These rates vary with diet in extant ungulates and can be studied via striae of Retzius: periodic structures created during enamel secretion that can be visualized with polarizing light microscopy. Distances between successive striae can be used to calculate daily secretion rate (DSR), and the angle between striae and the enamel-dentine junction can be used to calculate enamel extension rate (EER). Our preliminary results for the toxodontid indicate a DSR of ~28.82 μm/day and an angle of ~3.33°, resulting in an EER of ~181 mm/year. This is the highest rate yet recorded for a mammal, but is reasonable considering the EER of rabbits is 62.4 mm/year and that toxodontids are > 2 orders of magnitude larger. For the mesotheriid, DSR is ~33.68 μm/day, the angle ~4.69°, resulting in an EER of ~150 mm/year. These data suggest a correlation between EER and body mass in hypselodont species, contrary to what is observed in other mammals.

Project Mentor: Dr. Darin Croft, Department of Biology, CWRU

Machine Learning Traffic Flow Optimization

Liban Ahmed, Electrical Engineering; **Colin Myers,** Electrical Engineering; **Ethan Wilner,** Electrical Engineering

Current traffic control systems rely on static timers, basic computer algorithms, or costly human monitoring. The first two options lack the ability to adapt to the dynamic changes in a traffic environment. Traffic patterns change constantly as time passes, the environment changes, or driving habits change. Human monitoring systems can account for this change, but need constant supervision and are costly. Our system would function with the intelligence of human monitoring while utilizing the cost-effectiveness of a computer controlled intersection. Our solution will utilize counting technology to get an accurate gauge of traffic flow in real-time. Our method of counting will use Banner Laser sensors to detect vehicles moving by. These sensors detect vehicle presence, measure speed, and monitor the time intervals between vehicles. With a precise range of up to 25 meters, the lasers will cover the full length of the road. The motion data will be collected and counted via a Raspberry Pi in our device. This data will be sent to a computer with the machine learning algorithm calculating the wait time for each signal. Our machine-learning algorithm will use data from the laser sensors to detect vehicle presence and traffic flow in real-time. Analyzing the frequency and duration of vehicles passing through intersections allows the system to identify congestion patterns. The algorithm will then dynamically adjust traffic signals based on this data to optimize traffic flow, reduce delays, and minimize idle time. This integration of intelligent traffic monitoring and adaptive control demonstrates significant potential for cost-effective traffic optimization while highlighting the robustness of our solution.

Faculty Instructor: Dr. Greg Lee, Electrical, Computer, and Systems Engineering, CWRU

Project mentor: Dr. Christian Zorman, Electrical, Computer, and Systems Engineering, CWRU

Analysis of Astrocyte Morphology in Astrocytic Deficient VPS35 Mice

Ananya Nadgauda, Neuroscience B.S and Philosophy B.A, College of Arts and Sciences

VPS35, a component of a retromer protein complex responsible for recycling transmembrane proteins, has been linked to neurodegenerative diseases such as Alzheimer's and Parkinson's. Previous research from our lab has shown that VPS35 plays a key role in blood vessel (BV) development, including in the blood brain barrier (BBB). Using a GFAPcre VPS35^{FF} line showed that BV development was affected. VPS35 was knocked out in both developing neurons and astrocytes. Since astrocytes are critical to BBB formation and maintenance, the effects of VPS35 KO in astrocytes are an area of interest regarding neurodegenerative pathology.

To study this, we used the mouse ER system to specify VPS35 KO in astrocytes and targeted the P10-12 developmental stage – a key time for astrocytic development. We induced the KO in GFAPcreER VPS35^{FF} Ai3 mice via tamoxifen injection at P6 and then imaged individual astrocytes using 3D Airyscan imaging. GFAPcreER Ai3 mice were used as controls. When comparing the variables branch length, overall branch area, and cell body area using the microscopy image analysis software Imaris, astrocytic VPS35 KO mice had lower values than control mice. These results suggest a correlation between VPS35 KO and altered morphology of astrocytes.

These morphological differences could play a role in the reduced function of the VPS35 proteins and possibly affect overall astrocytic function. Since astrocytes are involved in BBB function, dysfunction could be a key factor in the disease state seen in many neurodegenerative disorders. A future point of interest would be analyzing the morphology of VPS35 KO astrocytic endfeet processes on BVs in the BBB to conclude whether astrocytic morphological dysfunction could contribute to BBB dysfunction.

Project Mentor: David Friel, Neurosciences; Wen-Cheng Xiong, Neurosciences, School of Medicine

Uncovering Polarity Markers in Border Cell Migration: Impacts of Septate Junction Protein Knockdown

Amita Nanda, Biology B.S. and Medical Anthropology B.A. at Case Western Reserve University

Border cell migration, a morphological process in Drosophila Melanogaster egg chambers, is used as a model system to study collective cell migration, an important process with roles in tissue morphogenesis, wound healing, and cancer metastasis. Within an egg chamber, polar cells secrete signaling molecules that recruit nearby follicular somatic cells to surround them, forming clusters of cells that migrate between nurse cells to the anterior side of the oocyte. Septate junctions, occluding junctions within Drosophila Melanogaster, are not formed yet during border cell migration, but have been found to have functions independent of their occluding junction role. We have found, using the GAL4-UAS system and antibody staining, that knockdown of multiple types of septate junction proteins leads to incomplete border cell migration, failure of the cell cluster to delaminate, or the dissociation of this cell cluster during migration. Potential hypotheses are that septate junction proteins may contribute to the actual polarity and orientation of border cells in order to migrate to their destination, adhesion of the border cell cluster, or movement of the structure via actin/myosin contractions. To further investigate the mechanisms of border cell migration, the GAL4-UAS system was used with wildtype flies and mutant KuneRNAi (a septate junction protein) knockdown flies and antibody staining was conducted for 10 different types of polarity markers within Drosophila Melanogaster. The identification of polarity markers which differ between varying septate junction protein expression may provide a pathway for future research and further understanding of the mechanisms underlying border cell migration.

Project Mentor: Robert Ward, Department of Biology, Case Western Reserve University

Does Culturally Responsive Mindfulness compared to Standard Mindfulness increase classroom engagement and decrease Behavioral Disruptions in 4th-5th grade students?

Angel Nieves, Psychology & Cognitive Science, Case Western Reserve University

This study explores the effectiveness of culturally responsive mindfulness practices in enhancing classroom engagement and reducing behavioral disruptions among 4th and 5th grade students in predominantly Black, low-income schools. Traditional mindfulness interventions have shown benefits in stress reduction, emotional regulation, and improved focus. However, such practices often lack cultural relevance, or are culturally neutral, potentially limiting their effectiveness in diverse populations. This research investigates whether a culturally responsive approach to mindfulness, tailored to reflect the cultural values and lived experiences of African American students, can outperform standard mindfulness practices in terms of student engagement and behavioral outcomes. Using a mixed-methods design, this study implements a culturally adapted mindfulness curriculum over five weeks, integrating themes of self-empowerment, interdependence, and storytelling. Outcomes are measured through teacher-and-staff reported engagement and behavior scales, as well as observational student assessment on mindfulness and emotional regulation. Preliminary findings from similar studies suggest that culturally responsive interventions can enhance students' sense of belonging, relevance, and emotional comfort, which may contribute to greater mindfulness engagement and sustained behavior improvements in the classroom setting. This research aims to contribute to culturally inclusive education practices and provide practical insights for schools into how mindfulness can be effectively integrated into elementary classrooms to enhance learning environments.

Project Mentor: Fey Parrill, Cognitive Science

Novel Methods of Communication for Non-Communicative Patients

Caleb Oh, Biology, Case Western Reserve University

Locked-in syndrome is a state where an individual is fully paralyzed, yet has full consciousness and cognitive ability. This issue is associated with patients with extensive pontine stroke, severe spastic quadriparesis, and late-stage amyotrophic lateral sclerosis. With so many conditions leading to locked-in syndrome, novel methods of non-verbal communication are emerging such as brain-computer interfaces (BCIs) and Biomusic. This review article will compare the multiple types of brain-computer interface and Biomusic technologies, focusing on how these methods can be applied to non-communicative patients and the ethics of their use. BCIs explored here include electrocorticography (ECoG), electroencephalography (EEG) and magnetoencephalography (MEG). Additionally, the basics of speech-related brain regions and electrode placement, the types of neural decoding algorithms used, and the success rates of the classification and speech onset and offset detectors will be discussed. Biomusic will also be addressed, including the physiological monitoring involved and possible future research directions. Finally, given the presented information, it is suggested that future projects should research methods to capture brain activity deeper into the brain to check for speech signals previously un-captured by electrodes due to decreased sensitivity with increased depth. Overall, this article discusses BCIs, important parts of the brain to record data on, the types of decoding algorithms of this data, success rates of classification of speech and speech onset and offset detection, Biomusic, and future research directions.

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

Assessing the Availability of Firearm Injury Prevention Information on State Public Health Department Websites

Isaac Opoku, Department of Sociology, CWRU

Firearm mortality and morbidity is a preventable public health emergency in the United States. Public access to evidence-based prevention strategies and firearm injury data are essential to addressing this crisis. State public health departments have a critical role to prevent firearm deaths, and it is unknown if firearm injury prevention materials and data are publicly available across state based public health websites. For each state, the following data elements were collected: state name, website URL, date accessed, and the most recent CDC state firearm mortality rate. Search words were decided by researchers using common language terminology. Web based resources were evaluated and scored from 0-3 based upon the ready availability of public facing media toward three key types of firearm safety information: safe firearm storage, firearm injury prevention, and firearm injury data. Chi-squared test was used to examine associations between availability of resources and state rates of firearm associated deaths. There is significant variation among states for easily available and updated firearm injury prevention information and firearm injury data on state public health websites. Addressing firearm morbidity and mortality in the US requires a broad, coordinated, and comprehensive public health approach. Despite the urgency of gun violence as a public health crisis, state level public health departments inconsistently prioritize this issue in their public facing information. Health advocates and providers must push for increased public health attention to gun violence at the state level.

Project Mentor: Dr. Sarah Sweeney, Population Health and Equity Research Institute, MetroHealth System

Evaluating the toxicity of different small molecule compounds designed based on PEP213

Michelle Orioha, Nutritional Biochemistry and Metabolism, Psychology, Case Western Reserve University. Taylor Wilcox, Medical College of Wisconsin. Michael Widlansky, Division of Cardiovascular Medicine, Medical College of Wisconsin.

Mitochondrial fission protein 1 (Fis1) has been linked to the health and function of microvasculature. Increased Fis1 appears to drive vascular disease in diabetic patients by inducing oxidative stress that leads to a decline in endothelial nitric oxide availability, leading to endothelial dysfunction. From a drug standpoint, pep213 was designed to inhibit Fis1 and subsequently prevent an impaired endothelium-dependent vasodilation in diabetes. However, pep213 due to its size and formulation will not make a good drug in clinic. Therefore, we performed cytotoxic assays on small molecule compounds designed based on Pep213. HUVEC cells were treated with increasing concentrations (12.5-300 μM) of each potential Fis1 inhibitor molecule (identified as 188, 278, and 288) and were incubated for an 18-hour period. Cell titer glo was used to assess luminescence.

HUVEC cells under normal glucose conditions and at. a 2 x 106cells/ml concentration showed a high luminescence after an 18-hour incubation with compound 188. The 18-hour incubation with compound 278 resulted in low luminescence except for at the lowest concentration (12.5 μM). Compound 288 showed lower luminescence at higher concentrations and higher luminescence at lower concentrations. Each compound was tested in triplicates on the plate for each specific concentration. Information collected about the various compounds suggests that compound 278 is too toxic for further testing, while compounds 188 and 288 have fewer toxic properties and can be moved forward to test for biological effects.

Project Mentor: Taylor Wilcox, Medical College of Wisconsin.
Faculty Mentor: Michael Widlansky, Division of Cardiovascular Medicine, Medical College of Wisconsin.

How does sleep deprivation influence dietary choices, particularly in terms of caloric intake and nutrient balance?

Sophia Osilaja, Case Western Reserve University
Major: Cognitive Science
Minor: Spanish

For my project, I am analyzing how sleep deprivation influences eating habits, specifically through dietary choices and nutrient balance. The average college student receives around 6 hours of sleep per night, while the recommended amount is 7 - 9 hours. There are many students who don't even sleep a full 6 hours per night. How does that affect their dietary choices during their waking life? Will they end up choosing higher calorie foods as results? Are people who receive adequate sleep more likely to make healthier eating choices? I will be answering these questions, and many more through a visual collage style art project. I am having my classmates collect data for me regarding their sleep and eating habits. I will then compile a full day's worth of the food they reported and photograph that. My plan is to compare the varieties of food and different food groups compared to the number of hours slept. Then I will compare and contrast the results of my project to the research I've done this semester.

Advancing Multilayer Plastic Recycling: Optimized DPD Simulations of Polymer-Catalyst Interaction

Mohamed Otefi, Mathematics and Physics, Case Western Reserve University

With over 150 million tons of plastics used in packaging, more than 25% are multilayer systems that combine different functional characteristics. Multilayered films, a common type of packaging plastic, generally contain polyethylene (PE) and polyethylene terephthalate (PET). Thus, recycling efforts targeting these films often focus on the depolymerization of these polymers. A promising method is catalytic cracking using zeolite structures, which breaks down polymer chains for more effective recycling. To enhance recycling efficiency, we integrate mesoscale computational modeling to optimize catalytic degradation, inform on microstructure development, and assess rheological behavior. Dissipative Particle Dynamics (DPD), a coarse-grained simulation method, is used to capture mesoscale interactions between the catalyst surfaces and polymer chains. However, current DPD modeling techniques offer limited performance and adaptability for our complex use case. This work addresses these limitations with two primary goals. First, we advance simulation capabilities for DPD by developing a specialized codebase tailored to simulate polymer-catalyst interactions, implementing various techniques to accurately model bond-breaking rates. Second, we optimize computational performance through advanced software and hardware techniques, leveraging CPUGPU architectures to match or exceed the performance of established frameworks like LAMMPS. Ultimately, our project aims to build a data-driven, machine learning-enhanced simulation pipeline, laying the groundwork for efficient and scalable modeling of polymer recycling processes.

Project Mentor: Dr. Soumya Ray, Department of Computer and Data Sciences, CWRU

Faculty Sponsor: Dr. Joao Maia, Department of Macromolecular Science and Engineering, CWRU

Effect of PBM on metabolism and persistence T cells

Antonio Padilla-Barroso, Biology B.S., Case Western Reserve University

Chimeric antigen receptor (CAR)- T cell therapy is a form of immunotherapy that directs immune cells to a tumor associated antigen by an engineered receptor. CAR-T cells have achieved significant success in treating hematological malignancies, such as B cell lymphomas and leukemias. Though, its efficacy against solid tumors remains inadequate major obstacle is the tumor microenvironment (TME) that is characterized by immunosuppressive factors that induce T-cell exhaustion and inhibit proliferation. These factors include inhibitory cytokines, hypoxic conditions, antigen escape, and metabolic competition for nutrients, all of which diminish the efficacy of CAR-T cells. Photo biomodulation (PBM) is the application of a non-surgical treatment that uses light to regenerate cells and tissues. Currently, there are uses for pain relief, inflammation reduction, and cell healing and tissue repair. PBM can be applied to T cells to improve proliferation, metabolic activity, and exhaustive state. While the exact mechanism is not known, literature suggests that laser treatment increases cellular respiration, leading to ATP production and increased metabolic activity. We have seen an increase in proliferation ex vivo at 30mW/0.5J treatment and aim to show in vivo expansion post PBM treatment. We also aim to show a decrease in exhaustive state and increased metabolic activity. Future studies will focus on elucidating the molecular mechanisms underlying PBM-induced metabolic changes and assessing the therapeutic potential in in vivo models of solid tumors.

Project Mentors:

Jude Franklin, MS., Department of Biomedical Engineering, School of Medicine

David Wald, MD, PhD, Department of Pathology, School of Medicine

Sarah Bagby, PhD, College of Arts and Sciences

Rheology of Dense Suspensions with Attractive Inter-particle Forces under Shear Reversal

Ryan Pappalardo, Department of Chemistry, 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. The quantification of these contacts 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 cerebral blood flow regulation in the absence of Hb ßCys93 in a murine exercise model

Joshua Park, Biochemistry BS, College of Arts and Sciences; Rongli Zhang, MD, PHD, School of Medicine; Jonathan Stamler, MD, School of Medicine

Tissue hypoxia is associated with oxygen delivery through the regulation of microvascular blood flow, a process known as blood flow autoregulation. Recently, it has been recognized that hemoglobin (Hb) plays a dual role, functioning not only as an oxygen transporter but also as a regulator of microvascular blood flow through the allosterically coupled release of vasodilatory S-nitrosothiol (SNO) in response to hypoxia. In vivo studies with β-globin Cys93Ala (βCys93Ala) mutant mice, which lack S-nitrosohemoglobin (SNO-Hb), exhibit significant impairments in microvascular blood flow and tissue oxygenation, mirroring microcirculatory dysfunction observed in various clinical conditions. However, the role of SNO-Hb in the regulation of cerebral blood flow (CBF) is unexplored, despite its essential significance. In normal physiology, exercise is known to acutely increase cerebral perfusion. Here, we demonstrate that β-globin Cys93Ala (βCys93Ala) mice with impaired SNO bioactivity are deficient in acute exercise-induced microvascular perfusion and tissue oxygenation increase in the cerebral cortex (n = 20). Thus, these results demonstrate that βCys93-derived SNO bioactivity is essential for normal cerebrovascular regulation during exercise, and possibly hints at other roles in CBF regulation for SNO-Hb.

Mentor: Rongli Zhang, MD, PHD, School of Medicine

PI: Jonathan Stamler, MD, School of Medicine

Characterizing Auditory Escape Responses In Aedes aegypti Mosquitoes

Apple Patel, Department of Cognitive Science, Case Western Reserve University; Dr. Gabriella Wolff, Department of Biology, Case Western Reserve University; Dr. Michael Rauscher, Department of Biology, Case Western Reserve University

With mosquito-borne illnesses spreading into new territory with climate change, it has become increasingly important to understand the basic biology of mosquitoes in order to combat disease transmission. Mosquitoes rely heavily on their auditory system for fitness as it plays a role in courtship and mating. Recently, studies have shown that the auditory system may also be used to mediate a predator escape response in mosquitoes. Lapshin and Vorontsov (2018) found repellent effects when sound stimuli in the 140-200 Hz range were played for male Aedes diantaeus mosquitoes. Negative phonotaxis was observed suggesting these sounds may represent signals of aerial predators such as dragonflies and birds. Here we used a tethered flight behavioral paradigm to characterize auditory escape responses in male and female Aedes aegypti mosquitoes by tracking the kinematics of their responses to a range of sound stimuli. High speed videography showed sound stimuli in the 140-200 Hz range elicited increases in wing amplitude and wingbeat frequency. Directional steering changes in the head and wings were frequently observed, but did not clearly reflect the azimuth of the originating sound stimulus. Males responded to the stimulus with a slower time to peak wing amplitude response compared to females, indicating a sexual dimorphism not observed in visually mediated escape behaviors. Our results are consistent with the hypothesis that mosquitoes respond to low frequency sound stimuli with escape steering maneuvers, which may provide information towards future efforts in developing novel methods of mosquito control.

Project Mentors: Dr. Gabriella Wolff, Department of Biology; Dr. Michael Rauscher, Department of Biology

TerraBite: Smart Pantry Management and Recipe Suggestions for Sustainable Grocery Optimization

Caroline Schafer, Department of Computer and Data Sciences; **Jessica Norek**, Department of Computer and Data Sciences; **Patrick Cahill**, Department of Computer and Data Sciences; and **Amala Penumaka**, Department of Computer and Data Sciences, CWRU

In a world facing increasing environmental challenges, sustainable consumption practices are essential. For multi-member households, such as families or roommates, shared pantry management complicates sustainable meal planning and grocery shopping. TerraBite is a smart pantry management and recipe suggestion system specifically designed to address this issue by promoting eco-friendly practices. Acting as an intelligent, user-centric platform, TerraBite integrates digital pantry tracking with personalized recipe recommendations, helping users make the most of the ingredients they already have.

Leveraging artificial intelligence, TerraBite offers recipe suggestions based on items in each household member's pantry, their shopping lists, and shared food preferences, all aimed at reducing unnecessary purchases and preventing food waste. In addition, TerraBite encourages users to prioritize ingredients that are already partially used in their pantry, promoting responsible and sustainable consumption habits.

The TerraBite system architecture includes a user-friendly frontend interface that emphasizes sustainability, alongside a robust backend. Built with a tech stack comprising React, Django, and PostgreSQL, the platform provides efficient inventory tracking and recipe recommendation capabilities. The backend database securely stores user data, enabling seamless updates and accurate tracking.

Through TerraBite, our team aims to contribute to sustainable living practices, demonstrating how technology can effectively support waste reduction while promoting a more mindful approach to food management. TerraBite's design reflects our commitment to using software engineering for environmental impact, offering households a practical solution for sustainable food consumption and waste reduction.

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

Anti-Depressive Effect of Deep Cerebellar Stimulation in Prefrontal TBI Rodent Model

Alexandra Pérez Robles[1], Dr. Hugh Chan[2], Dr. Kenneth Baker[2]

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Traumatic brain injury (TBI) often leads to post-traumatic depression, characterized by symptoms of anhedonia, apathy, and anxiety, for which effective treatments are limited. In this study, the effects of deep brain stimulation (DBS) of the cerebellar nuclei on depression-like behaviors were examined using a rodent TBI model. Eight adult Long Evans rats underwent controlled cortical impact (CCI) TBI targeting the medial prefrontal cortex (mPFC). After four weeks of post-TBI observation, DBS electrodes were implanted in the lateral cerebellar nucleus (LCN) of the right hemisphere, with stimulation (STIM+; n=4) or sham (STIM-; n=4) treatment administered for four weeks. Depression-like behaviors were assessed using the sucrose preference test (SPT) for anhedonia, the normal grooming test (NGT) and sucrose grooming test (SGT) for apathy, and the elevated plus maze (EPM) for anxiety-associated behaviors. Results showed DBS-treated animals exhibited greater sucrose preference in the SPT and longer grooming time in the NGT when compared to untreated controls, suggesting a DBS-mediated improvement in anhedonia and apathy. However, no decline in grooming time during the post-TBI phase was observed in the SGT of the STIM- animals. On the EPM, TBI lesioned animals spent more time in the open arms, suggesting increased risk-taking behavior associated with TBI. Furthermore, the average number of head dips over the EPM, another risk-taking behavior, was greater in the STIM- rodents when compared to the STIM+ group. In conclusion, LCN DBS treatment improved prefrontal TBI-mediated anhedonia and apathy, though its effects were less conclusive in relation to anxiety and risk-taking behaviors. Although additional research is needed to clarify the mixed effects observed across grooming tests, these findings support a potential therapeutic approach of LCN DBS on chronic TBI-induced deficits.

Project Mentor: Dr. Kenneth Baker, Department of Neurosciences, Lerner Research Institute, Cleveland Clinic

Biologically Inspired Rat Robot Design

Huy Pham, Department of Aerospace and Mechanical Engineering, Case Western Reserve University.

This interdisciplinary research presents the design and development of a biologically inspired rat robot. The robot is scaled up to 2.5 times the size of a female Sprague-Dawley rat. The hindlimbs are each equipped with 4 motors to control the hip, knee, and ankle rotation in the sagittal plane, and internal/external hip rotation. The forelimbs are equipped with five motors to control the scapula, shoulder, elbow, and wrist rotation in the sagittal plane, as well as abduction/adduction of the scapula. Additionally, the hands and feet of the robot are comprised of two sections, connected with a pin and torsional springs. This allows the feet to have passive compliance and better conform to the ground while walking. The leg segments are based on a scanned rat bones model with shapes modified for ease of assembly and 3D printing. Parts are printed using micro carbon fiber filled nylon, strengthened by various amounts of continuously inlaid carbon fiber. The scapula, shoulder, and hip joints are directly driven by motors, while the lower joints are driven by motors using a pulley-belt transmission system. This allows the motors to be mounted higher up on the leg, reducing the legs inertia. This robot serves as a physical platform to test and make predictions about the control system and how the animal may interact with the environment in a more realistic way than in simulations alone.

Project Mentor: Professor Roger Quinn, Department of Aerospace and Mechanical Engineering (CWRU)

RADAR Velocity Measurement

Minh Phan, Department of Electrical, Computer, and Systems Engineering.
Trang Nguyen, Department of Electrical, Computer, and Systems Engineering.

The primary objective of this project is to design and implement a portable, Bluetooth-enabled, radar-based speed detection system for monitoring the velocity of Big Wheels during the Cleveland Big Wheel Relay, a fundraising event for the Cleveland Hearing and Speech Center. Traditional velocity measurement systems are costly, less portable, and unsuitable for real-time public display. This project addresses these limitations by developing a low-cost, mobile device based on an ESP32 microcontroller and an HB100 Doppler radar sensor, which calculates speed via Doppler frequency shifts.

The system architecture integrates several critical components: (1) an amplifier circuit that amplifies the HB100's microvolt-level output to a desired over 2.5 volt signal, suitable for sampling by the ESP32's onboard ADC; (2) a battery-powered design with a custom charging circuit, equipped with a USB-C interface; and (3) a minimal custom PCB housing to support the sensor, amplifier, and charging circuits if time allows. Signal processing algorithms developed in Arduino sample the HB100's output, enabling real-time speed measurement of objects moving along to the sensor's boresight. Additional code uses the ESP32's Bluetooth to send speed data to a computer application for display, updating at over 1 Hz. On the user end, we developed a Python program that receives data transmitted from the ESP32, and displays the speed in real-time. Once connected, the program receives speed data as a string and updates a live display to show the speed measurements accurately.

Faculty Project Mentor: GregoryLee, Department of Electrical, Computer, and Systems Engineering.

Informed Copilots: Analyzing the Benefits of RAG for FrameNet Lexical Unit Generation

Charlie Prince, Cognitive Science, Case Western Reserve University

As LLMs develop rapidly and ingrain themselves in diverse domains, they provide new opportunities for researchers looking to extract novel insights and expedite their methodologies. In the field of cognitive linguistics, researchers are undertaking a concerted effort to develop and expand linguistic networks such as FrameNet, a database consisting of interconnected semantic frames. Recent work has established that, through careful prompt engineering, LLMs can aid FrameNet researchers by suggesting novel frames and lexical units (LUs) evoking said frames (Turner et al., 2023). While results are promising, this process can be optimized by the implementation of retrieval-augmented generation (RAG). Two processes crucial for FrameNet expansion, LU generation and multilingual FrameNet building, stand to benefit from RAG implementation; In this experiment, RAG allowed the LLM to access information from FrameNet's interconnected semantic frames, synthesize information from the target frame and related frames, and generate accurate LUs. To assess multilingual capacity, the RAG-based LLM was instructed to generate LUs in both English and French. Initially, contextual FrameNet information was provided manually to simulate RAG. Then, two RAG models with full, autonomous access to FrameNet data were built using OpenAI and Mistral LLMs. During English LU generation, access to frame data allowed RAG models to match, and in the case of the OpenAI model, exceed standard LLM performance while greatly reducing user input. Furthermore, retrieved data allowed for proficient generation of French-language LUs, providing FrameNet content for a target-language in FrameNet expansion efforts. These results indicate that optimized, RAG-based LLMs give researchers a powerful computational tool as they seek to understand and document the linguistic phenomena underlying human experiences.

Faculty Mentor: Dr. Mark Turner, Department of Cognitive Science, Case Western Reserve University

Physiologic Parameters and Ergonomics in an Operating Room For Anterior Cruciate Ligament Reconstruction

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1. Orthopaedic Surgery, University Hospitals Drusinsky Sports Medicine Institute

2. Department of Biology, Case Western Reserve University

Orthopaedic surgeons are prone to operating-related musculoskeletal overuse injuries due to the high volume of surgical procedures conducted. Studies have shown that up to 97% of orthopaedic surgeons experience procedure related musculoskeletal pain. Many orthopaedic surgical procedures lack optimal ergonomics and are demanding on the body. The aim of this study is to examine the physiologic parameters and ergonomics of an anterior cruciate ligament (ACL) reconstruction. Physiological and motion data was collected through five Movesense sensors that possessed accelerometer, gyrometer, and EKG sensors. Sensors were attached on the surgeon's skin over the xiphoid and left and right lateral triceps and over the scrubs on the cap and beltline. Steps of a bone-tendon-bone (BTB) autograft for ACL reconstruction were noted during the procedure, and the time of each step was recorded. Data was collected on flexion/extension, left-right rotation, abduction/adduction, and internal/external rotation. Ergonomically damanding positions were determined as >20 degrees of movement from neutral position for the neck, thoracic, and lumbar postures, and >45 degrees of movement for the left and right arm. Analysis was performed in Matlab using the IMUfusion package to estimate joint angles. The right arm [22.2%] and neck postures [47.3%] of the surgeon spent a large percent of time during an ACL reconstruction in an ergonomically demanding position. The left arm [13.3%], thoracic [15.8%], and lumbar [6.3%] postures spent a lesser percentage of time in an ergonomically demanding position. ACL reconstruction places significant ergonomic strain on the necks and right arms of an orthopaedic surgeon. Targeted ergonomics education and technology should be utilized to increase surgeon productivity by optimizing management of injuries.

Project Mentor: Andrew Moyal, Orthopaedic Surgery, University Hospitals

Faculty Sponsor: Michael Benard, Biology, Case Western Reserve University

Exploring the role of Asprosin in Anxiety Regulation

Andrew Qian, Department of Biology, CWRU; Bijoya Basu, School of Medicine, CWRU; Dr. Atul Chopra, School of Medicine, CWRU and Harrington Discovery Institute

Anxiety disorders are widespread, affecting millions and creating a significant impact on individuals and healthcare resources. Current treatments are often insufficient, with many patients experiencing limited relief or adverse effects. Identifying new pathways in anxiety regulation is essential for developing more effective and targeted therapies to improve patient outcomes. Previous research into the hormone, asprosin, found that it is released from white adipose tissue during fasting and responsible for stimulating the liver to release glucose into the bloodstream, helping maintain blood sugar levels. This study investigates the potential of asprosin, a fasting-induced hormone, in modulating anxiety behaviors. Our study employs a combination of mouse behavioral assays including Open Field, Light/Dark, and Elevated Plus Maze to evaluate the role of asprosin in anxiety. First, we found that both genetic ablation and pharmacologic inhibition of asprosin decreases the anxiety phenotype. We also found that heterozygous whole body knockouts of asprosin's receptor Protein Tyrosine Phosphatase receptor delta (Ptprd) also led to decreased anxiety. Finally, increasing levels of asprosin in mice through our adeno-associated virus, serotype 8 (AAV8) line increased the anxiety phenotype in mice. To further investigate the mechanisms by which asprosin influences anxiety behaviors, our current research focuses on identifying the specific neural pathways involved in this modulation. Asprosin binding competition assays showed that many regions in the forebrain including the hippocampus and amygdala had strong asprosin binding. We therefore have generated a partial brain Ptprd KO using the CaMKIIa-cre line to see if these regions in the forebrain are implicated in modulating anxiety via asprosin-Ptprd signaling. Our findings could have significant implications for developing treatments targeting asprosin-mediated pathways in anxiety disorders.

Faculty Project Mentor: Dr. Atul Chopra, School of Medicine, CWRU and Harrington Discovery Institute

Development of a Reliable Protocol for Accurate Quantification of GFP Using a Plate Reader

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GFP (green fluorescent protein) is a popular reporter for visualization and measurement of relative gene expression in cells or animals. However, currently GFP measurement is relative and accurate quantitative measurement of GFP protein levels in cells and tissues remains a challenge, especially for inter-study comparisons of GFP expression levels. This project aims to establish a fast and reliable protocol for accurate quantification of GFP protein in animal tissues using a standard fluorescence microplate reader. We optimized assay conditions and microplate reader settings to maximize signal-to-noise ratios and established a linear standard curve for quantitative enhanced GFP (EGFP) measurement in mouse tissues. This was done by (1) optimizing buffer composition and pH, tissue homogenizing procedure, (2) identifying assay time window with stable signals, and (3) adjusting plate reader settings such as excitation, emission, and the gain. Brain tissue from mice with no GFP expression (negative control) was homogenized and spiked with various amounts of recombinant EGFP (reference GFP). The GFP fluorescence was measured with a plate reader and plotted against the concentrations of the spiked EGFP, which established a linear standard curve for EGFP measurement for mouse brains that allows for quantitative measurement of EGFP in the range of 0.01-0.50 ng/µl. This protocol was successfully used to measure EGFP levels in the brain of an EGFP-expressing transgenic mouse line. Quantitative measurement of GFP levels for other GFP variants and/or in other tissues or cells can be achieved by establishing respective standard curves. Our simple GFP measurement protocol produces accurate quantitative GFP protein data that can be directly compared between experiments and between studies, which should greatly enhance the value of GFP as a reporter.

Mentor/Principal Investigator: Dr. Qingzhong Kong, Department of Pathology, Case Western Reserve University School of Medicine

Capstone Faculty Sponsor: Dr. Vivien Yee, Department of Biochemistry, Case Western Reserve University School of Medicine

Behind-the-Ear EEG Monitoring Device for Temporal Lobe Epilepsy

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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. As such, patients diagnosed with TLE experience a wide range of cognitive and emotional symptoms including hallucinations, panic, anxiety, and fear. To ensure patient safety during seizures, it is necessary to monitor TLE to detect seizure onset and alert patients and family members. The current standard of care involves a week-long hospital stay in an epilepsy monitoring unit. These are expensive, lack portability, and disrupt patients' lives. 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. Design components include two electrodes placed on the tragus and temporal bone, for reference and electroencephalogram (EEG) signal recordings, respectively. EEG signals are collected by an Arduino Nano 33 Sense Rev2 Board and additional information is transmitted through a Bluetooth low energy (BLE) module. In addition to spike counting as a means of seizure detection, we utilize the machine-learning capabilities of the board to improve detection accuracy. Our next steps will be to miniaturize the design with a custom printed circuit board (PCB) and encapsulate the device in a durable and flexible 3D-printed housing. Additionally, we plan to develop a phone app to allow the user and other clinicians to track seizure occurrences.

Faculty Mentor(s): Dr. Matthew Williams and Dr. Colin Drummond, Department of Biomedical Engineering, Case Western Reserve University.

Development of a nanobody-based C1q inhibitor that suppresses classical pathway of complement activation

Vigasini Rajaram: Department of Biology, Case Western Reserve University, Cleveland, OH 44106, United States of America

The complement system is a crucial part of the innate immune response and consists of a series of proteins that need to be activated through one of the three pathways—the classical, alternative, or lectin pathways—to be functional. Key roles of the complement system include fighting invading pathogens and clearing immune complexes to maintain homeostasis within the body. However, overactivation of a complement pathway can cause tissue damage that leads to the development of various diseases. Therefore, complement inhibitor-based therapies that specifically block one complement pathway can be utilized to combat complement overactivation and treat the resulting diseases. C1q is an essential component for classical pathway activation and therefore is a possible therapeutic target for certain classical pathway complement activation-mediated diseases. Nanobodies, unique single-chain antibodies derived from camelids, are considered the next generation of antibody-based therapeutics. In this project, we developed a panel of anti-C1q nanobodies by immunizing an alpaca with purified C1q and constructing a phage display library out of its B cells. We first identified C1q-binding nanobodies by ELISA and subsequently screened this panel of C1q-binding nanobodies using a complement classical pathway activation functional assay. We identified two C1q function-neutralizing nanobody clones that inhibited the classical complement activation cascade. These two clones, Anti-C1qNab1G8 and Anti-C1qNab1B10, could be further developed as potential therapeutics for certain classical pathway complement-mediated diseases.

Project Mentor: Fritz Petersen, PhD, Department of Biology, Case Western Reserve University, Cleveland, OH 44106, United States of America

Principal Investigator: Feng Lin, PhD, Department of Inflammation and Immunity, Lerner Research Institute, Cleveland Clinic, Cleveland, OH, 44195, United States of America

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Network Analysis of Non-Brownian Strongly Bidisperse Dense Suspensions

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Dense suspensions may undergo shear thickening where the suspension's viscosity increases dramatically with applied stress. Above a critical volume fraction frictional contacts between particles emerge with applied stress. Discrete element simulations can replicate shear thickening behavior by taking into account the resulting frictional contact network. Traditionally, these simulations are bidisperse only insofar as to prohibit crystalline ordering. However, recent works have examined the effects of strongly bidisperse systems with varying proportions of larger particles on viscosity. Using novel network theory approaches by our research lab, we characterized the frictional contact network to propose a mechanism by which microscopic bidispersity affects bulk behavior. The insights unveiled by this network theory approach reveal a breakdown of traditional analysis methods and calls for a more generalized approach to analyzing dense suspensions.

Bayesian optimization for obtaining optimal aerosol jet printing processing parameters for production of thin, precise, conductive silver electrical traces

Daniel Rakowsky, Department of Biomedical Engineering, Case Western Reserve University

Aerosol Jet printing (AJP) is a direct-write additive manufacturing method in which metallic inks are aerosolized, carried by gas flows, focused to achieve a collimated flow, and deposited on a substrate. This technique has a printing resolution on the order of tens of microns, and has potential applications in flexible electronics, smart textiles, and implantable biomedical devices. A key challenge for commercial application of this technology is identifying optimal printing parameters (e.g., atomization voltage, gas flow rates, platen temperature, print speed, etc.) for each ink-substrate pairing. We have previously studied the individual and interactive effects of printing parameters on the products of AJP produced from silver nanoparticle and precursor inks. The design of the experiment for this previous work was based on the Taguchi fractional factorial orthogonal array method. These data were used as a prior for batch bayesian optimization, which will fine-tune our previous recommended processing parameters. Bayesian methods can accomplish this by testing the input design space more continuously than the discrete orthogonal array method. Due to restrictions of time we have leveraged a batch bayesian optimization method using expected improvement, probability of improvement, gaussian upper confidence bound, pure explore, and pure exploit acquisition functions simultaneously. By testing the design space in this way, we may identify new parameters that improve product conductivity, printing precision, or trace width.

Project mentor and faculty sponsor: Janet L. Gbur, Department of Materials Science and Engineering, Case Western Reserve University

Forecastical: A Modern Weather App for the Digital Age

Alexander Ratte[*], Preston DeLeo[*], Theo Molina Wong[*], Pranav Dhinakar[*], Esteban Linarez[*], Grant Konkel[*]

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Forecastical is a modern weather application for the modern digital age. It gives users an improved weather interface, implementing artificial intelligence and machine learning models to actively update the weather using real-time data provided by the community.

Forecastical would not be a weather app without providing basic features expected from a standard weather app, such as the temperature, forecast and precipitation chances as well as more niche values such as UV index and air quality.

Our weather app, however, goes far beyond a standard weather app. As an application built for users, Forecastical gives real-time recommendations for users' clothing, tools, and activities based on the current weather, generated through the random forest technique. Another key innovation is Forecastical's interface for users to upload images of the current weather in their area. Users will also have the ability to view the most recent images others have posted. We also ensure that posted images are actually of weather by validating the images using a computer vision model. We also introduce community sentiment analysis where we calculate and display the community opinion on the day's weather by running an large language model on user-posted comments. Traditional weather applications are outdated and lack the advanced technology integration users now expect. Forecastical exists to challenge this.

Project Mentor: Shuai Xu, Department of Computer Science, Case Western Reserve University

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 of various proteins. The classic role of PRMTs is to regulate gene transcription and the splicing of RNA to form different genetic products. 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 identified specific differences in genetic transcription and alternative RNA splicing that occur as a result of PRMT1 and PRMT5 inhibition. By combining in silico RNA sequencing analysis with in vitro tumor cell culture, PCR, and gel electrophoresis, we 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 promoted more intron retention, whereas PRMT1 inhibition promoted more exon skipping. This knowledge of PRMT inhibitor effects at the genetic level could be used to refine PRMT inhibition approaches to cancer treatment.

Faculty Project Mentor: Dr. Daniel McGrail, Center for Immunotherapy & Precision Immuno-Oncology, Cleveland Clinic Lerner Research Institute

Military Culture and Mental Health Stigma: Reproduction of Stigma and the Effects on Treatment-Seeking Behavior

Esha Rawat, Department of Psychological Sciences and Sociology

Military culture has long been founded on the beliefs of physical and mental strength, promoting service members to perform to the best of their abilities. In recent years, there has been a cultural shift towards becoming more constrictive, instilling the idea that weakness and failure of any kind are not acceptable within the military (Cogan et al., 2021). This mindset shift has been to the detriment of many soldiers, specifically impacting their mental health. Service members and veterans make up more than 6% of the United States population (Moore, et al. 2023), however, more than half of veterans do not seek mental health treatment due to factors regarding stigma, professional barriers, loss of pride, or perceived weakness. This comprehensive literature review examines how military culture produces and propagates both perceived stigma and self-stigma and how this impacts help-seeking behavior among service members and veterans. To locate relevant articles, keywords used were “military culture,” “mental health stigma,” “active duty,” and “veterans” in databases like Google Scholar, National Library of Medicine, PubMed, and ScienceDirect. Literature review suggests that military leadership styles and the military identity perpetuate the association of weakness especially as it relates to mental health. Furthermore, the lack of promotion of treatment and adequate resources have prevented many service members from taking the perceived risks associated with seeking mental health care (Cogan et al., 2021). These findings support the assertion that military culture promotes negative self and perceived stigma towards mental health issues which decreases the likelihood of treatment-seeking behavior amongst veterans and service members with mental health concerns.

Faculty Mentor: Anastasia Dimitropoulos, Psychological Sciences

Epigenetics and its Role in Cancer, Developmental Disorders, and Mental Health Disorders

Sarah Reilley, Department of Biology, Case Western Reserve University

The study of epigenetics examines changes in gene expression that do not involve alterations in the DNA sequence. These modifications can be influenced by environmental factors such as stress, diet, or early-life experiences. Although the genetic code remains unchanged, these changes can have significant implications for various health conditions, including cancer, developmental disorders, and mental health issues. This paper provides a comprehensive review of existing literature on how environmental factors like diet, stress, and pollutants, affect gene expression and contribute to conditions such as cancer, developmental abnormalities, and mental health disorders through epigenetic mechanisms. With cancer, epigenetic changes have been linked to various types, including breast, lung, bladder, and esophageal cancers. Multiple studies highlight the potential use of circulating biomarkers, such as cell-free DNA (cfDNA) and microRNAs (miRNAs) for early detection, though challenges in specificity and accuracy persist. As for developmental disorders, studies emphasized environmental influences such as nutrition, maternal factors, and maltreatment could potentially lead to epigenetic changes in genes associated with social behavior and neurodevelopment, such as OXTR and GAD1, influencing conditions like autism spectrum disorder (ASD). Regarding mental health, the literature consistently points to epigenetic modifications affecting the NR3C1 gene, which regulates stress responses, therefore being implicated in disorders like depression. Furthermore, studies suggest a bi-directional relationship, where mental health disorders exacerbate epigenetic alterations. While consistent patterns are seen across studies, variability in the direction of methylation changes (whether higher or lower) suggests individual differences. Future research should emphasize the reliability of epigenetic biomarkers for early disease detection, develop epigenetic therapies to reverse gene silencing, and conduct longitudinal studies with larger participant groups to better understand the long-term effects of epigenetic modifications.

Project Mentor: Jean Burns, Department of Biology, Case Western Reserve University

Combination Treatment for Systemic Sclerosis (Scleroderma) Using PUVA (psoralen plus ultraviolet A) Light Therapy and Antifibrotic Therapies

Martina Richter, Biology, Case Western Reserve University

Systemic sclerosis, a form of scleroderma, is an autoimmune rheumatological disease characterized by the accumulation of fibrous connective tissue in the skin and internal organs, resulting in their progressive stiffening and eventual loss of function. It is incurable, which is why therapies aiming to slow the pace of systemic sclerosis are the most common in treating this illness. The pathology of systemic sclerosis, which includes the overactivity of fibroblasts that leads to dermal fibrosis, may indicate that a combination of two common treatments may be more successful in addressing the effects of systemic sclerosis on essential organs.

Temporary treatments such as PUVA (psoralen plus ultraviolet A) light therapy are successful in targeting overactive connective tissue, however are not able to be continuous for long periods of time due to the risk of UV radiation. Meanwhile, antifibrotic treatments interfere with the metabolism of collagen that leads to stiffening of skin, however, there are significant side effects, which highlight the urgent need for further research into targeted therapies. More novel treatments such as hematopoietic stem cell transplantation are modeled off of approaches that have had success in lung fibrosis patients, and, although also risky, are promising for people with systemic sclerosis. Other novel treatments address diseases with similar pathologies and symptom manifestations, such as targeted biological therapies for lung fibrosis, as this is a symptom of late stage systemic fibrosis. These therapies block the protein that is responsible for inflammation; IL-6.

This paper explores novel treatment avenues, emphasizing the potential combination of phototherapy with antifibrotic agents, and suggests further investigation into fibroblast behavior and concludes that a multifaceted approach integrating current and emerging treatments may provide a pathway to improved patient outcomes.

Faculty Mentor: Dr. Nicole Crown. Department of Biology, Case Western Reserve University

PORG (Processing Of Real-time Gestures)

Adam Rohrer[1], **Clay Preusch**[1], **Mariana Davis**[1], **Samuel Lovvoll**[1], Shuai Xu[1]

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American Sign Language, or ASL, is a visual language that uses movements in the hands, arms, and face to express meaning. The Rhode Island Commission on the Deaf and Hard of Hearing estimates that over half a million people throughout the U.S. use ASL to communicate as their native language. Despite ASL's prominence, there exists a significant communication barrier between ASL-speakers and those who cannot sign. Our solution provides a way for an ASL-speaker and someone unfamiliar with the language to communicate in real-time.

PORG is an application that will allow American Sign Language (ASL) speakers to communicate with non-ASL speakers using sign language alphabet translation. The program consists of a video platform to record or upload a video of an individual signing a series of letters. Then, the program will translate the signs into written English. PORG hopes to be an application used by both people who primarily use ASL to communicate and people who have never learned the language.

PORG will address current issues in state-of-the-art ASL translation technology. These current limitations include a heavily restricted set of recognizable characters and a strictly-enforced slow signing rate of 1 character per second, when the average ASL speaker signs at five to eight letters per second. We combine an image classification model with a time-series model to process ten signs per second and account for dynamic signs such as J and Z which include a non-static component. Furthermore, we host both the website and the inference server on the AWS cloud to ensure uniform performance agnostic of the user's device specifications.

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

Runtime Analysis and Improvement for Polarization Sensitive Optical Coherence Tomography (PS-OCT) Imaging via High-Performance Computing

Brianna Ross - CWRU Biomedical Engineering (BSE) and Computer Science (BS)

Atrial fibrillation is an incredibly common tachyarrhythmia caused by abnormal electrical activity in the atria of the heart. It is commonly treated with ablation therapy that attempts to isolate the source of the abnormal electrical activity by thermally damaging the surrounding heart tissue. Unfortunately, these procedures do not have a high success rate due to the inability to visualize the location and size of the damage. A promising alternative to provide information about the damaged tissue is polarization-sensitive optical coherence tomography (PS-OCT).

A currently existing algorithm that uses PS-OCT measures birefringence in attempts to identify pathology in the heart. This algorithm has an incredibly slow runtime that would prevent future clinical applications. To address this, initial runtime analysis was conducted and high-performance computing techniques including graphic processing unit (GPU) utilization and parallel processing were applied to improve the runtime. All optimization and analysis were done on 10 frames of a volumetric image containing thousands of frames to prevent memory related errors. Using these two methods of high-performance computing reduced the runtime from 20.991 seconds to 9.047 seconds. It is important to note that MATLAB's Profiler, the program used for analysis, does not provide exact runtimes and because it also needs resources to run, the true runtime is slightly faster than the provided estimates. In the future, alternative strategies such as load balancing can be applied to further improve runtime. Unfortunately, additional testing showed that further optimization of GPU utilization through CUDA core coding is incompatible with many necessary functions of the algorithm.

Project Mentor: Michael Douglass, Department of Biomedical Engineering, CWRU; Andrew Rollins, Department of Biomedical Engineering, CWRU

Temperature and Acoustic Analysis App for Coffee Roasting

Benjamin Rubinstein (Aerospace Engineering, CWRU)

Stephen Hostler, Mechanical and Aerospace Engineering

We present an IoT-based approach to acoustic analysis of coffee roasting. As more consumers engage in home roasting, the need for accessible tools to monitor and optimize roasting processes becomes increasingly apparent.

This project introduces a novel open-source device designed to measure coffee roast temperatures and monitor the acoustic signals generated during roasting. The two primary acoustic phenomena, known as "cracks," serve as indicators of the roast development stages and are analyzed using audio recordings processed through a Short Time Fourier Transform. Additionally, temperature data is collected using a thermocouple and a microcontroller, allowing for comprehensive monitoring of the roasting process. This project aims to support novice home roasters in achieving consistent and personalized roast profiles, thereby enhancing the overall coffee brewing experience.

The Rising Prevalence of Irritable Bowel Syndrome (IBS): Uncovering the Causes, Challenges, and Potential Solutions

Isabella Russo, Department of Biology and Psychology, Case Western Reserve University

Irritable Bowel Syndrome (IBS) is a chronic gastrointestinal disorder characterized by abdominal pain, bloating, and changes in bowel habits including diarrhea, constipation, or both, that severely impacts quality of life. This disorder has emerged as a global health issue, affecting 4% to 16% of the U.S. population. It is the most common diagnosis made by gastroenterologists, straining healthcare systems. Despite its prevalence, IBS has no identifiable structural cause. Here, I survey the recent proliferation of research on IBS, and I propose that the multifactorial etiology of IBS demands a holistic and personalized treatment approach that addresses both underlying causes and comorbidities to improve patient outcomes and halt the increasing prevalence of this disorder. Gut-brain axis dysregulation can lead to IBS by interfering with the communication pathways between the central nervous system and gastrointestinal tract, affecting digestion, pain perception, and stress response. Factors such as stress, emotional disturbances, abnormal serotonin levels, and altered vagus nerve activity collectively disrupt gut function. Modern lifestyle factors and stressors in America have increased the likelihood of developing IBS. Poor mental well-being, including anxiety and depression, can trigger chemicals in the brain that turn on pain signals in the gut, increasing the risk of developing IBS. Experiencing adversity in childhood can increase vulnerability to IBS, as early-life trauma can lead to dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis, resulting in abnormal cortisol levels. Furthermore, dysbiosis in the gut microbiome alters both the composition and function of gut bacteria, subsequently impacting immune response, gut motility, and sensitivity. The Western diet, often high in processed foods and low in fiber, further promotes gut inflammation and microbial imbalance, escalating IBS risk. These findings demonstrate that IBS is driven by multiple factors. Treating IBS successfully will require an integrative, personalized approach from a team of specialized providers that can address the disorder's diverse causes.

Project Mentor: Ronald Oldfield, Department of Biology, Case Western Reserve University

Investigating novel neuronal regulators of DLK signaling

Ramza Ryan, Department of Neurosciences, Case Western Reserve University

The Dual leucine zipper kinase (DLK) pathway plays a crucial role in regulating synaptic growth and response to axonal injury. This signaling pathway is conserved across species, and the fly homolog of DLK, Wallenda (Wnd), has been implicated in synaptic growth and response to injury in Drosophila motor neurons. Beyond its role in regeneration and synaptic growth, the Wnd/DLK pathway has been implicated in axonal degeneration
processes, suggesting its dual involvement in multiple downstream responses to injury. Upon injury, Wnd expression increases, initiating the regenerative response by signaling for nuclear changes that activate genes required for axonal growth and branching. Activation of this signaling cascade also activates a molecular reporter through transcriptional changes in the nucleus, the JNK phosphatase puckered. Activation of this pathway is cell autonomous, and it is used as an indicator of active Wnd/DLK signaling. To further understand the role of Wnd in regulating axonal growth and response to injury, my lab conducted a screen to identify novel Wnd inhibitors. To do this, we utilized the puckered reporter and through RNAi-mediated knockdown of neuronal proteins in motor neurons, we identified many neuronal proteins that could potentially negatively regulate Wnd under normal conditions. To further evaluate our hits from the primary screen, I conducted a secondary screen using an additional assay for Wnd activation, a reduction of the postsynaptic scaffold protein Discs-large (Dlg) at the Drosophila neuromuscular junction. By assessing changes in both puckered (puc-lacZ) and discs large (Dlg) protein expression levels, we aim to identify genetic regulators that influence DLK-mediated injury response and axonal growth. While still ongoing, this work aims to clarify the complex roles of DLK signaling in both regenerative and degenerative pathways, which could provide insights into therapeutic targets for neurodegenerative disease.

Project Mentor: Dr. Heather Broihier, Department of Neurosciences, Case Western Reserve University School of Medicine

Faculty Sponsor: Dr. Jon Niemi, Department of Neuroscience, Case Western Reserve University School of Medicine

A Deep Learning Approach to Predicting Kidney Stone Risk Using Genomic Data

Amr Salem : Applied Mathematics, Case Western Reserve University

Kidney stones pose a significant health burden, yet predicting the risk of developing this condition remains a challenge. Our research leverages deep learning, specifically Convolutional Neural Networks (CNNs), to predict kidney stone susceptibility using genotypic data from a cohort of 60 individuals and 400+ single nucleotide polymorphisms (SNPs) identified from Genome-Wide Association Studies (GWAS) summary statistics. We aim to use this model to estimate Polygenic Risk Scores (PRS), providing an advanced statistical and computational approach for risk stratification in this domain.

We began by carefully selecting relevant SNPs associated with kidney stones and preprocessing genotypic data to convert the extracted SNPs from GWAS into a format suitable for CNN input.Our model architecture consists of multiple convolutional layers optimized to capture intricate patterns in the data, followed by fully connected layers to output a binary risk prediction. The model was evaluated using metrics including accuracy, precision, recall, F1-score, and ROC-AUC. Our results showed an accuracy of 75%, with a precision and recall trade-off indicative of the model's balanced sensitivity and specificity. The ROC-AUC score of 0.8125 demonstrates the model's capability to distinguish between high and low-risk individuals effectively.

This study highlights the potential of CNNs to extract meaningful insights from genetic data, enhancing our ability to predict kidney stone risk with higher precision than traditional statistical models. Future work will focus on expanding the dataset and incorporating additional genetic and clinical features to improve model performance and clinical relevance.

Project Mentor: Anirban Mondal, The Department of Mathematics, Applied Mathematics, and

Statistics, Case Western Reserve University

Drug Target Overexpression Modulates Small Molecule Inhibitor Toxicity: Insights from DLD1 EBP and SC4Mol Overexpressing Cells

Salsabeel Salem

- Major: Chemical Biology
- Home Institution: 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

PI: Drew Adams - Department of Genetics and Genome Sciences, Case Western Reserve University

Auditory Blood Flow Monitor Using Thin-Film Piezoelectric Sensors

Andrew Chen[1], Angel Ramirez[1,2], Alden Salmons[1], Dr. Steve J.A. Majerus[1]

[1] Department of Electrical, Computer, and Systems Engineering

[2] Department of Biomedical Engineering

Patients undergoing hemodialysis rely on reliable vascular access for treatment. Vascular access stenosis (narrowing of the interior vessel size) leads to turbulent blood flow and increases the risk of blood clotting and can ultimately lead to loss of the vascular access. Currently, only angiography (x-ray based) or ultrasound imaging provide quantitative measures of access function; imaging studies are expensive and time-consuming. This project aims to develop an alternative low-cost device that can be used at home by the patient or primary caregiver for frequent monitoring.

The device includes four thin-film polymer piezoelectric sensors, two-stage amplifiers, an analog-digital converter, and a microcontroller with a display for data communication and control. Data is exported to a computer for further signal analysis. The sensors were selected for their low cost and designed to be placed on the skin surrounding the access site. The monitor is tested using a fluid pump device that reproduces pulsatile blood flow. The flow pattern produces bruits, a whooshing sound characteristic of turbulent blood flow, which are recorded and processed by the test device.

Project Mentor: Dr. Steve J.A. Majerus, Department of Electrical, Computer, and Systems Engineering

Investigating the Molecular Mechanism of Dopaminergic Dysregulation due to Zika Virus Infection

Sai Aakarsha Saridey, Department of Biology, Case Western Reserve University

The 2015-2016 Zika Virus (ZIKV) outbreak in the Americas resulted in an unprecedented surge in fetal birth defects. Prenatal ZIKV infection has been associated with structural abnormalities like microcephaly and brain calcifications, as well as behavioral defects such as ADHD and delayed neurodevelopment. Preliminary research has shown elevated dopamine levels in children exposed to ZIKV in utero, suggesting that ZIKV may dysregulate the dopamine pathway. This capstone project investigates the specific interaction between ZIKV non-structural-1 protein (NS1) and human monoamine oxidase-B (MAO-B), a mitochondrial enzyme that degrades dopamine. Co-immunoprecipitation assays of the different ZIKV NS1 domains and human MAO-B show a strong interaction between the ZIKV NS1 wing domain and human MAO-B. Additionally, an ELISA-based ZIKV peptide library screening assay identified peptides 41-48 within the wing domain as having the strongest affinity for MAO-B. These findings pinpoint key regions of ZIKV NS1 involved in dopamine dysregulation. Our results contribute to understanding the molecular mechanisms underlying ZIKV-associated neurodevelopmental defects and provide a foundation for future studies on potential therapeutic targets and small-molecule drug discovery.

Project Mentor: Dr. Weiqiang Chen, Infection Biology, Cleveland Clinic Lerner Research Institute

Faculty Sponsor: Dr. Fritz Petersen, Department of Biology, CWRU

The Enhancement of Palliative Care through Cultural Competence: A Global Perspective

Samantha Schall, Medical Anthropology and Communication Science, Case Western Reserve University

The purpose of this capstone project is to examine the crucial role of cultural competence in palliative care across diverse global contexts, drawing from a collection of contemporary literature. The aforementioned articles highlight how cultural ideologies, preferences, and practices shape the end-of-life care for patients and relatives. Key themes throughout the research include a necessity for healthcare providers to engage with cultural sensitivity to enhance patient-focused care, improve communication, and develop a space for shared decision-making. Studies from Singapore, Uganda, and an assortment of international contexts have shown disparities in the access to and quality of palliative care, further emphasizing the importance of integrating community engagement and cultural awareness into models of care. Continuing on, the insight from comparative analyses across different healthcare systems has shown barriers and facilitators that impact how palliative treatment is performed. Through the synthesis of those findings, this capstone project advocates for educational reform and policy initiatives aimed at promoting culturally competent practices within the field of end-of-life medicine. This exploration highlights the need for a more nuanced understanding of how cultural dynamics impact health, ultimately seeking to improve the outcomes and experiences of patients across healthcare systems.

Project Mentor: Lawrence Greksa, Department of Anthropology

Quantifying Myocardium in Swine: A Histological Analysis of Cardiac Tissue

Ellie Schneider, Biomedical Engineering, Case School of Engineering

Atrial fibrillation (AF) is a common arrhythmia characterized by irregular heartbeats and can lead to complications like stroke, heart failure, and impaired cardiac function. This condition is often associated with structural and electrical changes in the heart, including fibrosis—a process in which excess fibrous connective tissue develops, potentially disrupting electrical conduction pathways within the myocardium, or heart muscle tissue. The myocardium itself is the muscular layer of the heart wall, responsible for pumping blood through its contractile function. Changes in myocardial structure, such as increased fibrosis, are linked to altered electrical conduction, particularly in areas known as “low-voltage zones” where electrical signals are weaker and more disorganized, a hallmark often seen in AFmyocardium tissue from swine specimens is quantified through a comprehensive histological analysis to better understand the extent and location of fibrosis and other structural features in AF, low-voltage, and control zones. Using various software tools—MATLAB, RStudio, QuPath, and ImageJ—key metrics are generated, including fibrosis percentage over the entire tissue and within a focused 2 mm region, total tissue length, endocardium thickness, and distribution of adipose tissue. This data is visualized through plots and analyzed for patterns that may distinguish AF-affected areas from control or low-voltage regions. For quantification, images are segmented in QuPath, and statistical analysis is performed in RStudio and MATLAB. Regions with AF and low voltage zones are expected to exhibit higher levels of fibrosis and altered tissue morphology compared to control zones, which serve as indicators of structural disruption. Through these comparisons, insights are gained into how tissue composition affect cardiac conduction and function, providing potential guidance for therapeutic strategies, such as catheter ablation placement in AF management.

Project Mentors: Dr. Andrew Rollins, PhD, Michael Douglass PhD candidate, Department of Biomedical Engineering

Physician Position Monitoring System

Jarvis Chen[1,2], **Jacqui Palen**[1], **Jaden Rivera**[1], **Kunal Seetha**[1]

Faculty Project Mentor: Dr. Colin Drummond[1]

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More than 80% of surgeons experience work-related musculoskeletal injuries or illnesses 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 in surgeons, we designed a way for physician position to be monitored during surgery. Some key criteria we selected in our design were accurate measurements of position, size, comfortability, and affordability. The design we selected consists of 3 accelerometer/goniometer combined sensors placed along a comfortable compression shirt along the direction of the spine, and an additional accelerometer/goniometer combined sensor placed in headstrap. The goal is to be able to measure physician posture from the spine angle readings of the sensors, and provide insights on how physicians can better correct their position during surgery in order to reduce the risk of contracting musculoskeletal disorders. 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 or adjust the bed height 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 and cohesive analysis in order for the physician to follow key metrics that they find helps them the most in assessing and correcting their posture during surgery.

Hydraulic Impulse Tester

Peyton Seibert: Mechanical Engineering: Case Western Reserve University

John Manzuk: Mechanical Engineering: Case Western Reserve University

Tylok International is an instrumentation tube fitting and valve manufacturing company, in which their fittings must be ISO certified. ISO 19879 contains a test that includes a hydraulic impulse tester to evaluate the cyclical endurance of fittings. Tylok has been looking for their own inexpensive test unit to avoid expensive third-party testing. Our objectives for creating the hydraulic impulse tester are to design, manufacture, and implement the use of the tester into the regular evaluation of fittings for Tylok. Our design approach to complete the test requirements set by ISO 19879 is using a piston to build hydraulic pressure in our system. This piston is driven by an AC motor connected to a custom cam that will build the desired pressure wave. With completion of this project, we expect to be able to create a working test unit that can generate the required wavelength specified by ISO 6605, and eventually complete a full 1,000,000 cycles on a test fitting. We will determine this using a digital pressure gauge to compare it with the waveform. Results for this testing will relieve Tylok of heavy external testing costs for new product certification.

Project Mentor: Dr. Majid Rashidi, Department of Mechanical and Aerospace Engineering, Case Western Reserve University

Faculty Sponsor: Julia Wasielewski, Tylok International, jwasielewski@tylok.com

Potentiation of Resistance to Combination Treatments in Cutibacterium acnes

James Sewake[1], Lisa Long[2], and Dr. Mahmoud Ghannoum[3]

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Cutibacterium acnes causes acne and has grown resistant to treatments with only one antibiotic. This study aims to evaluate the potential of three combination acne treatments to induce resistance in C. acnes. Positive results, demonstrated by little change in the minimum inhibitory concentrations (MICs), would suggest these treatments can be routinely applied without becoming less effective. Three C. acnes isolates were passaged ten times against all three treatments and changes in MIC were recorded. Two treatments (Onexton and Cabtreo) did not induce significant changes in resistance in the isolates, while Benzamycin caused a sixteen-fold increase in the MIC of one isolate. Organisms from the first and last passages of this trial are being sequenced to determine any genetic differences that may contribute to this observation. These results suggest Onexton and Cabtreo are effective at preventing the development of antibiotic resistance in C. acnes.

Project Mentor: Lisa Long, Department of Dermatology, Case Western Reserve University School of Medicine, Cleveland, OH

Lab PI: Dr. Mahmoud Ghannoum, Departments of Dermatology and Pathology, Case Western Reserve University School of Medicine, Cleveland, OH

Capstone Faculty Sponsor: Dr. Emmitt Jolly, Department of Biology, Case Western Reserve University, Cleveland, OH

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

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

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 elderly and veteran patients facing accessibility challenges. This project aims to develop a non-invasive, at-home IOP monitoring device integrated with telemedicine capabilities to improve glaucoma management.

The proposed device incorporates non-contact tonometry using an air puff delivery system, coupled with a position-sensitive detector (PSD) for precise corneal displacement measurement. Signal processing is handled by an Arduino-based unit to determine IOP values. This semester's focus is on developing and refining the pneumatic and PSD subsystems. Future development will address user interface components, including an LCD display for feedback and an adjustable goggle headpiece to ensure proper alignment and measurement accuracy.

By reducing dependency on frequent clinic visits, this solution particularly benefits patients in remote or underserved areas, facilitating regular IOP monitoring. The device has the potential to transform glaucoma care through early detection of elevated IOP, 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

Imagining a New Paradigm: Assessing the Efficacy of Full-Body Immersion in Virtual Reality for Language Learning—A Comprehensive Literature Review and Meta-Analysis

Shayaan Shaik- Cognitive Science; Case Western Reserve University

Language acquisition is most receptive to embodied cognition, which states that a person's physical interaction with their environment may influence their cognitive development. This principle is especially critical for toddlers to acquire their first language, mainly through object-word games. As virtual reality accessibility and functionality increase, the paradigm of physical education shifts. Current literature suggests simulation technology can emulate the "perfect learning environment" for adolescents, capitalizing on students' perception of the physical surroundings to acquire a second language more effectively than traditional approaches. This paper contextualizes primary language acquisition and full-body emersion and how various factors influence a person's ability to learn a succeeding language, including age, motivation, environmental support, and negative transfer. The paper then discusses the current VR standards and software and references the latest attempts for VR-based education applications for second language acquisition. Finally, the paper synthesizes the key findings and shortcomings of each available VR-based language learning study, some of which include increased motivation but increased distraction for students and a steeper learning curve for some applications. Consolidating these findings will help later developers and educators create the best possible model system for a VR-based program for learning a second language.

Faculty Mentor: Todd Oakley, College of Arts and Sciences, Department of Cognitive Science, Case Western Reserve University

Design of an Abdominal Binder with Integral Pressure Measurement for Relief of Orthostatic Hypotension Symptoms

Albert Kim[1], B.S.E. Biomedical Engineering; **Andrew Shereshevsky**[1]**,** B.S.E. Biomedical Engineering; **Anne Straits**[1], M.S.E., B.S.E. Biomedical Engineering; and **Nicole Zhou**[1], B.S.E. Biomedical Engineering
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Orthostatic Hypotension (OH) is diagnosed by a consistent drop in systolic/diastolic blood pressure of at least 20/10 mmHg after standing up and can cause blurred vision, nausea, and fatigue. 30% of adults age 70 and over are affected by OH, and abdominal binders have been cited as an effective and convenient option to stabilize blood pressure without the use of drugs. An abdominal compression of 10 to 40 mmHg is optimal, but challenges in patient compliance with ensuring a correct fit has revealed an unmet need for patients who are advised to wear abdominal binders. Currently, there is no quantitative way for a patient to gauge the tightness of the garment or the amount of compression it applies. As a result, there is a need for a method to ensure a correct fit for patients utilizing abdominal binders at home to optimize the efficacy and safety of these devices. Our system uses an array of strain gauges to interpret the applied strain as pressure in mmHg. A separate, battery-powered, device will connect to the strain gauge system to read this measurement and communicate that information to the user. An approved caregiver can set the pressure required on the Arduino device. As the user tightens the ratchet system, the pressure monitoring device will provide auditory, tactile, and visual feedback to indicate a good or poor fit. Including all three modes of communication accounts for typically elderly users who may have certain impairments. The ratchet tightening system is simple to adjust incrementally. Using a separate device to power the entire device reduces bulkiness and increases durability from typical wear and tear over the device's lifespan.

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

Novel Application of Morcellator for Efficient Gastrointestinal Clot Removal

Kriti Shukla[1], Amanda Duban[1], Angel Ramirez[1,2], Abigail Roeckmann[1]

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Gastrointestinal clots are a condition that can significantly impact endoscopic procedures by obstructing the path and vision of the physician which prolongs the procedure. Current solutions used to remove these clots include a suctioning device combined with forceps, snares, and distal caps. However, these methods are ineffective when it comes to 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 would be composed of a rotating inner cannula with blades and a stationary outer cannula, both made of stainless steel. The inner cannula would rotate at a steady speed of 1700 RPM. The outer cannula would have small windows 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

Radar On The Race

Emma Shumaker, Electrical Engineering, Case Western Reserve University School of Engineering; **Isabella Devai Camacho De Oliveira,** Electrical Engineering, Case Western Reserve University School of Engineering; **Ishika Kanakath,** Computer Engineering, Case Western Reserve University School of Engineering

The Big Wheels Relay is a fundraiser event that is run by the Cleveland Hearing and Speech Center. The participants are in a relay race in which they compete on tricycles. To help the Cleveland Hearing and Speech Center fundraiser relay raise more money we are trying to increase the engagement and enjoyment levels of attendees, the team wishes to measure the tricycle speeds and share it with the crowd in real time. To accomplish this we will create a RADAR velocity measurement device for the event, which will connect via Bluetooth to a computer that can then display the velocity value to the audience. The device differs from similar products such as a RADAR gun as it can share results wirelessly and it will be cheaper than current options. The device will implement a HB100 RADAR chip to measure the velocity, an Arduino Uno to do signal processing, and an ESP32 to send data via Bluetooth. Velocity is measured by the HB100 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 objects movement, the chip then received 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 to ensure that the Arduino will be able to read it. Then this signal is sent from the arduino to the ESP32 to be shared with the audience using bluetooth.

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

Capstone advisor - Professor Lee, Electrical Engineering department

Quantitative Imaging of the SC Structure During Meiosis

Anjelyna Siamphone, Biology Major Case Western Reserve University

During Drosophila melanogaster meiosis, the synaptonemal complex (SC) serves as a protein scaffold that connects homologous chromosomes and facilitates crossing over. Although the SC is known to be involved in crossover formation, its structural dynamics and organization during this process remain poorly understood. In this study, we utilize both confocal and super-resolution microscopy to explore the relationship between the SC structure and function during crossover formation. By using Narya-GFP, a Iluorescently tagged protein that speciIically marks crossover sites, we aim to identify distinct morphological changes in the SC that correlate with crossover events.

Project Mentor: Nicole Crown, Biology Department

Adverse Life Events and Negative Auditory Hallucinations

Brendan Silva, Psychology, Case Western Reserve University

Elyssa Barrick, M.A. & Dr. Sarah Hope Lincoln, Department of Psychological Sciences

Background:

One of the most distressing symptoms of schizophrenia and psychotic disorders are auditory hallucinations. Hallucinations are often intense and contain negative content. In addition to these symptoms, research has found that adverse events are quite common in individuals with psychotic disorders. A relationship between adverse life events and auditory hallucinations has been attempted to be found, however the results have been mixed and focused primarily on adolescents. The purpose of this study is to clarify an association between adverse events and auditory hallucination content in adults. The type of adverse event will also be determined through the questionnaire to determine if a specific type of adverse event has a stronger relationship.

Methods:

Participants (n = 30) will complete self-report measures specifying the type of traumatic event (Brief Trauma Questionnaire) and their perception of the intent and intensity of their auditory hallucinations (Beliefs About Voices Questionnaire-Revised).

Results:

While data collection is currently ongoing, analyses will not be run until the target sample size (N = 30) has been completed. The hypothesis is that the adverse life events will have a significant positive relationship with the frequency and perceived negative intent of the voices. We will examine this relationship using a correlation analysis. Demographic information including age, gender, etc.

Conclusion:

Our conclusions will offer insight into whether there is a relationship between adverse life events and negative auditory hallucinations which could have implications in understanding how auditory hallucinations develops.

Project Mentor: Dr. Sarah Hope Lincoln

The Development of Instrument Controls for Millimeter-wave Cryogenic Systems.

Simon Silverstein, Physics B.S., Case Western Reserve University

The objective of this project was to create in-house monitoring software for the C.W.R.U. CMB Cosmology group's dilution refrigerator. Used in the lab to cool samples to 10 mK and below, the dilution refrigerator (DR) is required for the development and calibration of microwave detectors. The custom monitoring system offers real-time display and analysis of the DR's temperatures, pressures, and status via a dashboard of interactive graphs and dials. It functionally replaces the vendor-supplied system, which had severe limitations and was generally disliked by those who used it. The custom software has been successfully developed and installed and is ready for use in the lab's next experimental run.

This project was conducted under the mentorship of -

Johanna Nagy, C.W.R.U. Department of Physics

Cosmological constraints on anisotropic Thurston geometries

Ananda Smith[1], Craig Copi[1], Glenn Starkman[1]

[1]Department of Physics, Case Western Reserve University

Much of modern cosmology relies on the Cosmological Principle, the assumption that the Universe looks the same everywhere in all directions, but it remains worthwhile cosmological models that violate this principle slightly. We examine a class of such spacetimes that have direction-dependent, or anisotropic, spatial curvature. These spacetimes are endowed with one of five anisotropic model geometries of Thurston's geometrization theorem, and their evolution is sourced with perfect matter and dark energy. We show that the background evolution of these spacetimes induces fluctuations in the observed cosmic microwave background (CMB) temperature with amplitudes coupled to the curvature parameter ΩK. We find that, for these induced fluctuations to be no more powerful than those that are observed, $|\Omega K| \lesssim 1e\text{-}5$. This strongly limits the cosmological consequences of these models.

Project mentors: Dr. Craig Copi, Department of Physics, CWRU; Dr. Glenn Starkman, Department of Physics, CWRU

Post-Stroke Wearable Upper Arm Support

Ana Cecília Salvatore de Oliveira Gomes, Biomedical Engineering, Case Western Reserve University; **Ben Kwiatkowski,** Biomedical Engineering, Case Western Reserve University; **Andrew Smith**, Biomedical Engineering, Case Western Reserve University; **Victoria Rose Warady**, Biomedical Engineering, Case Western Reserve University

Over 790,000 people suffer a stroke each year and approximately 26% of them experience upper arm hemiparesis. Improper rehabilitation of the upper extremities can lead to learned nonuse and reinforce abnormal synergistic movements, both of 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 other muscles that do not normally participate in these movements. 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 can be counteracted when external effort is applied. Current solutions to mitigate this include active, motorized exoskeletons or arm supports. Existing active shoulder braces are bulky, and intended for vocational strength enhancement rather than movement support. Others provide little to no ambulatory capabilities. To address these issues, 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 potential for partial to full restoration of movement. The goal of the device is to actively facilitate flexion and extension at the shoulder and inhibit abnormal synergies, thereby increasing reach and ADL capabilities. A motor at the shoulder will provide active movement assistance. This 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.

Examining the most important factors driving food culture/behavior for Medicaid-eligible pregnant individuals in Cleveland receiving a home-delivered medically tailored groceries program.

Ella Solomon - Medical Anthropology and Spanish, CWRU

Nourishing Beginnings is a combination of research and a pilot program that provides nutrition resources, including nutritionally tailored home-delivered food boxes and recipes, for pregnant individuals to improve mother and child health outcomes in Cleveland through healthier eating. Prior research has demonstrated that incorporating food culture (how we think, feel, and behave regarding food) is essential for changing health-promoting behaviors.

This study investigates which food culture factors are most important to Nourishing Beginning participants. A six-question phone survey was administered to participants (n=10). Questions focussed on the interpersonal, environmental, and cultural factors influencing the participant's food culture and program effectiveness. The program's effectiveness was measured by how satisfied and engaged they were, and if any change occurred resulting in healthier food choices. The data is still being analyzed, but some preliminary insights have been determined.

Overall, participants had a positive view of the program. They found the program was convenient and stress-reducing by addressing behavior controls like access to food, transportation, and cooking supplies. Time, convenience, consistency, and family values often motivated participants to be engaged. There were mixed results of participants' initial food socialization, with some participants having more positive experiences and others having more negative experiences, characterized by lack of food security. Additionally, there was variation in whether participants grew up cooking but having cooking skills seemed to allow participants to engage more creatively with the boxes. Finally, there were inconsistent results for behavior change. Many participants who observed change mentioned an increased awareness of what they considered healthy, a greater selection of fresher ingredients while grocery shopping, and more intention to reduce food waste. For those who did not, economics was a contributing factor.

Project Mentor: Dr. Elaine Burowski PhD, FAAHB, Prevention Research Center for Healthy Neighborhoods, Case Western Reserve University, School of Medicine

How does Problem-Based Learning (PBL) enhance critical thinking and clinical problem-solving in dental education compared to traditional lecture-based approaches, and what challenges do students and faculty face in its implementation?

Max Song, Department of Cognitive Science, Case Western Reserve University

This research examines how Problem-Based Learning (PBL) enhances the development of critical thinking and clinical problem-solving skills in dental students, compared to traditional lecture-based approaches. The study involves a detailed review of existing literature on the use of PBL in dental education, focusing on its effectiveness in fostering essential skills needed for clinical practice. In addition to reviewing published research, interviews with current dental students provide both quantitative data and qualitative insights into their learning experiences with PBL versus traditional methods. The research focuses on students' performance in standardized diagnostic assessments to determine how well PBL prepares them for real-world clinical challenges. Moreover, it explores the subjective experiences of students to understand how PBL influences their ability to think critically and solve complex clinical problems in a collaborative setting. Beyond examining the benefits, this study also addresses the practical challenges faced by both students and faculty in the implementation of PBL. Specific areas of difficulty include managing the time demands of PBL, ensuring the availability of sufficient resources, and providing adequate training for faculty to lead PBL sessions effectively. By combining findings from research papers and firsthand experiences of dental students, this study

aims to offer a comprehensive understanding of both the advantages and obstacles of integrating PBL into dental education. Ultimately, the research findings will contribute to ongoing curriculum reform discussions, offering recommendations to optimize dental education and better equip students with the critical thinking and problem-solving skills necessary for success in clinical practice.

Project Mentor: Fey Parrill, Department of Cognitive Science

Knee Flexion Assistive Device for Post-Stroke Gait Improvement

Veronica Sorg, Department of Biomedical Engineering, CWRU

Sam Walters, Department of Biomedical Engineering, CWRU

A stroke often leads to leg weakness in one half of the body, which can dramatically affect an individual's mobility. This leg weakness affects the gait cycle, commonly reducing weight bearing capabilities and reducing hip and knee flexion. Common consequences are decreased walking speed, increased difficulty of traversing uneven/unexpected terrain, decreased balance, toe drag, and subsequent increased fall risk. This project aims to address decreased knee flexion for individuals with post-stroke leg weakness in order to improve gait symmetry. To address these needs, our team is designing a knee flexion assistive device, with the goals of increasing knee flexion & thus improving the swing phase of the gait cycle. The primary component of the device is an elastic band that spans from below the user's knee to above the user's hip. This band stores energy during the stance phase of the gait cycle which then supplies torque around the knee during the swing phase of the gait cycle, supplementing knee flexion. Additionally, the device is designed to be intuitive and user friendly, with attachments and straps being placed towards the non-affected side of the user. This system will be verified through assessments of walking speed and gait improvement (using the 10-meter walk test and a functional gait assessment). Additional verification will evaluate the comfort, size, weight, and durability of the device. Successfully proving the functionality of the prototype is the first step towards a final device that will allow for users to regain knee flexion and mobility, allowing individuals with leg weakness due to stroke to more easily perform everyday tasks.

Project Mentors:

Dr. Colin Drummond, Department of Biomedical Engineering, CWRU

Dr. Matthew Williams, Department of Biomedical Engineering, CWRU

m6A Methylation is associated with Hippocampal Pathology in Multiple Sclerosis Patients

Nethra Srinivasan, Department of Neurosciences, CWRU; Hiran Mendries, Department of Neurosciences, LRI CCF; Timothy Niepokny, Department of Neurosciences, LRI CCF

Multiple Sclerosis (MS) is an inflammatory demyelinating disease of the central nervous system (CNS). Among the plethora of neurological issues memory impairment occurs in 65% of MS patients. Investigating pathology, we found ~60% of MS hippocampus to be demyelinated. Demyelination was associated with decrease in genes associated with memory and synaptic functions. In addition, we also found epigenetic modifiers like microRNAs and DNA methylation of these key genes to be altered following demyelination. Recent studies have found m6A-methyladenosine (m6A) modification playing a role in multiple processes of the CNS including development and biological functions in neurodegenerative disorders. We investigated the possibility of m6A modification playing a major role in altering hippocampal gene expression and memory function in MS patients. Using postmortem brain tissues, we localized and identified the different components of the m6A methylation pathway in MS hippocampus. Using RNA sequencing datasets of MS hippocampus, we found altered mRNA levels of key genes associated with m6A methylation, m6A proofreading, and m6A methylation erasing pathways. Using immunohistochemical protocols, we determined the presence of these genes primarily in hippocampal neurons belonging to the CA1, CA3 and DG regions. Current work using sequencing approaches are ongoing to identify the genes that harbor the m6A methylation marks. The work therefore identifies m6A methylation as an epigenetic mechanism that may be operative in MS hippocampus and alter memory function following demyelination. Together with remyelination, targeting the m6A pathway would therefore be a viable strategy to enhance memory function in MS patients.

Project Mentor: Dr. Ranjan Dutta, Department of Neurosciences, Lerner Research Institute, Cleveland Clinic Foundation

Faculty Sponsor: Dr. Ashley Nemes-Baran, Department of Neurosciences, CWRU

Portable Therapy Stairs

Justin Storn, U.S. Department of Veteran Affairs, APT Center

The portable therapy stairs project was created by a physical therapist at the VA who saw a massive lack of efficiency and health risk in the treatment of mobility-impaired patients. The current practice is for patients to go up and down the same number of stairs that they have in their home to ensure their safety before discharge from the hospital.

In order to do this, the physical therapist escorts them from the patient's room, down to the physical therapy room, where they use therapy stairs. For instance, if the patient has 12 stairs to climb in their residence, and the therapy stairs are only 4 stairs, then they would have to go up and down the stairs 3 times in order to get discharged from the hospital. Once they do this, the physical therapist takes them back to their room before moving on to the next patient. This process can be quite time-consuming for physical therapists. Patients with mobility issues often walk at a slow pace, which increases their risk of falling.

The portable therapy stairs aim to address these challenges by bringing the stairs directly to the patient. Rather than having patients walk long distances—an approach that is not only inefficient but could also jeopardize their health—the portable therapy stairs provide a safer and more effective solution. The portable therapy stairs function similar to current therapy stairs, but made so they can fit through any hospital doorway and in any patient room. Designed with rotating steps, casters, gas springs, and more, these stairs offer a unique and versatile solution for physical therapy.

Project Mentor: Dr. Colin Drummond, Professor and Assistant Chair, Department of Biomedical Engineering

Fatigue Reliability of Conductive Threads for Instrument Prosthetic Liner

Sai Subramanian, BS Candidate in Department of Electrical, Computer, and Systems Engineering, Case Western Reserve University
Alden Salmons, BS Candidate in Department of Electrical, Computer, and Systems Engineering, Case Western Reserve University
Lexi Miskey, Department of Biomedical Engineering, Case Western Reserve University

Instrumented prosthetic liners require a reliable electrical connection between the componentry. Conductive threads perform this function while withstanding strain from typical liner use. Flex bending fatigue testing evaluates the durability of the conductive threads by mimicking the strains of donning and doffing of a prosthetic liner. Data collected from these tests can be used to predict fatigue failure and inform design choices such as comparing different thread materials and stranded architectures.

Two sizes of steel mandrels (i.e., smooth rods) were chosen for the fully reversed, flex bending fatigue tests. The mandrels measured 1.94 mm and 1.19 mm in diameter and represented the largest anticipated applied strains for the application. Six stainless steel thread (0.12 mm diameter) specimens were prepared for a 1 Hz test on each mandrel and tested to failure. Specimens were examined with optical microscopy and scanning electron microscopy to provide additional insight into failure mechanisms.

Fatigue test results to date ranged from approximately 10^5 to 10^6 cycles-to-failure on both mandrels. We expect that lower applied strains will result in higher cycles-to-failure. Even within the preliminary data, we find that the conductive stainless steel threads should exceed the one-year lifetime of common commercial prosthetic liners. This methodology will be used to compare alternative thread materials and architectures for a reliable connection between the electrical components.

Project Mentor: Janet L. Gbur, Department of Materials Science and Engineering, Case Western Reserve University

Hypersonic Projectile Catch

Leo Sullvian, Mechanical and Aerospace Engineering, Case Western Reserve University

The hypervelocity projectile light gas gun (HOPLITE) is a two-stage light gas gun used to launch small projectiles to hypersonic speeds through controlled conditions for aerodynamic research. After traveling through a test section, the projectiles need to be safely stopped. The current projectile catch works, but requires up to an hour to disassemble, reload, and reassemble between tests. This project aims to improve the catch system by developing a structure that reduces reassembly time to ten minutes, reducing the extended downtime, while maintaining safety and durability.

There are two main stages to this project. The first is design and modeling, and the second is manufacturing and testing. In the first stage, the focus was on developing a more rigid supporting structure that can withstand the high forces exerted during HOPLITE gun firings and improve reassembly time. The design was optimized through modeling, using Solidworks and Ansys, to ensure safety, durability, and ease of disassembly, while maintaining the proven configuration of consumables.

Once the design was finalized, it was manufactured and integrated into the HOPLITE gun. The gun was fired, and both the reusable components and the consumables were examined. The result was compared to the behavior predicted by the models, and any needed adjustments to the structure were made to ensure the system meets the desired efficiency and safety standards. The system also aims to reduce material waste and costs by optimizing the consumable configuration.

Achieving this improvement will significantly enhance the efficiency of hypersonic testing, allowing for faster test cycles and better use of resources. This design has the potential to improve similar aerodynamic research setups and to contribute to advancements in the study of hypersonic projectiles and related fields.

Project Mentor: Bryan Schmidt, Mechanical and Aerospace Engineering, Case Western Reserve University

Understanding the role of Microglial Refinement of OPCs in the Cerebellum in Autism pathogenesis.

Amulya Surabhi, Department of Neuroscience, CWRU

Autism Spectrum Disorder (ASD) is a neurological and developmental disorder that affects how people interact with others, communicate, learn, and behave. One of the major morphological changes found in the brains of those with ASD is cerebellar white matter degeneration. White matter refers to a collection of axons surrounded by the myelin sheath within the central nervous system (CNS). Neurons within the CNS are accompanied by non-neuronal glial cells, such as oligodendrocytes and microglia. Oligodendrocyte Progenitor Cells (OPCs) are cells that mature into myelin-basic protein expressing oligodendrocytes that myelinate axons. Microglia are the resident immune cells of the CNS. Previous work in the DeSilva lab has shown that amoeboid microglia infiltrate the cerebellum (prominent cerebral white matter tract) postnatally and prune OPCs in a fractalkine receptor dependent manner as part of normal development. Literature also shows that proper myelination is important for Purkinje cell(the major efferent output neurons for the cerebellum) development and function while a deficit of Purkinje neurons has been observed in ASD. Hence, in this project we aim to understand if the mechanism regulating this process is impaired in the white matter tracts of the cerebellum in the Pol(I:C) mouse model of ASD. To study this, our experimental methods include sagittally cryosectioning the control and experimental mouse brains and performing immunofluorescence staining of microglia and OPCs on the cerebellar sections. The sections are then analyzed for the microglial phagocytosis of the oligodendrocyte progenitor cells using Imaris and Nikon software. Understanding the mechanisms of this impaired white matter development will be a step towards creating targeted pharmaceutical medications for ASD.

Project Mentor: Dr. Tara DeSilva, Department of Neurosciences, Cleveland Clinic LRI

The Effects of Social Media & Other Psychological Disorders on Compulsive Buying Disorder

Elsa Syed, Psychology, CWRU

Compulsive buying disorder (CBD) is understudied and unrecognized as an independent mental disorder in the DSM-5, despite its growing lifetime prevalence of 5.8% in the US. Defined as the chronic purchasing of items and the inability to control buying impulses, CBD results in significant financial and other negative consequences. It is often found to exist comorbidly with other psychological disorders that may affect obsessiveness and impulse control. The continuously increasing usage of social media and growing "influencer culture" are strong proponents of materialistic culture. Algorithm driven advertising and the accessibility of online shopping also enables compulsive buying behavior. This narrative literature review examines the relationships between the psychological disorders that CBD is typically comorbid with and the role that social media plays in these relationships and symptoms of CBD. Key words and phrases such as comorbidity, compulsive buying, and social media were searched in scholarly engines such as PsychInfo, Web of Science, Google Scholar, and PubMed. Overall, findings suggest strong comorbidity between related psychological conditions such as anxiety, depression, and low-self esteem and CBD, as well as strong direct relationships between increased social media usage and these conditions. The results indicate that social media fuels the cycle of individuals experiencing poor mental health turning to social media for relief, but in turn further damaging their mental health. It can be concluded that understanding the antecedents and implications of CBD requires a multidisciplinary approach, and treatments should consider both the influences of other mental health conditions and social media use.

Project Mentor: Dr. Anastasia Dimitropoulos, Department of Psychological Sciences, CWRU

Cancer stem cell mediated coagulation drives hyper-thrombotic activity in glioblastoma

Liza Tack[1,4] (BS in Neuroscience), Anthony R. Sloan[2,3,4,5],Tanvi Navadgi[1,4], George Bukenya[3,4], Justin D. Lathia[2,3,4,]

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Cancer-related thrombosis is the second leading cause of death for cancer patients and glioblastoma (GBM), the most common primary malignant brain tumor, is associated with approximately a 30% risk of venous thromboembolism, deep vein thrombosis, or pulmonary embolisms. While this remains a major clinical issue, the interaction between platelets and cancer cells has been underexplored in solid tumor models that do not metastasize, including GBM. GBM is a tumor that contains a high degree of cellular heterogeneity and has populations of therapeutically resistant cancer stem cells (CSCs) that drive tumor growth. Our group has previously shown that GBM tumors endogenously produce thrombin through an intrinsic coagulation cascade. We have further shown a bidirectional interaction between platelets and CSCs that acts to increase the oncogenesis of cancer stem cells. Despite this work, no research has been done that explores the effect of genetic knockdown of specific factors within the coagulation cascade on CSC growth. In this study, we genetically targeted coagulation factor 11 (F11) and coagulation factor 12 (F12) to see if these coagulation factors contribute to CSC aggressiveness. We hypothesized that genetic reduction of F11 and F12 would decrease CSC proliferation and stem-cell capacity in vivo. We found that when F11 and F12 are knocked down there is a decrease in cell proliferation and sphere formation. It was also observed that when the cells were implanted in vivo in mouse GBM models, mice injected with mouse cells with genetic reduction of F12 and F11 had prolonged survival compared to mice injected with wild-type cells. These findings identify novel mechanisms of CSC maintenance and potentially novel therapeutic strategies to target the CSC population of GBM cells.

Faculty Sponsor: Dr. Ashley Nemes, Department of Neurosciences Case Western Reserve University

Role of Primary Cilia in Alzheimer's Disease

Phoebe Templin, B.A. in Biology, Case Western Reserve University

Alzheimer's Disease (AD) is a progressive neurodegenerative disease that impairs memory, cognition, and behavior. AD is the most common cause of dementia, accounting for nearly 60 – 80% of all cases, and currently affects around 6.9 million Americans who are living with Alzheimer's. Emerging evidence links primary cilia to AD. Primary cilia are sensory, microtubule based organelles that act as signaling hubs and sensors that receive and integrate extracellular signals. Primary cilia and ciliary signaling pathways are involved in aging and various brain disease related cellular processes. Defects in the structure and function of primary cilia lead to both cognitive and reduced brain mass, which are both common symptoms observed in AD. In my research I am to explore a novel pathophysiological process in AD: the role of primary cilia deterioration in AD.

Primary cilia function depends on Adenylyl Cyclase (AC3), a key enzyme within primary cilia, regulates cyclic AMP levels and downstream signaling, making it a prominent marker of primary cilia in the brain. My project will investigate the health and deterioration of primary cilia using AC3 in both preclinical mouse model of AD, and AD subjects relative to non-AD controls. By utilizing a combination of both genetic and immunohistochemical approaches, I aim to test my central hypothesis: that primary cilia deteriorate early in AD progression. Establishing this link could reveal primary cilia as a novel locus of injury in the progression of AD.

Mentors: Dr. Andrew Pieper, MD, PhD and Emiko Miller, BS, Case Western Reserve University School of Medicine, Harrington Discovery Institute, University Hospitals, Louis Stokes Veteran Affairs Hospitals

Single-cell-resolution longitudinal analysis of brain endothelial cell development and maturation

Vani Thakur, Department of Neuroscience; Dr. Ryota Matsuoka, Department of Neurosciences, Cleveland Clinic Lerner Research Institute

Brain vasculature displays extraordinary heterogeneity fundamental to brain homeostasis and function. This diversity is reflected in the functional heterogeneity of brain capillaries and striking morphological differences in their two main endothelial cell (EC) types, fenestrated and blood-brain barrier (BBB) capillaries. Fenestrated capillaries develop small EC membrane pores enabling great vascular permeability while BBB capillaries, constituted of tight junctions, yield low vascular permeability.

Initial investigations were conducted on fenestrated and BBB EC establishments which remain understudied. To this end, we analyzed phenotypic differentiation of brain ECs at the single-cell resolution and time-point. We determined significant differences in parameters regarding BBB and fenestrated EC lumen coverage and size, with non-significant variation in individual cell arrangement. However, despite these findings, structural variation and developmental trajectories across developmental stages remain ambiguous.

This project aimed to track BBB and fenestrated EC morphology until vascular maturation. Using the EC-specific knock-in zebrafish line (Etv:gal4, UAS:Kaede), expressing Kaede photoconvertible protein localized at ECs, we studied brain vasculature at key developmental time-points. We employed confocal microscopy for photoconversion and characterization of individual ECs; high-quality z-stack images were captured for precise 3-D vessel reconstruction and quantifications. Targeted BBB and fenestrated ECs were examined 54, 78, and 102 hours post-fertilization and at a mature 10 days post-fertilization. Through development, we preliminarily observed dynamic and heterogenous cell arrangements and lumen sizes, alongside migratory trends. However, greater samples may be necessary for significant conclusions. Related findings may demonstrate broader implications for entire brain vasculature and developmental and maturation pathways. Our upcoming investigations will employ longitudinal methods and investigate observed morphology. We aim to delineate identified structural differences across development and discern vascular heterogeneity in the brain.

Project Mentor: Dr. Ryota Matsuoka, Department of Neurosciences, Cleveland Clinic Lerner Institute

Stereo Electronic Stethoscope: Detection of Cardiac Arrhythmias and 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 arrhythmias and murmurs are relatively common conditions that affect 1.5%-5% and about 10% of patients, respectively [1,2]. 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 [3]. Secondly, there are limitations to the human auditory system, particularly with high-frequency or low-magnitude sounds [4]. Finally, the proficiency of detection is highly dependent on the training the physician received [5]. 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 arrhythmias and 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 connect to a Raspberry Pi. Using MATLAB, the Raspberry Pi filters out external noise and lung sounds to isolate the heart sounds. The Raspberry Pi then sends the filtered signal to earpieces to play the two heart sounds from the different cardiac locations in separate ears. The Raspberry Pi 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. The output of heart sounds from two different locations is an important end goal for this semester and more progress will be made in the future. These innovations will aid physicians and cardiologists in detecting cardiac arrhythmias and murmurs and improve auscultation practices.

Project mentors: Dr. Colin K. Drummond, Department of Biomedical Engineering, CWRU; Dr. Matthew Williams, Department of Biomedical Engineering, CWRU

Infrared-Driven Air Conditioning Optimization Device

Leo Burton, Electrical Engineering at Case School of Engineering; **Jerry Hu**, Electrical Engineering & Computer Engineering at Case School of Engineering; **Adam Thompson**, Electrical Engineering at Case School of Engineering; Case Western Reserve University

Our project team aimed to develop an automatic vent system for window-mounted air conditioning units in order to provide comfort, reduce energy use, and lower cooling costs for individuals in small apartments or rooms without central air conditioning.

In the United States, air conditioning units account for 19% of total power consumption in abodes, and in certain urban or relatively arid environments, this number could rise up to as high as 65% during peak summer months. In single-occupant homes, rooms, or under-equipped dormitories, these units are traditionally window-mounted and will often be left running inefficiently and for prolonged periods, cooling entire rooms even when nobody is inside. This leads to increased and unnecessary energy costs. While redesigning a more energy efficient air conditioning unit at a more affordable cost may be beneficial, we elected to design an attachment that would boost the efficiency of existing air conditioning units in single occupant environments, thus reducing waste.

To achieve this goal of an attachment to boost energy efficiency, we designed a vent system that tracks the location of an individual in a room and directs airflow toward them. When a person enters the room, the system will begin directing cool air toward the person with the idea of cooling the person, not the entire room. When no person is detected, the system will automatically shut off. This concept seeks to reduce overall energy consumption, provide quicker localized cooling, and offer a more sustainable alternative to traditional AC systems. Because this device is intended to improve small window mounted units, our project is designed to be used in a room or home where there is typically a single occupant.

Project Mentor: Dr. Evren Gurkan Cavusoglu, Department of Electrical Engineering, CWRU

Faculty Sponsor: Dr. Gregory Lee, Department of Electrical, Computer and Systems Engineering, CWRU

Insertion of LIS-1 Sequence in Flax in Response to Environmental Stress

Ei Mon Thura, Biology, Case Western Reserve University

This study investigates the role of circular extrachromosomal DNA in facilitating rapid genome rearrangements in flax plants (Linum usitatissimum L.) under stress conditions. Specifically, I examine the occurrence and completeness of the LIS-1 genomic insertion and its potential transmission to subsequent generations. Flax is known for its ability to undergo significant genome alterations, including insertions, deletions, and single-nucleotide polymorphisms, when exposed to environmental stress. This research focuses on whether LIS-1, a sequence associated with these genomic shifts, integrates into the plant's genome and whether it is inherited in subsequent generations. PL flax lines were grown under inducing conditions, and a variety of phenotypic responses were observed, indicating genomic rearrangements. DNA extractions from different tissues were analyzed using PCR and electrophoresis. the findings suggest a complex hierarchy of genomic rearrangements in flax, with possible extrachromosomal involvement. This research enhances understanding of flax's genomic plasticity, contributing to the broader goal of developing stress-resilient crops in response to climate change.

Faculty Project Mentor: Christopher Cullis, Department of Biology

Investigating the Efficiency of Fraction Strategies: Half Comparison Strategy

Clara Todd, B.S. in Nutrition and B.A. in Psychology, Case Western Reserve University, Anna Kan, B.S. in Systems Biology, Case Western Reserve University

Previous research has shown children struggle to solve fractions in elementary school. Solving fractions develops skills needed to succeed in higher math classes and it is therefore crucial that a solid understanding is formed early on. The experiment investigates the most efficient strategies in ranking fractions according to magnitude among 50 college-age students. Based on previous research, it is predicted that the most effective strategy used to rank fractions according to magnitude is comparing the fractions to ½. Participants completed a background questionnaire with questions concerning previous math classes taken, confidence level in math, and career goals. Then participants took 6 minutes to complete as many fraction ranking problems as accurately and quickly as possible. Each problem consisted of a row of 5 fractions and participants had to rank greatest in magnitude to least in magnitude labeling the fraction 1-5 (1 being the least and 5 being the greatest). They were asked to verbally explain the strategies used to solve the problem in a voice recorder once time was up. Written answers were also allowed if they did not want to be recorded. There were 13 strategies used among the participants. A T-test will be used to determine the most common and accurate strategies used. The most accurate strategies found can later be used in teaching children to improve their comprehension of fractions.

Project Mentor: Dr. Lee Thompson, Department of Psychological Sciences, Case Western Reserve University

Frequency-Driven Spotted Lanternfly Trap

Jen Lawrence, Department of Electrical, Computer, and Systems Engineering, CWRU; **Justice Smith**, Department of Electrical, Computer, and Systems Engineering, CWRU; **Angela Tsang**, Department of Electrical, Computer, and Systems Engineering, CWRU

Spotted lanternflies are an invasive insect species that have been spreading rapidly in the northeastern and midwestern United States in recent years. They are sap-sucking insects that feed on a wide variety of plants and can cause significant crop damage. Current solutions for spotted lanternfly management include sticky traps and pesticide, which are non-selective and can cause significant harm to the environment and other organisms in the habitat. As a result, new strategies for spotted lanternfly management are necessary to mitigate the threat these insects pose to plants. Recent research has shown that spotted lanternflies are receptive to vibrational signals. In particular, they have been found to be attracted to vibroacoustic stimuli with a frequency of 60 Hz, which is the frequency of electrical power lines. Our solution utilizes a low-power signal generator circuit to produce a 60 Hz tone and converts it to a vibrational signal to selectively attract spotted lanternflies. The electrical component of the design is affixed to a mechanical trapping mechanism to contain the spotted lanternflies.

Project Mentor: Prof. David Kazdan, Department of Electrical, Computer, and Systems Engineering, CWRU

Faculty Sponsor: Prof. Gregory Lee, Department of Electrical, Computer, and Systems Engineering, CWRU

Characterizing Strain Diversity of Gardnerella vaginalis in Bacterial Vaginosis

Julia T Hochstetler, Department of Biology, Case Western Reserve University; 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 common condition that causes vaginal discomfort for women globally. BV is characterized by the dominance of a diverse community of anaerobic bacteria and increases the risk for a series of adverse outcomes, including STI acquisition, preterm birth, and cancer. Gardnerella vaginalis is the most common bacterial species present in BV samples. G. vaginalis is known to have rich intraspecies diversity, with varying virulence potential between strains. However, the role of intrapersonal G. vaginalis strain diversity in vaginal microbial community stability and BV pathogenicity remains largely unexplored. To investigate this, I conducted a literature search of in vivo and in vitro experimental models for their ability to mimic the vaginal environment and successfully grow vaginal microbes, including G. vaginalis. Based on these findings, I experimented with different media, supplements, and antibiotics to optimize a rich, selective medium for G. vaginalis growth. To compare the phenotypes of G. vaginalis strains, I conducted a growth curve experiment on strains isolated from three BV-positive women, identifying substantial diversity of bacterial growth. In addition, I used matrix-assisted laser desorption ionization-time of flight (MALDI-TOF) mass spectrometry to identify four different bacterial species isolated from BV-positive, clindamycin-treated clinical vaginal samples of the same woman at two different time points, including a possible persistent strain. I will sequence the genomes of these strains and conduct phenotypic assays to study the role of strain diversity of these taxa in BV. The work presented here offers insight into models available for BV research and will ultimately contribute to understanding the role of intraspecies diversity in BV development and treatment resistance.

Faculty Project Mentor: Gina R Lewin, PhD, Department of Pathology, Case Western Reserve School of Medicine

LA28 Olympic Haptic Experience

Jihye Lee - Biomedical Engineering, Case Western Reserve University

Aidan Nathan - Biomedical Engineering, Case Western Reserve University

Xianzhe Tan - Biomedical Engineering, Case Western Reserve University

Evelin Urbancsok - Biomedical Engineering, Case Western Reserve University

This presentation outlines the process of design and development for a haptic feedback wristband designed to provide a more immersive experience to fans of the 2028 summer Olympics in Los Angeles. Our device aims to guide users to signatures of athletes that are virtually hidden throughout the city using directional and proximity-based vibration cues. Inspired by virtual reality and augmentation games, the wristband provides interactive, location-based feedback, vibrating with greater intensity the closer the user is to the hidden signature.

Utilizing the built in components, the wristband has the potential of delivering unique haptic patterns for every single signature, enabling all athletes to have their own “haptic signature” which lives in the virtual space as a pre-defined vibration pattern. Our project’s initial goal is to create a functional prototype that incorporates basic components that will be present in the final system, including vibrational motors and a microcontroller that will prompt this vibration based on location away from the signature.

The testing plan will focus on making sure the directional feedback algorithms successfully prompt vibration of the motors at different frequencies and intensities, and vibrate motors on different sides of the wristband based on which side is closest to the signature. The testing will focus more on the functionality of the directional algorithm than finer details, such as comfortability, battery life, and functionality of a mobile app based user interface.

Capstone Project Mentors:
Matthew R. Williams, PhD - Department of Biomedical Engineering, Case School of Engineering, School of Medicine
Colin K. Drummond, PhD, MBA - Department of Biomedical Engineering, Case Western Reserve University & Cleveland Clinic

Palatal Myoclonus and Dysphagia: A Literature Review

Gabrielle Vaccaro, Department of Psychological Sciences, Case Western Reserve University

Swallowing consists of an oral preparatory phase, a pharyngeal phase, and an esophageal phase. Safe and effective swallowing is necessary for adequate nutrition and hydration and contributes to overall health, social participation during mealtimes, and quality of life. During a swallow, the velum, or soft palate, elevates posteriorly; in conjunction with contraction of the lateral and posterior pharyngeal walls, this action closes the passageway between the nasopharynx and the oropharynx. Dysphagia (difficulty swallowing) may occur due to structural or functional abnormalities. One such variant in oral and pharyngeal functioning is palatal myoclonus (PM), a rare movement disorder, that occurs when there is oscillating movement of the soft palate caused by rhythmic contractions of the palatal muscles. Additional pharyngeal and laryngeal muscles are occasionally involved. PM in the symptomatic form may occur due to various etiologies such as stroke or a lesion within the brainstem. PM may contribute to dysphagia due to a disruption of velopharyngeal elevation resulting in reduced pharyngeal pressure for bolus transit and nasal regurgitation. A literature review was conducted to investigate the association between dysphagia and PM, as well as to conceptualize the characteristics of dysphagia that may occur with PM. Eighty-two articles were reviewed and twenty-one were included. Of these articles, only 14% (3/21) included >1 participant, indicating very limited sample sizes. Within the included studies, 92% of patients with PM (35/38) had co-occurring dysphagia. The features of dysphagia were different in each individual case, but consistent trends of aspiration and abnormalities with swallowing were noted. These results emphasize a need for awareness of this rare movement disorder as a possible exacerbating condition in patients with dysphagia.

Project Mentor: Dr. Rachel Mulheren, CCC-SLP, Assistant Professor, Case Western Reserve University, College of Arts and Sciences, Department of Psychological Sciences, Program in Communication Sciences

Generating a set of CRISPR knockouts in Drosophila simulans

Alekhya Vadlakonda, Biology major, Case Western Reserve University

The synaptonemal complex (SC) is a zipper-like structure that connects homologous chromosomes during meiosis. In many species, the SC is key to the formation of crossovers, as double stranded breaks (DSB) occur after the formation of the SC, and crossover events between homologous chromosomes occur as a consequence of these double stranded breaks. In some species, however, the SC is not needed for DSBs and crossovers to form.

Drosophila simulans is a sister species of the well-studied model organism Drosophila melanogaster and has not been significantly studied in terms of individual genetics. As such, not much is known about its basic processes like meiosis and DNA repair mechanisms. Drosophila melanogaster is prone to chromosomal inversions, a type of mutation wherein a section of DNA is inverted following a DSB in the DNA. Inversions are found in Drosophila melanogaster frequently in nature, and can also be easily induced using various methods. However, inversions have never been found naturally in Drosophila simulans, indicating a fundamental structural difference between these two species.

As the larger goal, this project aims to understand the structural reasoning behind Drosophila simulans's resistance to inversions by affecting various genes integral to the SC via selective deletions with CRISPR and observing the impact of these changes in Drosophila simulans.

Project Mentor: Dr. Nicole Crown, Department of Biology

Influence of surfactants on electrode slurries used for flow battery application

Samhita Vasudevan, Dept. of Chemical Engineering, Case Western Reserve University

Flow batteries are an emerging technology used for energy storage on the grid-scale level. The performance of a flow battery greatly depends on the efficiency of the slurry electrode, which affects the conductivity, capacity, and stability of the slurry during inactive periods. To improve slurry stability, surfactants have been added into the carbon black slurry electrode. One non-ionic surfactant, Triton-X 100, has shown a relationship between concentration of surfactant and slurry stability. It was shown that surfactant concentration affected slurry stability at a critical mass ratio of surfactant to carbon black ($\alpha = c_{surf.}/c_{CB}$) which for Triton-X 100 was 0.7. Here, the surface area of the carbon black is saturated with surfactants which inhibit interparticle interactions, leading to an unstable slurry. This study was extended to two more surfactants, Triton-X 45 and Triton-X 405, to investigate the relationship between surfactant molecular weight and slurry stability. Adsorption studies concerned finding critical α for both Triton-X 45 and 405. Results show no significant difference in critical α between all three surfactants. The molecular weight of surfactant does not affect surfactant saturation at the particle surface. Sedimentation studies measure the settling behavior of carbon black particles with the addition of surfactants. Previous studies have demonstrated that carbon black slurries behave like a colloidal gel interparticle attraction, but collapse under gravitational stress, leading to phase separation. The sedimentation behavior of gels are influenced by particle concentration, gel strength/elasticity, and the presence of surfactants. Sedimentation experiments with Triton-X 45 and Triton-X 405 were conducted, to understand how concentration of surfactant and surfactant size affect gel collapse behavior over time. Studies are ongoing for various carbon black weight percentages and α values.

Faculty Mentor: Dr. Christopher Wirth, Dept. of Chemical Engineering

Additional Mentor: KangJin Lee, Dept. of Chemical Engineering

Exploring Microglial Engulfment of Interneurons in Cerebellar White Matter During Neurodevelopment and Neurodevelopmental Disabilities

Lakshmi Venkat, CWRU

White matter abnormalities are prominent features of neurodevelopmental disorders, including Autism Spectrum Disorder (ASD) and Schizophrenia. White matter consists of myelinated axons essential for neural connectivity. Previous work in the DeSilva lab showed that microglia, the brain's resident immune cells, play a role in cellular refinement during neurodevelopment. This study showed that at postnatal day 7, microglia infiltrate the cerebellar white matter and engulf oligodendrocyte progenitor cells (OPCs) essential for myelin formation in a fractalkine receptor (CX3CR1) dependent manner. Notably, OPCs lacked apoptotic markers (phosphatidylserine), indicating non-apoptotic pruning, while phosphatidylserine was observed on other non-OPC cells, prompting further investigation.

Pax2-expressing GABAergic interneurons maintain the excitation-inhibition balance in the cerebellum. The dysregulation of this balance is implicated in neurodevelopmental disorders like ASD and Schizophrenia. These interneurons infiltrate the cerebellar white matter at a similar developmental time point as microglia, suggesting that microglia may also target these interneurons. Given the timing and proximity of microglial and interneuron infiltration, along with the presence of phosphatidylserine-positive non-OPC cells, we hypothesize that microglia engulf interneurons during normal development.

To test this hypothesis, we will use immunofluorescence staining for Pax2 (interneurons) and

Iba1 (microglia) in sagittal cerebellar sections from wild-type tissue, a maternal infection-related ASD model (Poly I:C), and a genetic ASD model (CX3CR1 knockout). Engulfment analysis will be performed using Imaris software to compare microglial interactions with these interneurons in wild-type and disease models. This study will elucidate microglial involvement in interneuron refinement, contributing to our understanding of neurodevelopmental disorder pathogenesis and potentially informing therapeutic strategies.

Determining Diet of Platyrrhine Primates Using Dental Topography

Sophie Verbeke, Department of Biology, CWRU

In order to understand modern neotropical biodiversity, we must understand the evolution and paleoecology of species in the past. The goal of our study is to test whether neotropical (platyrrhine) monkeys with different diets (folivore, frugivore-insectivore, frugivore, exudate feeder, and seed eaters) can be distinguished using dental topographic metrics (DTMs), which can measure different aspects of tooth shape and complexity. If so, DTMs can be used to predict diets of extinct primates and perhaps other ecologically similar mammals. We focused on the second upper molar (M2), since a previous study focused on the second lower molar (m2). Dental topographic data were collected from skull CT scans downloaded from Morphosource. 3D slicer was used to create a surface mesh, and these files were imported into MeshLab for isolation. Finally, MeshMixer was used to reconstruct and fill in minor holes and cracks in the teeth. The upper right molar was isolated and processed. The Rstudio package molaR was used to calculate three different DTMs: relief index,(RFI), orientation patch count rotated (OPCR), and Dirichlet normal energy (DNE). We will test the discriminatory ability of these variables via a quadratic discriminant analysis in R. We predict that upper molars will display patterns similar to those documented for lower molars by a previous study: strong separation based on diet with OPCR and RFI, but low separation with DNE. Furthermore, we predict that the OPCR values will be progressively greater from folivores, to frugivore-insectivores, frugivores, exudate feeders, and seed eaters.

Faculty Mentor: Dr. Darin Croft, Department of Biology, CWRU

HoloLens: Clio

Shane Szczecinski, Electrical Engineer, Case Western Reserve University

Hunter Voithofer, Electrical Engineer, Case Western Reserve University

Erick Zetino, Computer Engineer, Case Western Reserve University

The HoloLens: Clio project is an augmented reality (AR) application developed to transform museum and historical site tours by overlaying digital content onto physical artifacts through Microsoft HoloLens 2. This immersive experience, triggered by strategically placed QR codes, incorporates 3D models, audio guides, interactive quizzes, and historical narratives, providing a dynamic alternative to traditional, static displays. By allowing visitors to engage directly with cultural and historical information, the project enables a deeper exploration of artifacts and exhibits, including detailed 3D reconstructions, video narratives, and textual explanations that enrich context and understanding.

The application design follows a structured, location-specific approach to QR code placement, ensuring that each site can be customized to present relevant content in an engaging format. Built with Microsoft's Mixed Reality Toolkit (MRTK) and Unity's XR Interaction Toolkit, the HoloLens: Clio project adheres to high standards in AR accessibility and interaction quality, making it inclusive and user-friendly for diverse audiences. This approach not only maintains consistent performance across sites but also guarantees that users of various abilities can fully participate in the experience.

Designed with an emphasis on interactivity and learning, the project transforms the tour experience from passive observation to active engagement. By integrating AR elements thoughtfully, it provides museums and historical sites with a flexible, memorable, and immersive platform that promotes educational value and fosters a meaningful connection with cultural content. This innovative framework enables visitors to experience and interpret historical artifacts in new ways, offering museums and historical sites an adaptable solution to enhance visitor engagement and satisfaction.

Project Mentor: Jared Bendis, Electrical, Computer and Systems Engineering

Development Aerosol Jet Printing on PMMA for Sensorized Contact Lenses

Tyler Vu, Mechanical and Aerospace Engineering, CWRU; **Zachary Halsey**, Biomedical Engineering, CWRU; **Kennidi Kresier**, Biomedical Engineering, CWRU; **Sylvie Crowell**, Materials Science and Engineering, CWRU

Real-time health monitoring through wearable technologies represents an approach to daily personal health management. The ability to detect signs of conditions such as diabetes, high blood pressure, and various cancers directly via the exosomes carried in the eye fluid holds the promise of revolutionizing preventive healthcare. This study focuses on developing a proof-of-concept sensorized contact lens, leveraging aerosol jet printing (AJP) to deposit conductive and dielectric inks precisely onto a polymethyl methacrylate (PMMA) substrate. PMMA, a transparent thermoplastic used in early contact lenses, was selected for its structural properties, zero water content, and ease of handling, despite challenges of deformation at high sintering temperatures.

A vital aspect of this work is understanding the adhesion of the flexible electronic circuits to the PMMA substrate. It also involves evaluating the material and ink characteristics—physical and electrical—after sintering at various times and temperatures. Optimizing AJP parameters including atomizer voltage, aerosol and sheath gas flows, platen temperature, layer count, and print speed, is critical for creating reliable, conductive, and thin printed traces that will be used to create the interdigitated capacitor. We employed characterization techniques such as optical microscopy, laser profilometry, scanning electron microscopy (SEM), focused ion beam (FIB) milling, and electrical testing. These tests assessed deposition quality, conformation to print geometry, conductivity, and adherence to the printed structures and led to an optimized solution.

Future work will focus on transitioning from PMMA to hydrogel lenses, more common in modern contact lenses, using a novel plasma-curable ink under development. This approach aims to broaden the application of sensorized contact lenses in continuous, noninvasive health monitoring, potentially impacting preventive healthcare and disease diagnostics.

Project Mentors: Janet L. Gbur, Materials Science and Engineering, CWRU; Douglas B. Shire, VA Northeast Ohio Health Care System

Organization of Ribosomal DNA in Saccharomyces Cerevisiae

Ashleigh Walker, Neuroscience, CWRU CAS

The nuclear genome of Saccharomyces cerevisiae is distributed among 16 chromosomes. 150-200 copies of ribosomal DNA (rDNA) are found as head-to-tail repeats along the long arm of chromosome 12. We study cells arrested at metaphase, at which point the bud has enlarged to a size that equals that of the mother. At this point, most chromosomes form a single mass that transits between the mother and bud domains, while the nucleolus, including the rDNA "axis," remains in the mother cell. Since "standard" staining procedures using DAPI are not satisfactory for yeast, we developed an alternative procedure to detect rDNA and bulk DNA using the same probe.

Using our modified procedure, we noticed that the contour of rDNA was not of uniform width and appeared discontinuous. We compared the contour to the distribution of proteins implicated in stimulating (Hmo1) or repressing (histones) rDNA transcription. Since half of the rDNA repeats are normally expressed and about half of the rDNA repeats are known to assume an "open" conformation, we hypothesize that the variable appearance of rDNA reflects the presence of segments that are more or less actively transcribed. The distribution of Hmo1 and the histone are consistent with this hypothesis. We suggest that transcription alters the geometry of the minor groove of rDNA so that the affinity for the fluorescent dyes is reduced. Ongoing experiments directly assess the level of transcription along the rDNA axis and compare that to the intensity of staining with DAPI.

Project Mentor: Alan Tartakoff, CWRU SOM, Department of Pathology

The Relationship Between Stimulus Complexity and Behavioral Variation in Aplysia californica

Alexander Waltman[1] and Hillel Chiel[2]

1. Department of Biology, Case Western Reserve University, Cleveland, OH
2. Departments of Biology, Neuroscience, and Biomedical Engineering, Case Western Reserve University, Cleveland, OH

The ability to adapt behavior is critical for survival in a world with an ever changing environment. The goal of this project was to investigate how the nervous system supports organisms to adapt their behavior to different stimuli on a moment-to-moment basis and to quantitatively measure the changes in the nervous system in response to different stimuli. I will examine how the model organism, Aplysia californica, responds on a neural level to food with different complexity. The hypothesis was that complex tasks will elicit more varied neural responses than simple tasks. To monitor the neural activity in a freely feeding animal, a multichannel hook electrode will be surgically implanted within the Aplysia's head onto the nerves controlling its feeding apparatus. The electrodes will be attached to two nerves that transmit the motor signals for feeding movement, which can be used to determine how long the animal spends in the section of its feeding cycle where it directly interacts with the food. During experiments, the animal will be fed Nori, a homogenized uniform sheet of seaweed, as a simple food, or Gracilaria, a red seaweed that branches and bifurcates irregularly, as a more complex food. The data from the in-vivo recordings will then be analyzed to determine if the neural signals in response to varying food complexity differed in the activity level. Preliminary data has shown that their simple foods elicited more similar responses while complex foods elicited more varied responses, suggesting that complex foods required more behavioral adaptation from the animal.

Facility and Project mentor: Hillel Chiel, Departments of Biology, Neuroscience, and Biomedical Engineering, Case Western Reserve University, Cleveland, OH

Maternal Substance Use and its Impacts on Mothering Practices

Haley Weis, Department of Anthropology, CWRU

Substance use disorder continues to be a serious health concern for a significant portion of the population in the United States. Women and pregnant individuals, especially those in marginalized communities, are uniquely impacted by the effects of having a substance use disorder. In addition to struggling with substance use, many of these women must contend with hegemonic ideals of acceptable mothering practices and the structural, public, and internalized stigma exerted upon mothers and pregnant individuals who use drugs or have a substance use disorder. Ideals of mothering practices in the United States are shaped by white, middle-class, heterosexual standards, which many women with substance use disorder may fail to achieve. Current literature lacks a comprehensive demonstration of the impacts of substance use disorder on mothering and child rearing practices. This research aims to coalesce current scholarship regarding the ways in which societal perceptions of mothers with substance use disorder, the women's own perceptions of their mothering practices, and the actual mothering practices of women with substance use disorder differ as well as how their concurrent substance use and maternal responsibilities impacts treatment uptake and retention and involvement with social services.

Project Mentor: Dr. Lee Hoffer, Department of Anthropology, CWRU

Optimizing Small Molecule Inhibitors of CD40-TRAF2

Matthew Weng; Systems Biology, Case Western Reserve University

New and effective therapies against inflammatory disorders are needed. The CD40-CD154 pathway is a known target against IBD and other inflammatory disorders. Clinical trials showed that anti-CD154 antibodies reduced inflammation but caused thrombosis (unrelated to CD40 inhibition). Moreover, global inhibition of CD40 predisposes opportunistic infections (OI). Finding a small molecule that inhibits CD40-driven inflammation and does not induce thrombosis or OI will be a major advance in the treatment of inflammatory disorders.

CD40 signals by recruiting TNF Receptor Associated Factor 2 (TRAF2) or TRAF6. CD40TRAF6 but not CD40-TRAF2 is needed for immunity against OI. We showed that disrupting CD40-TRAF2 interaction inhibits inflammation while preserving protection against an OI. We identified a small molecule (CCI2260) that binds TRAF2, blocks CD40 and diminishes inflammation in 3 mouse models of IBD. CCI2260 did not impair resistance to an OI. We will use reporter cells that express CD40 that signals only through TRAF2 or TRAF6 to identify potent analogs that inhibit CD40-TRAF2 but not CD40-TRAF6 signaling. We will then confirm that activity inhibitors do not impair CD40-driven cell mediated immune responses (antimicrobial activity, IL-12 production). In addition, we will test whether these analogs inhibit receptors that signal through TRAF2 (TNFR1-TRADD, CD30, Lymphotoxin b receptor). The project is expected to result in an optimal, potent, small molecule inhibitor of CD40.

Project Mentor: Sarah Vos, Department of Infectious Diseases and HIV Medicine, Case Western Reserve University School of Medicine

Principal Investigator: Carlos Subauste, Department of Infectious Diseases and HIV Medicine, Case Western Reserve University School of Medicine

Capstone Faculty Sponsor: Karen Abbott, Department of Biology, Case Western Reserve University

The Use of Role-Playing Games as a Therapeutic Intervention for Mental Health

Serena Wheeler, Department of Psychological Sciences, Case Western Reserve University

During the pandemic, companies saw an increase in the purchase of tabletop roleplaying games (TTRPGs), likely due to increased social isolation and compatibility to be played in a virtual format. Following the pandemic, health professionals have observed increases in anxiety and depression in adolescents and young adults. Research has supported the use of TTRPGs as having positive benefits on mental health, such as decreasing feelings of anxiety and depression, and increasing social skills, namely conflict resolution and collaborative problem-solving. More research has also been done on the use of role-playing games in a therapeutic setting, referring to them as therapeutically applied role-playing games (TA-RPGs). However, there is minimal research surrounding the use of virtual role-playing games (VRPGs) as an alternative therapeutic intervention, despite research citing the potential benefits of these games on mental health. This paper proposes that role-playing games, regardless of format, can be a cost-effective therapeutic tool for adolescents and young adults.

To gather literature, scholarly databases, such as Google Scholar, Web of Science, and PubMed were searched using the following keywords: role-playing games, mental health, tabletop role-playing games, virtual role-playing games, and dungeons and dragons. Findings suggest that TTRPGs, notably Dungeons and Dragons, positively affect mental health. Virtual role-playing games, such as World of Warcraft, have observed positive mental health benefits, although overuse can leave users at risk for gaming addiction. If used in a controlled format with proper motivations, the risk of gaming addiction is limited. Further research should be conducted to understand better how virtual role-playing games could be used in a therapeutic setting.

Project Mentor: Dr. Anastasia Dimitropoulos, Department of Psychological Sciences, Case Western Reserve University

Resilience: Understanding the Relationship Between Social Cognitive Functioning and Protective Mechanisms in Trauma Survivors

Sabrina Wicker, Department of Cognitive Science at Case Western Reserve University

Maltreatment and adversity in childhood have been previously found to result in adverse affective outcomes in adolescence and adulthood for trauma survivors. While prior research has examined the affective outcomes of childhood trauma, less research has focused on the social cognitive impacts in people who have experienced childhood adversity.

Furthermore, the mechanisms contributing to a trauma survivor's ability to maintain a high level of social or functional ability after experiencing trauma are even less understood. Prior research suggests that experiencing psychological trauma can be associated with impaired working memory functioning, mentalizing ability, and functional network connectivity (Cao et al, 2024; Ding & He, 2021; Haczkewicz et al, 2024; Steven & Jovanovic, 2020).

One primary mechanism that has been thought to play a role in a trauma survivor's socioemotional outcomes after exposure to trauma is resilience. Drawing on the previous literature examining the role of resilience in preventing adverse outcomes after experiencing trauma, the proposed analysis aims to understand the role of resilience in determining an individual's cognitive outcomes after experiencing trauma. The present study aims to understand the role of resilience in mediating the negative effects of trauma on cognitive functioning in memory, specifically working memory, cognitive and affective empathy, and mentalizing or perspective-taking ability.

Project Mentor: Todd Oakley, Department of Cognitive Science, Case Western Reserve University, Cleveland, OH

Spacekey - An Immersive and Virtual Approach to Space Education

Albert R Wilhelmy V, Electrical Engineering, Case Western Reserve University

Space education stands apart from other contemporary science subjects in the sense that K-12 students cannot directly engage with it in a first-hand manner. Teachers can provide experimental tools and lesson plans that allow students to immerse themselves within chemical reactions, biological processes, thermodynamics, and many other topics, but not outer space. The closest interaction that a young student can have with the stars is either a telescope in their backyard, or second-hand media provided by government space agencies and private companies.

This project attempts to provide a framework for a classroom devoted to first-hand space education. The initial prototype demonstrates this process by which an end-user has the ability to control the movements of a camera in order to interact and explore its real-time environment. This first model utilizes Raspberry Pi's and off the shelf components to achieve this by submerging the prototype in water as a proof of concept and substitution for the harsh environment of space. Funding and time willing, this project would someday culminate with a constellation of satellites in space devoted solely to educating the people of this planet with their universe.

The software component of this project will utilize the Raspbian OS, the Python programming language for numerous scripts, as well as the use of multiple communication protocols such as TCP and MQTT. The use of Putty was also heavily relied upon in the early stages of development. The hardware is relatively simple, consisting of microcontrollers, modular camera devices, and basic wire management. The apparatus was made only as complex as was necessary to achieve the desired outcome in a testing environment that involved water.

The ultimate goal of this project is to highlight an aspect of modern early scientific education that can be improved upon to better prepare future generations for the world that awaits them. Outer space will undoubtedly become an increasingly important part of our daily lives, thus, it is only sensible that we equip future generations with the experiences and intuition so that they may be able to ask the questions that we never could.

Project Mentor: Nick Barendt, Executive Director, Institute for Smart, Secure and Connected Systems (ISSACS)

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 describes the intense fear of needles and is characterized by symptoms such as anxiety, palpitations, nausea, sweaty hands, and breathlessness. The condition affects roughly two out of every three children and 25 percent of adults. It is classified as a biopsychological condition and has seen increased clinical relevance since the advent of the Covid-19 pandemic. Unfortunately, people suffering from trypanophobia are less likely to receive vaccinations, resulting in increased likelihood of contraction of communicable disease. A number of pharmacological and non-pharmacological approaches to trypanophobia exist, with non-pharmacological methods generally being preferred for their simplicity and minimal risk. However, many of the current solutions are designed with pediatric patients in mind, potentially resulting in stigmatization among older individuals. Additionally, most products currently available have yet to achieve significant market penetration. Many of these devices are made as small batch products without the backing of larger companies. Leveraging principles of spatial summation, we designed a device capable of augmenting the pain felt during standard intramuscular injections. This device was also designed to be used in all age groups. When attached to a patient's arm, our device utilizes thermal and mechanical stimulants to saturate the sensory nerves surrounding the injection site. As posited by the gate control theory of pain, these non-painful stimulations could reduce the perception of pain. Our device also serves to obstruct the vision of a patient, as visualizing a needle puncturing the skin can be a source of anxiety. The device was designed with the clinician in mind and should not necessitate any significant retraining or increased time of treatment.

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

FilmFinder: A Web Application Using Natural Language Processing to Find Movie Similarities

Shreeya Chugh, Donovan Wu, James Xu, Kieran Williams, Joshua Meyer

Computer Science, CWRU

Many people will watch a good movie and want to find other movies like it. Rather than scouring the web to find similar movies, FilmFinder makes this easy by taking a movie as an input and outputting the most similar movies from a set of hundreds of thousands. This functionality is packed into a user-friendly interface that makes it easy to decide on the next movie to watch.

This project has several primary components. First is the movie dataset, which is based on "The Movie Database" (TMDB), a dataset of over one million movies. From this dataset, we first filter out movies that we don't want to recommend (too old or too short for example). Then, we remove some of the data points that aren't useful (urls to their poster for example). Of the remaining movies, many don't contain critical information, such as plot summaries, so web scraping is used to fill in the gaps.

Second is the movie analysis component which vectorizes movies and uses distance metrics to find the most similar movies. Vectorization entails processing data about a film to create a unique vector that represents it. To generate each vector, data such as plot summaries and genres are encoded with a Universal Sentence Encoder (USE), and the spaCy library is used to find semantic similarities. Clustering methods are then used to group similar movies. By searching a cluster that an inputted movie is in, FilmFinder can return the most similar movies.

Last is the web application, which provides an interface to interact with the movie analysis component. It enables the user to filter output movies by characteristics such as genre, ratings, and release year.

Faculty Project Mentor: Shuai Xu, Ph.D., Department of Computer and Data Sciences, CWRU

Investigating the therapeutic potential of the DNA aptamer, M3

Hanwen Yan, Department of Biology, CWRU

Aptamers are short, single-stranded nucleic acid sequences that selectively bind to specific targets. Aptamers have been shown to inhibit biological processes, such as cell migration, cell growth and angiogenesis. My project aims to analyze the therapeutic potential of a novel DNA aptamer M3 in inhibiting migration of triple-negative breast cancer cell line MDA-MB-231. M3 aptamer was developed by Li et al., 2018 to capture circulating tumor cells(CTCs) to predict metastasis. I investigated the effect of M3 on cell migration using a wound-healing assay. This assay assesses the migration of cells into a denuded area. Interestingly, our results showed that M3 does not inhibit MDA-MB-231 cell migration. I then further investigated the interaction between M3 and various cell types, including MDA-MB-231, human umbilical vein endothelial cells (HUVEC), and HeLa cells using confocal microscopy. Results indicate that M3 binds to the surface of both MDA-MB-231 and HUVEC cells. Notably, in HeLa cells, M3 not only binds to the surface but it also appears to internalize into the cells, suggesting distinct cell-specific interactions. Based on these findings, in future studies, we will perform flow cytometry to assess M3 binding across these cell lines quantitatively. Overall, my data suggest the M3 DNA aptamer does not inhibit cell migration in breast cancer cells but it does have a potential therapeutic effect on HeLa cells.

Project mentor: Yolanda Fortenberry, Department of Biology, CWRU

Mechanical Evaluation of Neuromodulation Leads and Feedthrough Connections

Jerry Yang, Biomedical Engineering, CWRU**; Wenfei Zhao,** Biomedical Engineering, CWRU

The Cleveland Open-Source Modular Implant Innovators Community (COSMIIC) aims to create an open-source, modular platform for neuromodulation therapies. COSMIIC's system relies on conducting electrical stimulation from a pulse generator to an implanted nerve excitation module, as well as relaying information back to biopotential recording modules. This work discusses mechanical testing for the connections in COSMIIC's Neural Open-Source Versatile Array (NOVA), which consists of an implantable 32-channel system for neural recording or stimulation.

To represent NOVA's 32 channel lead-to-feedthrough-pin interface, witness specimens were fabricated using a platinum alloy pin encased in an epoxy cylinder. A stainless steel ferrule containing a 1x7 arrangement of 35N LT silver-cored, drawn-filled tube insulated strand was welded to the pin. A second set of witness specimens were fabricated by surrounding the interface with silicone to simulate the backfill present in the NOVA that will prevent fluid ingress upon implantation. Both sets were tested under tension, with custom grips to minimize stress concentrations, and fracture surfaces were evaluated using optical light microscopy and scanning electron microscopy. Data will be used to improve the lead-pin interface and inform future design.

Project Mentors: Douglas B. Shire, VA Northeast Ohio Healthcare System; Janet L. Gbur, Materials Science and Engineering, CWRU

Artificial Intelligence-Assisted Segmentation of MRI for Osteoarthritic Knees

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2. Biomedical Engineering, Lerner Research Institute, Cleveland Clinic

Knee Osteoarthritis (OA) has a multifactorial origin and is characterized by articular cartilage damage, bony osteophyte formation, and sclerosis of the subchondral bone, resulting in pain around the knee joint and disability. Post traumatic osteoarthritis (PTOA), a subtype of OA, develops after joint injury such as intra-articular fracture or ligament, meniscus, or articular cartilage injuries. Anterior cruciate ligament (ACL) injury is a major risk factor for PTOA, with a reported incidence as high as 87%. Further, ACL reconstruction (ACLR) surgery itself can also lead to knee joint trauma and joint inflammation. Since OA and PTOA are chronic conditions, identifying markers of its pathology, including the morphology and geometry of the knee, provides valuable insight for making clinical inferences. Segmentation is a technique often used to identify and extract regions of interest (ROIs) in the radiographic images for further analysis of anatomical data. Traditionally, medical image segmentation has been a manual, time consuming process; however, new developments in artificial intelligence (AI), machine learning (ML), and deep learning (DL) technologies have provided efficient and fully automated means of ROI extraction. This study aims to evaluate the accuracy of META's Segment Anything Model 2 (SAM2) on non-fat-saturated SPACE sequence MRIs. Bilateral knee MRIs at 10-year follow-ups from 20 patients who underwent unilateral ACLR were collected. SAM2 was used to segment the patella of all 40 scans. Then, the segmented images were manually corrected under the supervision of a board-certified radiologist. The percentage of subjects that required correction, the percentage of area over- and under-segmentation by the model, as well as the Dice Similarity Coefficients were measured.

Project Mentor: James R. Peters, Biomedical Engineering, Lerner Research Institute, Cleveland Clinic

Genetic reduction of glycative stress in high glycemic diet fed mice reduces Age-Related Macular Degeneration (AMD)-like features

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Purpose: Western dietary patterns are associated with increased AMD risk. High glycemic diets cause hyperglycemia, metabolic stress and increased oxidative damage. Chronic hyperglycemia increases levels of glycoxidative products known as advanced glycation end-products (AGEs), which are associated with and potentially causative for AMD. Here, we test the importance of AGE formation in a mouse model of AMD by transgenic overexpression of glyoxalase 1 (Glo1), a detoxification enzyme that reduces AGE formation.

Methods: WT or Glo1-Tg littermate male mice were aged to 12-months on regular diets and fed macronutrient- and calorie-matched low glycemic (LG) or high glycemic (HG) diets for an additional 12-months. Glycemia was evaluated by intraperitoneal glucose tolerance test. Eyes were evaluated in vivo by fundus photography or histological retinal and RPE examination. Metabolomics and analysis of AGEs was performed on fasting tissue and plasma samples by LC-MS/MS. Glyoxalase activity was tested by enzymatic assay. Statistical analysis was performed using 2-way ANOVA with Tukey's post hoc.

Results: Mice fed HG diets became obese and glucose intolerant, irrespective of genotype. Glyoxalase activity was unaffected by diet but decreased with aging and increased with Glo1 overexpression. Aging of WT HG-fed mice led to increased white-yellow fundus lesions relative to WT LG-fed mice. HG-fed Glo1-Tg mice had fewer fundus lesions. Several AGE levels were increased in HG-fed mice and decreased in Glo1-Tg mice or LG-fed mice. Mice fed HG diets had loss of photoreceptors, increased RPE vacuolation, and large lipid-containing basal deposits. AMD features were reduced by Glo1 overexpression like those in mice fed LG diets. Analysis of the plasma metabolome revealed distinct metabolomes for HG-fed compared to LG-fed mice. We also identified metabolites that were altered in Glo1-Tg mice compared to WT mice.

Conclusions: AMD feature development caused by HG diet is a combined effect of altered metabolism and glycative stress downstream of chronic hyperglycemia. Glycative stress reduction by Glo1 overexpression ameliorated the effect of poor diet on retinal health. Therefore, interventions against AGE levels may have potential therapeutic benefits.

Project Mentor: Vincent M. Monnier, Department of Pathology, Case Western Reserve University
Faculty Sponsor: Sheldon Rowan, JM-USDA Human Nutrition Research Center on Aging, Tufts University; Department of Ophthalmology, Tufts University School of Medicine; Friedman School of Nutrition Science and Policy, Tufts University

The Effect of Citrulline in a DSS Mouse Model of Experimental Inflammatory Bowel Disease

Hannah Zacharia, Department of Anthropology, Case Western Reserve University

Inflammatory bowel disease (IBD) is a chronic inflammatory disease of the gastrointestinal tract. Citrulline is recognized as a marker for evaluating gut function, a regulator of protein metabolism, and a key precursor in the synthesis of arginine. In catabolic states, arginine levels drop, impacting wound healing, hormone production, and immune response. Large doses of arginine are needed to replenish levels, but its breakdown in the gut and liver often causes gastrointestinal discomfort. Citrulline efficiently restores arginine without the side effects. This study aimed to explore the effect of citrulline supplementation on the DSS induced colitis model of experimental IBD. SAMP1/YitFc (SAMP) mice were used for their phenotypic similarity to the chronic, relapsing inflammation and tissue damage characteristics of Crohn's disease. 14-week-old SAMP mice were randomly assigned into two groups; (i) Citrulline group (n = 6) that received citrulline at a dose of 0.2 mg/g per day, and (ii) Control group (n = 6). Citrulline was given via oral gavage for 3 weeks prior to the induction of colitis by DSS treatment. Fecal samples were collected weekly and analyzed for myeloperoxidase (MPO) activity. The MPO activity was decreased after one and two weeks of citrulline administration. The MPO activity of mice treated with citrulline were significantly lower than that of control group after one and two weeks of citrulline intake (MPO activity $Log_{2,}$ after week 1; Citrulline group: 4.5 ± 0.8 vs Control: 7.2 ± 0.6, $p < 0.002$, after week 2, Citrulline group: 4.4 ± 0.6 vs Control: 7.5 ± 0.7, $p < 0.002$). This shows that Citrulline plays a role in decreasing the intestinal inflammation.

Project Mentors:

Drishtant Singh, Department of Nutrition, School of Medicine, Case Western Reserve University

Fabio Cominelli, Digestive Health Research Institute, University Hospitals Cleveland Medical Center

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Reciprocity Between Social Media, Self-Perception, and Relationships

Jason Zhang, Cognitive Science, CWRU

The purpose of this literature review is to explore the reciprocal relationship between social media usage, self-perception, and relationships with others. Social media has been well documented and linked to many pathologies associated with adverse social comparisons, including lack of self-esteem, unrealistic body image expectations, and feelings of self-isolation. However, despite contributing to worse mental health, the growing number of users indicates that individuals either do not care about these conditions or that there is some underlying function of social media that outweighs these concerns. Through a cognitive science lens, this review will attempt to explicate the mechanisms of social media that trap users into a cycle of harmful comparisons, one mechanism being the incentives social media users receive despite the detriments to their mental health. The history and structure of various social media will be touched upon first, followed by an introduction to the concept of panopticism (constant surveillance that creates self-regulating behavior due to a fear of perpetual observation) and why individuals feel the need to disclose their lives to the world. Next, this paper will examine whether users present their true selves (ipse identity) on these platforms by compiling testimonials from online sources such as Reddit, as well as the potential causes for those differing self-presentations. In addition, the phenomenon of identity shifts (behaviors that are internalized in a mediated setting affect self-perception) will be explored in active social media use. Finally, the study will consider potential avenues for social media users to recognize, reflect, and possibly alter the self-destructive patterns of behavior that result from these cycles of damaging social comparison.

Project Mentor: Todd Oakley, Department of Cognitive Science, CWRU

3D cilium model reconstruction and cilium-fluid interaction analysis

Tingting Zhang, Department of Mathematics, Applied Mathematics, and Statistics.

Understanding the cilia-fluid interaction in low Reynolds number regimes is crucial for its biological applications, such as fluid transport in respiratory system. This study aims to develop a model for analyzing cilia-induced fluid flow. Firstly, we utilized the two-camera tracking data of one cilium to reconstruct its 3D cilium movement. To enhance smoothness, the cilium movement was parametrized along three abscissas, and third-order polynomial fits were applied. Secondly, the method of regularized Stokeslets was employed to solve the fluid flow in the low Reynolds number regime. In our result, the 3D reconstruction of cilium movement, and the movement of fluid particles driven by cilium motion were provided.

Project Mentor: Dr. Longhua Zhao, Department of Mathematics, Applied Mathematics, and Statistics, CWRU.

Programmable Waveform-based Vibrotactile Display

Anyongyong Zhao, Department of Engineering (CWRU)
Keyu Song, Department of Engineering (CWRU)
Juho Jeon, Department of Engineering (CWRU)

Background

This project introduces a programmable, waveform-based vibrotactile display developed to help children aged 3 to 8 years improve focus and engagement in educational, therapeutic, and medical settings. The device is designed as a compact, palm-sized unit that delivers diverse tactile feedback through controllable vibrations generated by varied sound waveforms. The vibrotactile feedback is crafted using natural metaphors to create a more intuitive experience, going beyond simple vibrations by incorporating low-frequency components to mimic realistic touch sensations.

Methods

The system's core is a Teensy 4.1 microcontroller, chosen for its high-performance ARM Cortex-M7 processor, substantial memory (1MB RAM and 8MB flash), and ease of interfacing with MATLAB, which is used to program and control waveform generation. But in order to drive our voice coils at the end. We have to transfer the digital code into analog signals. As a result, we chose a DAC with four independent output channels allowing for multi-channel vibration control, providing distinct outputs across voice coil actuators. Signal amplification is managed with a class-D amplifier, selected for its high efficiency making it ideal for battery-powered or portable devices.

Communication between components is facilitated by the I2C protocol, ensuring compatibility and scalability with other microcontroller-based systems.

Key milestones include designing custom waveforms tailored for four channels between 0-300 Hz, testing the system in a standalone configuration, and preparing for a final demonstration. Future work aims to enhance functionality by enabling signal switching through onboard buttons and transitioning towards a fully portable, PC-independent device.

Goals

The programmable vibrotactile display exemplifies a novel approach to using tactile feedback as an engagement tool for young users. With potential applications in education and therapy, the system leverages advanced hardware and software integration to offer a customizable, immersive tactile experience that could significantly aid children with attention difficulties.

Mentor: Zonghe Chua, Assistant Professor, Department of Electrical, Computer and Systems Engineering

Principal Investigator: Assistant Professor, Department of Electrical, Computer and Systems Engineering

On The Value of Chess Pieces

Haitian Zhong, College of Arts and Sciences, Applied Mathematics

This paper proposes various approaches to calculating the relative value of chess pieces. The standard evaluation, which assigns fixed values to each piece(pawn=1, knight=3, rock=5, etc.), is generally accepted but has some shortcomings such as its inability to explain the combination of pieces. Thus, some more complicated math-based evaluations appear such as the mobility model and the attack proteck-model. The paper reproduced the mathematical formulas and calculated the values based on the models, and applied these models to 10,000 real chess games, finding slight deviations from their theoretical expectations. Therefore, the paper referenced some modern approaches, which involve machine learning and chess engines. These approaches only appeared in recent years since traditional engines evaluate positions in centipawns, the measure material advantage, so it is impossible to derive piece values without causing circular reasoning. However, with the emergence of engines like Lc0 in 2018, which leverage neural networks to evaluate winning probabilities instead of centipawns, it is now feasible to derive more dynamic and context-sensitive piece values based on engine evaluations. The paper constructed a regression model that uses features such as piece moves, captures, controlled squares to map engine evaluations to piece contributions. The results indicate that this approach significantly improves the understanding of the relative value of pieces in practical gameplay.

Mentor: Erkki Somersalo, Department of Mathematics, Applied Mathematics and Statistics

Discovering the role of neuronal lactate transporters in mouse barrel cortex when triggered by whisker stimulation

Chengyu Zhou, Neuroscience, CWRU; Daehoon Lee, Department of Neurosciences, CWRU; Wen-Cheng Xiong, Department of Neurosciences, CWRU

Our research focuses on understanding how sensory stimuli are processed in the mouse barrel cortex, specifically investigating the role of neuronal lactate transporters in response to whisker stimulation. The lactate transporters are critical for meeting the metabolic demands of neuronal activity, facilitating angiogenesis, and increasing cerebral blood flow to ensure nutrient delivery. To explore this, we employed a range of scientific techniques, including mouse breeding, genotyping, whisker stimulation experiments, viral injections, brain slice imaging, immunostaining, and Western blotting. Our study primarily aimed to compare the density of blood vessels (BV) between whisker-stimulated and unstimulated sides of the primary somatosensory cortex, focusing on how lactate transporters influence activity-induced angiogenesis. We investigated the effects of the MCT1/2 inhibitor AR-C155858 on blood vessel increases following whisker stimulation. Preliminary results showed that the elevation of MCT1+ blood vessels observed after stimulation was significantly reduced in AR-C155858-injected mice compared to controls, suggesting a critical role for MCT1/2 transporters. Using shRNA to selectively target MCT2, we observed reduced blood vessel density even without stimulation, implying a basal role for MCT2 in vascular development and maintenance. These findings point to the essential involvement of neuronal-specific lactate transporters in both neural activity-induced and basal angiogenesis in the mouse barrel cortex. Our ongoing analysis seeks to further delineate the specific contributions of these transporters to sensory processing and cortical plasticity.

Project Mentor: Dr Wen-Cheng Xiong, Department of Neurosciences, CWRU School of Medicine

Faculty Sponsor: Dr Ashley Nemes, Department of Neurosciences, CWRU School of Medicine

Exploring Cytokine Modulation and Cellular Responses through Aptamer-Based Intervention in Breast Cancer Cell

Sihan Zhou, Department of Biology, Case Western Reserve University

Breast cancer metastasis is heavily influenced by cytokine modulation, which is a process regulates cell migration and angiogenesis. It is critical to tumor progression. This study investigates aptamer-based intervention in cytokine responses of the MDA-MB-231 breast cancer cell. We focuse on the effects of transfection with the aptamer R-10-4, which is an inhibitor of plasminogen activator inhibitor-1 (PAI-1). By targeting PAI-1, we hypothesized that R-10-4 would influence cytokine activity related to cell migration and angiogenesis. After transfecting cells with R-10-4, conditioned media were collected from both treated and control groups and analyzed using a cytokine array. The experiment was repeated four times to ensure the accuracy. Results demonstrated that R-10-4 significantly decrease the expression of CCL5, a chemokine known to enhance cancer cell migration and can be expressed with the existance of PAI-1. This inhibition of CCL5 suggests that R-10-4 block the signaling pathways that facilitate tumor migration and vascularization. The outcome of this study is valuable because it identifies a potential way to limit breast cancer spread. It also offers a foundation for developing aptamer-based therapies that could precisely control metastatic processes in cancer.

Key Words: Breast Cancer, Cytokin, R-10-4

Mentor: Dr. Yolanda Fortenberry, Department of Biology, Case Western Reserve University

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; **Correy Zemon**, Department of Biomedical Engineering; and **Rahul Darbkahul**, Department of Biomedical Engineering, CWRU.

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 when 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 advanced sensing technology capable of detecting key biomarkers associated with infection, such as pH changes and temperature fluctuations. The bandage will provide visual alerts from the data collected, 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, as well as 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 also 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.