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Exploring a Lactobacillus species as a novel probiotic therapy in the SAMP1/YitFC mouse model of Crohn's disease-like ileitis.

Ankita Achanta, Drishtant Singh, Katie Wong, Harrison Delffs, Sophia Mita, Alexander Rodriguez-Palacios, Fabio Cominelli, Abigail Basson Raffner, Department of Nutritional Biochemistry and Metabolism

Objective: Crohn's disease (CD) is a chronic gastrointestinal disorder involving host genetics, environment, and the gut microbiota. Given the crucial role of gut microbiota in CD pathogenesis, microbial-based approaches hold high therapeutic potential. This study focused on the potential of a lactic acid-producing Lactobacillus species, a probiotic candidate identified in our laboratory, to attenuate intestinal inflammation in SAMP1/YitFc mice, a mouse model of CD-ileitis.

Methods: We tested the potential of a Lactobacillus species, to; (i) protect against the severity of dextran sodium sulfate (DSS)-induced colitis (Experiment 1; acute flare model), (ii) prolong dexamethasone (DEX)-induced remission in older SAMP mice with established ileitis (Experiment 2; remission model), (iii) prevent/attenuate disease onset in young SAMP mice (Experiment 3; preclinical model). In all experiments, SPF SAMP mice were orally gavaged with either the Lactobacillus (1×10^6 CFU, 200µl) or 1X PBS (control group) daily. In experiment 1, 14-week-old SAMP mice received the probiotic for 4 weeks followed by 3% DSS in drinking water for 7 days, and were sacrificed 2 days later. In experiment 2, 14-week-old mice were given DEX intraperitoneally for 7 days (5 mg/kg/day) to induce remission, and given the probiotic or vehicle control for 6 weeks. In experiment 3, 4-week-old SAMP were given the probiotic for 6 weeks. Body weight, fecal myeloperoxidase (MPO), colonoscopy, histology, and gut permeability (FITC-dextran) were assessed.

Results: In all experiments, Lactobacillus treatment significantly reduced fecal MPO (log2 µ/g), a marker of gut inflammation [(Exp 1, Pre-DSS; Probiotic: 3.7 ± 0.2 vs control: 5.5 ± 0.1 P = 0.004), (Exp 2, DEX week 5: probiotic; 4.2 ± 0.3 vs control: 6.8 ± 0.4, P = 0.002)]. Data collection for the ongoing experiments is in progress.

Conclusion: Preliminary data suggests that the administration of a probiotic candidate Lactobacillus may have anti-inflammatory potential in experimental CD-ileitis.

Faculty Project Mentor: Abigail Basson Raffner, Department of Nutrition

Investigating the role of strain-level diversity in vaginal microbiome stability through the use of asimulated vaginal fluid (SVF)

Camila Acosta Matos, Systems Biology; Anya Wojtkowiak, School of Medicine

The female genital tract is naturally colonized by diverse bacterial communities, with Lactobacillus species supporting vaginal health by producing lactic acid and maintaining a low pH. Disruption of this balance can lead to bacterial vaginosis (BV), a condition affecting nearly 30% of women worldwide and linked to higher risk of sexually transmitted infections and adverse pregnancy outcomes. Despite its prevalence, BV's causes remain poorly understood, and nearly half of treated cases recur within a year. Recent studies have shown that in addition to species-level diversity, an individual's vaginal tract also contains diversity within species, but a major knowledge gap is the role of this intrahost intraspecies diversity within the vaginal microbiome. We hypothesize that increased microbial intraspecies diversity of lactobacilli within a host promotes a more stable and optimal vaginal microbiota. To test this, we are analyzing intraspecies diversity within clinical vaginal swabs collected through THRIVE, a longitudinal cohort study in Winnipeg, Manitoba, following BV-positive and BV-negative women over six months. Thus far, from a single host, we have obtained over 200 bacterial isolates, including multiple strains of the same species. We are currently characterizing strain-level diversity within these isolates. To further test our hypothesis, we also aim to experimentally culture microbial populations and test their resistance to environmental disturbances. As a first step, we conducted a literature review on simulated vaginal fluid (SVF) formulations to identify a physiologically relevant medium that supports the growth of core vaginal microbes while mimicking in situ conditions, such as vaginal pH and osmolarity. This will inform our experimental culturing conditions. Future work will involve continued bacterial isolations, strain identification, and culturing experiments in SVF. Together, this work will contribute to a deeper understanding of the microbial ecology of the vaginal environment and may inform future microbiome-based treatments for BV.

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

Apoptosis of PVH Neurons by Infiltrating Immune Cells Following Traumatic Brain Injury

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Traumatic brain injury (TBI) is a leading cause of death and economic burden worldwide, with TBI-related issues costing approximately $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 range in severity from mild to severe and are associated with a wide spectrum of symptoms and disease progression. Among its physiological consequences, TBI causes both acute and chronic alterations in the immune system, contributing to neuroinflammation and neurodegeneration. However, the connection between TBI and the hematopoietic system remains poorly understood.

We hypothesized that immune cell infiltration into the paraventricular hypothalamus (PVH) following TBI induces apoptosis or degeneration of neurons in that region, thereby contributing to hematopoietic dysregulation. To test this hypothesis, we performed immunofluorescence staining on 40 μm anterior coronal brain sections from mice. We used an anti-oxytocin antibody to label the PVH, a TUNEL assay to assess cellular apoptosis/degeneration, and an anti-CD11a antibody to evaluate the presence of infiltrating immune cells following TBI.

Our progress to date has focused on optimizing the experimental protocol. We determined that the appropriate concentration of the anti-oxytocin antibody is 1:4000 following TUNEL staining. Additionally, we incorporated a permeabilization step using Triton X-100 and blocked endogenous peroxidase activity with 0.3% hydrogen peroxide (H_2O_2). This optimized protocol will now enable us to investigate whether PVH neurons undergo degeneration and apoptosis based on the colocalization of oxytocin and TUNEL staining. The extent and role of CD11a+ immune cell infiltration into the PVH after TBI remain to be further investigated.

Understanding this neuroimmune interaction may reveal novel therapeutic targets to mitigate immune-related effects in TBI patients. Our study emphasizes that the impact of TBI extends beyond the brain, disrupting essential physiological systems through targeted neuronal loss.

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

SynthoPlate, a Synthetic Platelet Surrogate, Reduces Blood Loss in Preclinical Models of Severe Thrombocytopenia

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Uncontrolled hemorrhage is a leading cause of preventable mortality, yet the clinical utility of platelet transfusions is critically limited by their short shelf-life, stringent storage logistics, and alloimmunization risks. This necessitates the development of a stable, off-the-shelf hemostatic agent that can be deployed instantly at the point of care. Here we report the design, synthesis, and characterization of SynthoPlate (SP), a fully synthetic, lyophilized liposomal nanoparticle engineered as a platelet mimetic hemostatic agent. SP is surface-decorated with a synergistic combination of peptides that emulate key thrombotic functions without requiring blood-type matching. Upon intravenous administration, SP emulates primary hemostasis by adhering to the vascular injury site through von Willebrand factor-binding peptide (VBP) and collagen-binding peptide (CBP) and amplifying aggregation of activated platelets through fibrinogen-mimetic peptide (FMP), essentially forming the 'platelet plug.' SP is manufactured via thin-film hydration, extrusion, and lyophilization of the liposomal drug, which then is characterized by physicochemical parameters such as size, zeta potential, pH, osmolality, and high-performance liquid chromatography (HPLC). In severe thrombocytopenic animal models, SP demonstrated potent efficacy, reducing total blood loss by 73% in murine tail transections and by up to 30% in rabbit ear lacerations, with hemostatic rates comparable to donor platelets. Exhibiting a robust safety profile with a >250-fold therapeutic window, SP is a promising, readily deployable therapeutic poised to address the critical unmet need for immediate hemorrhage control in trauma, surgery, and the management of thrombocytopenia.

Faculty Project Mentor: Dr. Michael Bruckman, CEO of Haima Therapeutics, LLC

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

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Oncogenic transcription is commonly induced by the recruitment of co-factors such as the homologous histone acetyltransferases (HATs) CBP/p300. These HATs catalyze the acetylation of histones, weakening the interaction between DNA and histone, loosening the chromatin structure, and allowing for increased transcription. In fusion-positive rhabdomyosarcoma (FP-RMS), the fusion transcription factor PAX3-FOXO1 (P3F) recruits CBP/p300 to its activation domain (AD). Previous studies have shown that mutating the AD of P3F prevents binding of CBP/p300, leading to decreased FP-RMS cell proliferation and downregulation P3F target gene expression. To disrupt this dependency in a therapeutic manner, we developed a dual targeting CBP/p300 inhibitor, IHK-44, using structure-guided medicinal chemistry. Treatment with IHK-44 and other structurally distinct inhibitors and degraders of CBP/p300 in FP-RMS cell lines resulted in decreased histone acetylation. Furthermore, we tested these small molecules in a panel of RMS cell lines and measured cell proliferation. We observed that IHK-44 was much more potent than other CBP/p300 inhibitors, comparably potent to CBP/p300 degraders, and that the FP-RMS cell lines were more sensitive to targeting of CBP/p300 than fusion negative RMS. Furthermore, we discovered that H2B acetylation may serve as a biomarker for enhancer-addicted cancers and may be a strong predictor of cancer cell vulnerability to CBP/p300 inhibition. We plan to investigate the exact mechanisms of action for IHK-44, and the other CBP/p300 small molecules, that lead to the cell death observed in the cell proliferation data. Our data suggests a promising therapeutic option for patients with FP-RMS.

Faculty Project Mentor: Berkley Gryder

Effect of Methane Emissions on Mortality Rates in Ohio

Yousif Al-Rawi, SDLE/UH

Air pollution is recognized as the number two cause of mortality worldwide. Harmful gasses and chemicals entering the Earth's air are caused by air pollution. In this project, we will specifically focus on methane emissions, which are a major component of air pollution. Methane is mostly caused by cattle emissions. Our project aims to investigate whether there is a correlation between methane emissions and mortality. The results will give awareness for public efforts to reduce methane and hence the risk of mortality. We began by first examining the mortality and air pollution in Ohio counties. Then, we analyze deeper into data such as which counties have the highest amount of methane and then assess potential correlations to mortality. Next, we plot a heat map of Ohio and the mortality cases of each county. We believe mortality is higher for counties with a higher population. Methane emissions are a very important topic when bringing up air pollution, as they have a strong impact on mortality.

Faculty Project Mentor: Dr. Erica Barcelos, Department of Materials Science and Engineering

Bright Lights, Loud Noise: Environmental Stressors and Chronic Disease in Vulnerable U.S. Communities

Yousif Al-Rawi, Data Science; Santosh Kumar Sirasapalli, Dr Zhuo Chen, Dr Sanjay Rajagopalan, Cardiovascular Research Institute

Environmental stressors such as excessive nighttime light and noise exposure have been increasingly recognized as contributors to adverse health outcomes. These exposures can disrupt sleep, elevate stress levels, and interfere with physiological recovery, potentially increasing the risk of chronic diseases. However, research remains limited on how environmental burdens interact with social vulnerability to compound health risks, especially at a granular geographic level. This cross-sectional study investigates how these environmental stressors are associated with the prevalence of chronic conditions—including hypertension, diabetes, obesity, and chronic kidney disease (CKD)—across U.S. census tracts, with a focus on socially vulnerable communities. Health outcome estimates are drawn from CDC PLACES and analyzed alongside satellite-derived data on ambient light and noise pollution. Social vulnerability is assessed using the CDC Social Vulnerability Index (SVI), which captures community-level factors such as income, education, housing, and disability status. Geographic patterns of disease burden and environmental exposure are visualized using spatial mapping techniques. Multivariable linear regression models are used to examine associations between pollution exposure and disease prevalence, adjusting for potential confounders. Interaction terms (e.g., Light × SVI, Noise × SVI) are tested to evaluate whether social vulnerability modifies these relationships. Alternative modeling strategies, including Poisson regression, are employed to assess robustness. Preliminary expectations suggest that higher levels of light and noise pollution will be significantly associated with increased prevalence of chronic conditions, with the strongest effects observed in census tracts with higher SVI scores. These findings highlight the compounding effects of environmental and social stressors on health and emphasize the need for targeted public health and urban planning interventions that address both environmental injustice and the social determinants of health.

Faculty Project Mentor: Santosh Kumar Sirasapalli, Dr Zhuo Chen, Dr Sanjay Rajagopalan, Cardiovascular Research Institute, CWRU, University Hospitals

The Impact of Particle Bidispersity in Force Chain Formation and Rheology of Dense Suspensions

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Oobleck is a fascinating system that is liquid-like at rest and can turn solid with pressure. The computer simulations in our group have reproduced this behavior. Rheology is the study of change in shape of materials and how they deform and flow with stress. Suspensions are solid particles moving throughout a liquid and not dissolving. Dense suspensions are types of suspensions in which there are more particles than liquid, which can be tightly compact. With not as much liquid in between particles, the particles are able to interact with each other, leading to non-Newtonian behavior such as shear thickening and shear jamming. We are studying the fundamental aspect on how particle interactions, for example in a mixture of cornstarch and water, can change with shear rate, which is the force applied. Specifically, when the particles interact we look at what are called force chains, which shows how particles interact with each other in terms of the strength of frictional force between the interactions. These force chains form a network, which can explain the shear thickening and shear jamming behaviors.

Using the simulations from the group, we look into how to change the color of the particles depending on their size and changing the representation of force chains. We find out that, depending on the ratio of particle sizes, the types of interaction between particles varies, changing the behavior of the suspension under varying stresses. An impact we encounter is to get a visualization of how rheology plays a part in coding with particles, which is relevant to a number of everyday materials, such as shampoo, paint, and condiments.

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

Vigilance-Dependent Modulation of Cortical Evoked Potentials Elicited by Dentate Nucleus Stimulation in Post-Stroke Patients.

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The deep cerebellar nuclei are increasingly being explored as potential targets for neuromodulation-based therapies for neurological and psychiatric indications due to their robust, widespread connections with cerebral cortical circuits (Dum & Strick, 2003). As part of our phase I/II trials to enhance motor rehabilitation for individuals with chronic post-stroke motor deficits, participants undergo unilateral deep brain stimulation (DBS) lead implantation targeting the dentate nucleus (DN) contralateral to their stroke-affected cerebral hemisphere (Baker et al, 2023). We use low-frequency DBS-cortical evoked potentials (CEPs) to characterize the effect of different contact locations and pulse parameters on cerebral cortical activity as part of an effort to improve therapeutic programming. Here, we report how fluctuations in participant state, or vigilance, can confound these measures, altering CEP component characteristics. Scalp EEG data were recorded continuously as low-frequency (<6Hz) DBS was delivered using the implanted lead. Participants were seated comfortably in a reclined chair and asked to alternately open and close their eyes, with the eyes-closed states extended for up to 20 minutes to encourage vigilance changes. EEG data were subsequently divided into 30-second epochs, and sleep staged (Awake, N1, N2, N3, REM) using USleep v1.0 (Perslev, M., Darkner, S., Kempfner, L. et al, 2021). Sleep stage-specific DBS-CEPs were created by segregating pulse timing-locked EEG segments by stage and averaging. Comparisons between conditions were made using changes in peak-to-peak amplitude, latency, RMS power, and wavelets. CEP morphology was found to vary significantly across sleep stages, marked by amplitude attenuation and latency delays that increased with decreasing vigilance. This drop in cerebellocortical modulatory effect likely reflects thalamic gating or increased cortical/hippocampal inhibitory feedback in the presence of sleep-related, slow-wave oscillations (Torres-Herraez et al, 2022). These results suggest that future closed-loop therapies may wish to consider how changes in vigilance impact real-time therapy delivery, and if DBS-CEPs are to be used for programming, it is imperative to ensure that the data are not misinterpreted due to unrecognized fluctuations in vigilance.

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Faculty Project Mentor: Kenneth B Baker, Department of Neurosciences

Mechanical Characterization of a 32-channel 35N LT DFT Lead Body

Grace W. Anyalisa, Mechanical and Aerospace Engineering; Jerry Yang, Biomedical Engineering and Electrical Engineering; Douglas B. Shire, Advanced Platform Technology Center, VA Northeast Ohio Healthcare System; Janet L. Gbur, Materials Science and Engineering

As neuroprosthetic research advances, there is a growing demand for high-density, multi-channel leads that can withstand prolonged physiological stresses when implanted. This study investigated the mechanical and electrical properties of a novel 32-channel neuroprosthetic lead body. The lead body joins 32 channels into a single, multi-channel lead. A lead body is a mechanical and electrical structure that joins different components (e.g., power source, electrodes, etc.) in a neuroprosthetic system. The 32-channel lead body is composed of drawn filled tube (DFT) wires that are stranded in a 1x7 arrangement and insulated with perfluoroalkoxy alkane (PFA) - also called filars - and gathered within a medical grade silicone jacket. The DFT wires are a metallic composite consisting of a high-strength outer sheath (cobalt-nickel-chromium-molybdenum alloy) and conductive silver core with a 25% fill ratio. Fully-reversed flex bending fatigue tests were conducted to evaluate the lead body's long-term stability, flexibility, and resistance to mechanical wear. Five specimens were evaluated beginning with optical microscopy and electrical resistance measurements prior to preconditioning in phosphate buffered saline at 32°C for a minimum of 10 days. Resistance measurements were taken again post-test and prior to the fatigue testing. Each specimen underwent a two-stage test wherein 20 cycles of flex bending fatigue were performed over a 2.5 mm bend radius at 1 Hz followed by electrical resistance measurements. Next, each specimen was subjected to a 20 mm bend radius for 1.2 million cycles at 1 Hz and resistances were measured. The fatigue tests were intended to simulate more acute handling and surgical conditions followed by worst-case in-vivo behavior, respectively. Post-fatigue, all five specimens were analyzed with optical microscopy. Findings in this study will be added to an ongoing study evaluating the mechanical reliability of implantable leads for neuroprosthetic systems.

Key Words: fatigue testing, neuroprosthetic lead body, silver-cored DFT

Faculty Project Mentor: Dr. Janet L. Gbur, Department of Material Science and Engineering, CWRU

Validating IMU-Based Foot Deviation Detection for Injury Prevention in Powered Wheelchairs

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Powered wheelchairs (PWC) are commonly prescribed as a primary mode of transportation for individuals with spinal cord injury (SCI). However, improper foot positioning on PWC footplates can lead to serious injuries, especially for users with SCI who may have compromised or absent sensory or motor functions and may not be able to perceive their foot position. Common PWC-related injuries include fractures, lacerations, and abrasions, with 6.7-33% of lower extremity injuries caused by the leg or foot getting caught on door frames during PWC use. Despite the risks, commercially available "smart" wheelchairs with active injury prevention systems are not currently available. To address this gap, Dr. Henzel and her team at the Louis Stokes Cleveland VA Medical Center developed a smart wireless footplate pressure and position sensor, FootSafe, to monitor foot position and detect changes in force distribution and proximity caused by inadvertent foot misplacement. In this study, we developed a method to detect true foot deviations from the wheelchair footplate which will serve as the gold-standard for validating the FootSafe system. First, we collected trials from a neurotypical participant using a wheelchair indoors, with motion capture markers and inertial measurement units (IMUs) placed on the feet and wheelchair. Half of the trials involved no foot movement, while the others contained purposeful foot misplacements. Using this motion data, we developed a MATLAB algorithm to detect deviations in IMU acceleration data between the foot and footplate, and used this algorithm to identify foot deviations in a repeated set of wheelchair mobility experiments outdoors. These results showed a true positive rate of 91% across the trials, suggesting that the IMUs are a suitable tool for validating the FootSafe system in practical, non-rehabilitative environments.

Faculty Project Mentor: Sandra Hnat, Department of Biomedical Engineering; Kath M. Bogie, Department of Orthopedics; M. Kristi Henzel, Department of Physical Medicine and Rehabilitation

Optimization of Extracellular Matrix Microparticles for Cardiac Repair

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Heart failure remains the leading cause of death worldwide, with no clinical strategies currently available to repair the failing heart. Decellularized heart matrix (DHM) derived from donor tissue shows promise as a tissue engineering approach to cardiac repair. We previously generated DHM microparticles by electrospray emulsification. We demonstrated their therapeutic potential in mice with heart injury based on slow release of pro-repair protein signaling from DHM. To improve this technology towards clinical relevance, we are addressing challenges with poor yield and limited control of release kinetics. In this study, we functionalized DHM with methacrylate groups (DHMMA) to merge tunable UV-crosslinking with emulsion-based microparticle fabrication with the goal of improving in vivo stability. In addition, we optimized DHMMA microparticle fabrication using a bulk emulsion approach, which produced higher yields and more uniformly shaped microparticles. To optimize DHMMA microparticle formation, we varied key parameters, including DHMMA concentration, emulsion oil, surfactant, and UV crosslinking duration. The most stable and uniformly sized microparticles were achieved using 3% Tween 80 in the aqueous (DHMMA) phase and 5% Span 80 in an isooctane oil phase. A UV crosslinking time of 30 minutes produced solid microparticles that resisted aggregation and maintained their shape after sonication. Optimizing the wash steps was critical for removing residual oil and surfactant, enabling biocompatibility for bioactivity studies in cell culture. Scanning electron microscopy (SEM) and microscopy evaluated particle size and surface topography. Additionally, successful encapsulation of fluorescent large polysaccharides and polystyrene nanobeads demonstrated the potential of DHMMA microparticles as carriers for macromolecular therapeutics, drug delivery, or nanoparticle transport in cardiac applications.

Faculty Project Mentor: Dr. Samuel Senyo, Department of Biomedical Engineering

Cluster Pattern Analysis of Socioeconomic and Socio-environmental factors and quantifying their influence on Cardiovascular, Kidney, and Metabolic Mortality: A Geospatial Clustering Analysis of the United States Counties

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Cardiovascular, kidney, and metabolic (CKM) conditions remain leading causes of mortality in the United States, driven in part by geographic and socioenvironmental disparities. While individual risk factors are well studied, the role of environmental exposures and built infrastructure in shaping CKM outcomes is less understood. This project explores how counties across the U.S. cluster based on shared environmental and socioeconomic characteristics and how these clusters relate to CKM mortality.

Using publicly available data from CDC Wonder agencies, we constructed three separate clustering models using k-means and hierarchical clustering to capture patterns within key domains: air pollution (including PM2.5, NO_2, and ozone), built environment (including traffic proximity, NDVI, artificial light, and noise pollution), and urban form (including population density, road density, and impervious surface area). Each cluster revealed distinct environmental typologies among counties. We then linked these clusters to county-level age-adjusted CKM mortality rates to assess spatial disparities.

Preliminary analyses suggest that counties in air pollution - dominant clusters - marked by high concentrations of PM2.5 and NO_2 - have consistently elevated CKM mortality. Built environment clusters characterized by low green space and high artificial light and noise exposure show moderately elevated mortality rates, while urban density clusters reveal more heterogeneous outcomes, possibly reflecting interacting social and environmental stressors.

These findings highlight the importance of multidimensional place-based analysis in understanding population health risks. By moving beyond single-variable associations and instead characterizing environmental co-exposure patterns, this study provides new insights into how geography and infrastructure intersect with public health. Ultimately, the work supports targeted policy and intervention strategies in high-risk regions, particularly those with compounding environmental burdens.

Faculty Project Mentor: Sanjay Rajagopalan, Cardiovascular Research Institute, Case Western Reserve University School of Medicine

Fat Depots on CT Calcium Score Scans Predict Heart Failure Risk: A Dual Assessment of Epicardial Adipose Tissue and Peri-Aortic Fat Volumes

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Epicardial and periaortic fat depots actively contribute to cardiovascular remodeling via inflammatory and metabolic pathways. While calcium scoring from CT calcium-score scans (CTCS) is used for cardiovascular risk prediction, the impact of epicardial adipose tissue (EAT) and periaortic fat (AOfat) in predicting heart failure (HF) remains under-explored. We conducted a retrospective study of 765 adults (5.1% with HF) who underwent CTCS in a 6-year follow-up study. We segment heart and aorta using TotalSegmentator deep learning framework and manually refined in 3D Slicer. Then we created masks by filtering noise and applying threshold for fat volumes using fat-specific Hounsfield Unit (HU) ranges. We designed univariate and multivariable Cox PH regression, adjusted for EAT and AOfat, along with traditional clinical risk factors. The EAT-based model achieved a 2-year area under the curve (AUC) of 0.75, which improved to 0.80 when AOfat was included. The addition of clinical variables provided a marginal improvement (AUC = 0.81). In our fat and clinical model, EAT was associated with increased HF risk, while AOfat demonstrated a protective effect. Notably, clinical variables such as age, male sex, and BMI were also associated with elevated HF risk. These findings suggest that CT-derived EAT and AOfat volumes offer independent prognostic value for heart failure and may enhance early risk identification when integrated into routine CTCS assessments.

Faculty Project Mentor: Ammar Hoori, Department of Biomedical Engineering

Material and Process Analysis for Laser Powder Bed Fusion

Rhylie Barrett, Saint Martin De Porres High School

Laser powder bed fusion (L-PBF) is an Additive Manufacturing (AM) technique that uses a high-energy laser to melt and fuse layers of metal powder to create 3D objects. It is widely used to fabricate complex geometries in aerospace, automotive, and medical applications. While L-PBF offers advantages such as reduced material waste, high design flexibility, and compatibility with a wide range of metals, successful implementation requires a deep understanding of both the powdered materials and the process conditions during the printing process. In this research, we focus on four materials commonly used in L-PBF: 316L Stainless Steel, 304L Stainless Steel, M-300 Tool Steel, and 718 Inconel. We investigate their compositional differences, mechanical properties, and application-specific advantages. These materials have different material properties such as strength, corrosion resistance, weldability, and thermal conductivity. This comparative analysis supports informed material selection for different manufacturing scenarios. We also analyzed time-series pyrometer data collected during the L-PBF printing process using the Aconity3D system. Exploratory data analysis was conducted in RStudio to visualize trends in temperature and laser activity. These visualizations provide insight into how heat is applied and distributed during printing, which are key factors for optimizing build quality and minimizing defects. Additionally, we studied safety protocols associated with handling metal powders, which can pose risks such as skin irritation, fires, and respiratory infections, which is essential when working with fine powders in the L-PBF process.

Faculty Project Mentor: Laura Bruckman, Department of Materials Science and Engineering

Geospatial Data Analysis of Fertilizer Prices across the U.S.

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Understanding regional and temporal variability in fertilizer pricing is essential for developing cost-effective and sustainable alternatives in agriculture. This project analyzes a dataset of 984 observations of fertilizer prices for different commodities, such as Ammonia, Urea, diammonium phosphate fertilizer (DAP), and Potash, across different U.S. regions including Tampa, Cornbelt, and Northern Plains. It includes seven variables: Date, Month, Quarter, Year, Commodity, Region, and Price. Each row represents the average price of a specific fertilizer type in a given region and time period. The structure of this dataset allows for identification of seasonal patterns and regional price differences. The dataset is valuable for understanding spatial and temporal trends in fertilizer pricing, which is crucial for agricultural planning, economic forecasting, and supply chain logistics. By breaking down prices by region and time (month, quarter, and year), stakeholders can identify seasonal patterns, regional disparities, and potential market disruptions. This data can be used by policymakers, agronomists, and supply chain managers to assess how transportation, supply constraints, or policy changes affect fertilizer availability and cost. More specifically what we are trying to do for this project is to see what region of fertilizer and the prices of fertilizer and what we can do to lower the prices. Thus understanding regional price differences can help optimize fertilizer transport routes and reduce supply chain bottlenecks. The pricing data used in this project can serve as a benchmark for evaluating and accurately pricing a novel nitrogen-based fertilizer currently under development. Ultimately, this work contributes to a more efficient and equitable fertilizer market, paving the way for alternative nitrogen solutions.

Faculty Project Mentor: Erika Barcelos, Department of Material Science

Does Childhood Poverty Have an Impact on High School Graduation Rates?

Josh Bates, Finance + Data Science, **Zoe Bates** - Sociology

This project investigates the relationship between childhood poverty and high school graduation rates across school districts in the state of Washington and Alabama. We merged multiple public policy data from the Washington Office of Superintendent of Public Instruction, the Alabama State Department of Education, and the U.S. Census Bureau' s Small Area Income and Poverty Estimates (SAIPE) to build a comprehensive view of district-level characteristics. Our methodology included linear regression models, quartile-based stratification, and novel visualizations.

In Washington, we found a statistically significant negative relationship between childhood poverty and graduation rates ($p < 0.01$, $\beta = -0.41$). Specifically, a 10 percent increase in childhood poverty was associated with a 4.1 percentage point decrease in graduation rate. However, this relationship was not statistically significant and small in Alabama, despite a wider range of poverty levels across districts. This contrast may point to differences in state-level education policies, poverty support systems, or reflect data limitations. This work investigates family and educational inequality through the lens of data science and sociology. It contributes to ongoing efforts to quantify and address social inequalities and highlights the power of interdisciplinary collaboration.

Faculty Project Mentor: Dr. Haoming Song, Department of Sociology, Case Western Reserve University

Phenotyping Postpartum Depression in the All of Us Research Program

Bemnet Bekele, Carly DaCosta, Dana C. Crawford, Cleveland Institute for Computational Biology, Department of Population and Quantitative Health Sciences, Case Western Reserve University School of Medicine, Cleveland, OH.

Postpartum depression (PPD) is a difficult-to-define complication of pregnancy. Risk factors include age (mothers < 35 years) and race (African Americans). To identify PPD risk factors in multiple populations, we accessed the All of Us Research Program, a longitudinal cohort of U.S. residents with de-identified electronic health record data. We identified PPD cases using two definitions: 1) women with a PPD-qualifying ICD-10 code (F34.1, F43.21, F32.9) within 2.5 years of a pregnancy-associated ICD-10 code (Z34.00, Z34.80, Z34.90, O09.511,O09.521, O09.821-O09.823, O09.829, O09.891-O09.8933, O09.899, Z39.2, Z36.0, Z36.89, Z36.9, Z36.3, Z13.9); and 2) women with the PPD OMOP condition and a pregnancy-associated ICD-10 code. Controls were non-case women with a pregnancy-associated ICD-10 code. The mean ages for PPD-qualifying cases, PPD condition cases, and controls were 34.89, 32.91, and 34.84 years, respectively. African American women made up 21.23%, 17.16%, and 19.94% of PPD-qualifying cases, PPD condition cases, and controls, respectively. Logistic regression was performed to assess the association between case-control status (outcome) and race and age (predictors) for each definition. For the PPD-qualifying (OR = 1.74, 95% CI 1.71-1.77) and PPD condition (OR = 2.60, 95% CI 2.50-2.70) case definitions, age (< 35 years) adjusted for race was significantly associated with an increased risk for PPD ($p < 2e-16$). Surprisingly, African American race (compared with white) adjusted for age was significantly associated with a decreased risk for PPD ($p < 2e-16$) using both PPD case definitions (PPD-qualifying OR = 0.88, 95% CI 0.86-0.90; PPD condition OR = 0.44, 95% CI 0.41-0.46). Work is ongoing to refine the PPD clinical definition and to test for additional factors associated with this complex outcome.

Faculty Project Mentor: Dana C. Crawford, Cleveland Institute for Computational Biology, Department of Population and Quantitative Health Sciences, Case Western Reserve University School of Medicine, Cleveland, OH

Machine Learning in the Classification of Ultra High Energy Cosmic Rays

Alison Berry, Aerospace Engineering

Ultra high energy cosmic rays (above 10^18 eV) are observed indirectly by using detectors on the ground to study the secondary particles that shower onto Earth when the cosmic ray interacts with Earth's atmosphere. The knowledge of the primary particle type of a cosmic ray is essential to determining the origin of high energy cosmic rays, as well as insight into other questions, such as the abundance of each element in the universe, among others. While the primary particle is most easily determined through a particle's mass, due to fluctuations in the properties of the first few hardonic interactions in a shower, the primary's mass cannot be measured on an event-by-event basis but must be inferred using the distribution of shower maxima of an ensemble of cosmic ray events, which could potentially prove to be a beneficial place to implement machine learning. Specifically, this project aims to create and evaluate the performance of machine learning models for the purpose of classifying primary particles as protons or iron using CORSIKA (Monte-Carlo) simulated data.

Faculty Project Mentor: Dr. Pawan Tripathi

Learning Arduino

Alexandria Brown, ACS Seed Envoys summer internship program

To begin, I have learned how to code many different sequences such as binary counting, SOS code, and flashing light. To do this I had to learn how to binary count, how to code in Arduino and how to use a breadboard. I also learned how to solder wires together, how to heat seal plastic around wires and much more. I learned how to build and test touch sensors with an Arduino.

Faculty Project Mentor: Mackenzie Elmer, Human Fusions Institute

Investigating the effects of Cystic Fibrosis mutations on the splicing of CFTR exon 3 and if they can be rescued with Exon Specific U1 snRNA

Ayanna Brown, Case Western Reserve University, Neuroscience discipline Annabelle Elsner Pacheco, Case Western Reserve University, School of Medicine, Genetics and Genome Sciences Jenell Betts, Case Western Reserve University, School of Medicine, Genetics and Genome Sciences Grace Glasser, Case Western Reserve University, School of Medicine, Genetics and Genome Sciences Hua Lou, Case Western Reserve University, School of Medicine, Genetics and Genome Sciences

Cystic Fibrosis (CF) is a condition which impacts 100,000 people worldwide due to a mutation in the CFTR gene that encodes an ion channel. Splicing is an important step in pre-mRNA processing when introns are removed. The first step of splicing is when U1 snRNA binds to the 5' splice site (5'ss). When a mutation at the 5'ss occurs, U1 fails to bind which can cause exon skipping, leading to genetic diseases such as CF. An approach to correct exon skipping due to mutations at the 5'ss is to engineer U1 to bind nearby in the intron. This approach is called Exon-Specific U1 (ExSpeU1), and can be a potential therapeutic strategy to target splicing defects. In this project, we are investigating if CF patient mutations, 273+1 G>A, 273+2 T>G, and R74Q, cause exon 3 skipping. If so, can we use ExSpeU1 to restore inclusion of the exon? We hypothesize that some of these mutations will cause exon 3 skipping and are recoverable using ExSpeU1. We first performed site-directed mutagenesis to a CFTR minigene to create mutant splicing reporters. Then, we transfected the mutant minigenes into human bronchial cells. Following, we did RNA isolation and RT-PCR analysis to evaluate whether or not exon 3 was skipped. The data show that 273+1 G>A and 273+2 T>G mutations caused exon 3 skipping, while R74Q did not. Next, we will use ExSpeU1 to attempt to correct exon 3 skipping due to mutations 273+1 G>A and 273+2 T>G. To do this, we will co-transfect mutant reporters and ExSpeU1. Results from this study will show whether or not ExSpeU1 will correct exon 3 skipping for these mutations, which could lead to future therapeutic development to improve the quality of life for CF patients.

Faculty Project Mentor: Annabelle Elsner- Pacheco, Department of Genetics and Genome Sciences

Identifying an Optimal Substrate for Aerosol Jet Printed Sensors to Instrument a Prosthetic Liner

Quincy N. Brown, Hawken Upper School; Lexi Miskey, Biomedical Engineering; Douglas B. Shire, Advanced Platform Technology Center, VA Northeast Ohio Health Care System; Janet L. Gbur, Materials Science and Engineering, Advanced Platform Technology Center, VA Northeast Ohio Health Care System.

Many lower limb amputees utilize a prosthetic device for improved mobility. One major issue with lower limb prosthetics is the skin breakdown that occurs on the residual limb. Often, the prosthetic socket fit and shape does not match the residual limb geometry; therefore, the pressure varies throughout the socket. The issues caused by pressure imbalances inspired the idea of a liner instrumented with flexible circuitry to measure the pressure in different locations, offering a direct interface between the residual limb and the socket. These readings would allow the prosthetist to adjust the fit of the prosthetic, thus decreasing the chances of skin irritation. Aerosol jet printing (AJP), an additive manufacturing technique, can be used to create a flexible circuit. This process uses a conductive ink, which is atomized, then deposited onto a flexible substrate. Surface roughness is a factor that plays a large role in the adherence of the ink to the substrate and conductivity of the circuit.

In this work, the surface roughness of eight candidate substrate materials was measured using a light profiler and laser profiler under 10x and 50x magnification, respectively. For each substrate, three different locations were selected and five fields of view were analyzed per location, yielding 15 area measurements. Arithmetical mean height (Sa) and standard deviation were recorded for the three locations and the average and standard deviation reported for the substrate. Five test prints were fabricated using AJP with silver ink and deposited onto each substrate. The deposition was evaluated with optical microscopy, electrical resistance testing, and profilometry. Materials were down-selected based on their electrical resistance, ink adhesion, and conformance to the printed design. Data from this study will help inform design and fabrication of AJP sensors for instrumented prosthetic liners.

Faculty Project Mentor: Dr. Janet L. Gbur, Department of Materials Science and Engineering, Advanced Platform Technology Center, VA Northeast Ohio Health Care System.

Influence of ACEi and ARB use on HAI Response to Seasonal Influenza Vaccination

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Abstract:
Background: Angiotensin Converting Enzyme Inhibitors (ACEi) and Angiotensin Receptor Blockers (ARB) have anti-inflammatory properties via decreasing AT1R binding/levels, reducing Reactive Oxygen Species (ROS) and cytokine activation. This study investigated whether these medications can negatively impact hemagglutination inhibition (HAI) responses to influenza vaccination.
Methods: Participants, ages 18 – 90, were consented and enrolled in the study to receive an influenza vaccine during the 2024-2025 influenza season. Participants were classified into individuals on either ACEi or ARB. Healthy controls were selected based on age-sex-body mass index (BMI) matching and a second control group of participants were diagnosed with hypertension (HTN). but on taking these medications. Analysis focused on relative risk ratios (RR) for seroconversion to the influenza vaccine, in addition to day 28 geometric mean titers (GMT), number of seroprotected participants, and fold change was carried out.
Results: We observed a lower trend of seroconversion amongst participants taking either medication compared to the HTN controls and did not observe any differences compared to the healthy controls. There were no differences in day 28 GMT, although the HTN controls had statistically significant higher fold changes in HAI titers compared to the healthy controls. Compared to the treatment groups, the HTN controls had a non-significant higher fold change against all three strains included in the influenza vaccine.
Conclusions: Overall, the use of medications did not impact seroconversion when compared to healthy controls, but participants did have a lower trend for seroconversion compared to the HTN controls. This could be due to reduced inflammatory markers in people taking these medications, but this reduction in titer is similar to that in healthy participants. More studies comparing inflammatory markers related to medications in people are needed. In addition, determining the impact of the use of ACEi and ARB on lymphocyte responses is critical for effective influenza vaccination strategies.

Faculty Project Mentor: Ted Ross, Department of Infection Biology

Investigating the Association Between Caregiver Dental Anxiety and Child Caries Status

Kian Burt, Nutrition

Dental anxiety in adults has previously been shown to relate to caries status. Based on the literature, no studies have reported the level of dental anxiety in parents and examined the relationship between parent dental anxiety and child caries status in the US. Therefore, the objective is to investigate the association between dental anxiety in parents/guardians and caries (cavities) in their Medicaid-enrolled preschool-aged children (3-6 years old). A cross-sectional study (n = 977) was conducted using baseline data from a previously completed randomized controlled trial investigating two behavioral interventions to increase dental attendance in children. Parents completed a questionnaire providing responses to socio-demographics, and a 5 item Modified Dental Anxiety Scale (MDAS) on a 5 point Likert scale (score range: 5 -25). Child caries status was defined as the presence of untreated primary decayed teeth (dt), with dental exams conducted by trained and calibrated licensed dental hygienists using the International Caries Detection and Assessment System (ICDAS). A multivariable logistic regression was performed with untreated decay (dt>0) as an outcome and MDAS score as a predictor with adjustment for socio-demographic covariates (child age, sex, race, ethnicity, and parent age, sex, and education). Children were 55% male and 45% Black/African American. Parents were 90% female, 51% white, and 56% had completed high school or a higher education degree. Dental anxiety in parents (MDAS ≥19) comprised 10% of the sample. Logistic regression analysis showed that MDAS was not related to child's caries status. But, older child age (OR: 1.182, p = 0.005), Black race (OR: 1.437, p = 0.014), and parents with <= high school education (OR: 1.368, p = 0.027) significantly increased odds of caries. In parents of preschool-aged Medicaid-enrolled children, dental anxiety is relatively low (~10%) and does not appear to be associated with their child's caries status.

Faculty Project Mentor: Dr. Suchitra Nelson, David Selvaraj, Christy Bales, Department of Community Dentistry, Case Western Reserve University School of Dental Medicine

Advancing Keratoconus Research with Three-Dimensional Corneal Organoids

Henry Busch, Neuroscience BS; Andy Chen, CWRU School of Medicine; Kayleigh Bauer, Biomedical Engineering

Keratoconus (KC) is a progressive, non-inflammatory, degenerative corneal disorder and a leading cause of vision impairment among young adults. Characterized by central corneal thinning, stromal degeneration, and ectatic protrusion, KC compromises the cornea's refractive precision, responsible for nearly 70% of the eye's focusing power. Histological hallmarks include disruptions in the collagen- and proteoglycan-rich stromal layer. Global prevalence is estimated to be 0.138%. Onset typically occurs during adolescence and progresses into middle age. While a strong genetic component is evident, supported by familial clustering and twin studies, environmental risk factors such as eye rubbing, contact lens use, UV exposure, and allergies also contribute to disease progression. To better understand KC pathogenesis, we are developing a three-dimensional corneal organoid model using induced pluripotent stem cells (iPSCs). iPSCs are ideal for disease modeling due to their self-renewal capacity and pluripotency, enabling the generation of complex, multi-layered tissues that recapitulate the native corneal structure. Organoid formation involves aggregating iPSCs in U-bottom wells, followed by neural induction, vesicle formation, and corneal maturation. Once organoids are validated, molecular analyses such as qPCR and bulk RNA-seq will assess gene expression changes in extracellular matrix (ECM) components, inflammatory markers, oxidative stress genes, and apoptotic pathways. Additional analyses, including proteomics, histological evaluation, functional assays, and structural characterization, will help establish the utility of this model in studying KC. Currently, we are optimizing our differentiation and maturation protocols, as challenges in reproducible organoid formation have limited our ability to fully model keratoconus. Refinement of these methods is essential to enable robust, physiologically relevant studies of KC and its underlying mechanisms.

Faculty Project Mentor: Dr. Ashleigh Schaffer, Department of Genetics and Genome Science, CWRU, School of Medicine

Exploring bioisosteres of N-acetyl-glucosamine to improve ligand efficiency to develop novel inhibitors of lytic transglycosylases to combat antibiotic resistance

Lucy Candeub, Department of Biochemistry, Biochemistry BS; Dr. Focco van den Akker, Department of Biochemistry

Antimicrobial resistance (AMR) is predicted to be the direct or indirect cause of death of 208 million people over the next 25 years. Developing new antibiotics poses a risk of continued bacterial resistance. An alternate approach to reducing AMR is restoring the efficiency of established antibiotics. CjLT, a soluble lytic transglycosylase (LT) protein from C. jejuni, is involved in C. jejuni's antibiotic resistance pathways and its inhibition can restore the efficiency of beta-lactam antibiotics. Serendipitously, DMSO was found to bind to the same position in the active site as the N-acetyl-glucosamine moiety of the one known inhibitor of LTs, bulgecin A. The scaffold of bulgecin A makes it difficult to optimize, so we explored whether DMSO and similar smaller bioisosteres could be used instead to improve ligand efficiency. We are probing both DMSO analogs for which binding was previously confirmed by protein crystallography and novel bioisosteres with a similar hydrogen-bond accepting group and hydrophobic moieties.
These compounds were tested with both computational and wet lab experiments. The intermolecular interactions and protein/ligand stability of the specific compounds were examined with Docking and Molecular Dynamics Simulations. On the non-computational side, these compounds were tested with Differential Scanning Fluorometry, a technique that tests whether compounds bind to proteins by measuring a change in protein thermal stability. This method revealed several of the tested compounds had a destabilizing effect on CjLT which suggest binding, however further crystallographic experiments are needed to determine if the compounds specifically bind to the active site. Our MD simulations also suggested that when bulgecin A is bound in the active site, that the catalytic residue of CjLT, glutamic acid 390, is likely in its deprotonated, negatively charged state. The bulgecin A protein interactions more closely resemble that of the crystal structure compared to when this residue is protonated.

Faculty Project Mentors: Focco Van den Akker, Department of Biochemistry, CWRU; Jacob Boorman, Department of Biochemistry, CWRU

Investigating How Cathepsin G Activation of PAR4 Influences Activation of Adhesion Proteins on Platelets

Sofia Castro, Cognitive Science; NaShea Kendrick, Department of Pharmacology

Platelet activation through protease-activated receptor 4, PAR4, plays a critical role in hemostasis, inflammation, and thrombosis by regulating adhesion receptors that enable intercellular interactions. At injury sites, neutrophils release the serine protein enzyme cathepsin-G (CatG), cleaving PAR4 in a non-canonical location through an unknown mechanism. This project investigated how CatG-induced platelet activation impacts the function of adhesion receptors (integrin αIIbβ3 and P-selectin), platelet-platelet aggregation, and platelet-neutrophil interactions. We used flow cytometry to quantify αIIbβ3 activation and P-selectin surface expression on washed platelets in response to low (0.8 μM) or high dose (2 μM) CatG. BMS-986120, a PAR4 antagonist, was used to determine CatG-induced activation of adhesion receptors through PAR4. BMS-986120 reduced P-selectin, suggesting PAR4 signaling, but had little effect on CatG-induced integrin activation, with no effect at the high dose. Upon platelet activation, ADP is secreted from dense granules and signals through the P2Y12 receptor. 2MeSAMP, a P2Y12 antagonist, was added to test for secondary activation. Combined inhibition decreased integrin signaling, suggesting PAR4 and P2Y12 pathways synergize during platelet activation. We next measured platelet-neutrophil aggregation by stimulating whole blood with fMLP+Cytochalasin B. Inhibitors for CatG and PAR4 were used alone or in combination. Contrary to our hypothesis, the results showed no significant differences when CatG or PAR4 were inhibited. We propose CatG is activating platelets through a different or weaker mechanism than canonical PAR4 activation by thrombin, leading to less efficient activation of integrin αIIbβ3 and P-selectin. PAR4 inhibition reduced platelet-platelet aggregation, but did not affect platelet-neutrophil aggregation, highlighting the need to further investigate the mechanisms of intercellular crosstalk in thromboinflammatory contexts.

Faculty Project Mentor: Dr. Marvin Nieman, Department of Pharmacology

Mannequin Voice Analytics: Insights from a Pilot Study

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Clinical education increasingly leverages advanced simulation mannequins to provide effective training experiences. While significant technological progress has yielded highly realistic simulators, a common limitation persists: most mannequins still employ a standardized "healthy voice" for trainee interactions. Integrating the ability to mimic pathological patient voices would substantially enhance the fidelity and quality of the training experience, especially given the emerging potential of voice analytics for non-invasive pathology detection. A critical gap exists in the research and open-access datasets focused on voice as a biomarker, particularly concerning statistical parameters that differentiate healthy from pathological vocalizations. This scarcity impedes the development of next-generation simulation mannequins capable of advanced vocal realism. The current research addresses this crucial void by examining pediatric cases, where distinct vocalizations (sounds, voices, and cries) indicate varying states of health or pathology in infants. To gain further understanding of the nuances of voice with and without pathology, recordings were collected of existing mannequins. Preliminary analytics were conducted on key voice parameters, including pitch, harmonics, frequency, duration, and harmonic-to-noise ratios, to better delineate the challenges and inform future advancements in mannequin vocal fidelity.

This study examined acoustic features in recordings of infant cries to establish a baseline between healthy and pathological vocalizations in simulation mannequins, aiming to identify potential vocal biomarkers. Comparing human and mannequin cries provides insights into how simulation-based training can better align with clinical presentations. Given the reliance on simulation in medical education, improving the acoustic fidelity of pathological cries could enhance diagnostic training. Enabling learners to recognize subtle vocal pathologies may support earlier identification and intervention in clinical settings. These findings lay groundwork for refining auditory diagnostic cues in simulation curricula. Future research will expand this analysis to include additional pathologies—such as neurologically induced cry patterns or respiratory distress—to bridge the gap between training and diagnostic accuracy.

Faculty Project Mentor: Professor Colin Drummond, Department of Biomedical Engineering

The Timing of Hormone Therapy Throughout the Menopausal Transition: Weighing Perimenopausal Benefits with the Postmenopausal Risks

Ify Chidi, (Medical Anthropology)

Abstract

Objective: This study aims to evaluate the impact of hormone therapy initiated during perimenopause on the risk of breast cancer, heart attack, and stroke, compared to hormone therapy started after menopause, and no hormone therapy at all.

Methods: A retrospective cohort analysis was conducted using electronic health record data from the TriNetX Research Network, which includes data from over 120 million patient records. Three cohorts were defined using ICD-10 codes: perimenopausal women who had used hormone therapy for at least 10 years before menopause (Cohort 1), menopausal women currently using hormone therapy (Cohort 2), and menopausal women not using hormone therapy (Cohort 3). Propensity score matching was used to reduce selection bias and ensure comparability between cohorts. Health outcomes of interest included breast cancer, heart attack, and stroke, with risk, odds, and hazard ratios calculated for each outcome.

Results: The findings revealed that Cohort 1 had significantly lower odds of developing breast cancer, heart attack, and stroke compared to both Cohort 2 and Cohort 3 (approximately 60% lower). When compared to Cohort 3, while Cohort 2 exhibited slightly lower odds of breast cancer (0.864[CI 95%:0.825,0.905]) and heart attack (0.964[CI 95%:0.927,1.003]), it had a 4.9% higher likelihood of experiencing a stroke (1.049[CI 95%:1.009,1.090]).

Conclusions: Hormone therapy initiated during perimenopause offers substantial protective benefits against breast cancer, heart attack, and stroke, while starting hormone therapy after menopause provides only limited protection and may increase the risk of stroke. These findings highlight the importance of early initiation of hormone therapy during perimenopause for optimizing long-term health outcomes. Further clinical research is needed to confirm these results and to explore the long-term effects of hormone therapy at different stages of menopause.

Faculty Project Mentor: Dr. Rachel Pope, Division Director, Female Sexual Health, Urology Institute, University Hospitals

Analysis of Materials and Printing Process for Laser Powder Bed Fusion

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Laser Powder Bed Fusion (L-PBF) is an additive manufacturing (AM) process that fabricates 3D metal parts by selectively melting and fusing metal powder layer by layer using a laser. L-PBF offers several advantages over traditional manufacturing, such as design flexibility, reduced material waste, and shorter production times. Due to these advantages, L-PBF is widely used in aerospace, medical, and automotive industries. Several metal alloys can be used as raw ingredients for L-PBF to print 3D parts. However, these alloys exhibit different thermal behaviors during the printing process, which affects the mechanical properties of the final product. In this research, we examine four popular metal alloys used in L-PBF: 304L and 316L stainless steel, M300 tool steel, and 718 Inconel. We investigate the mechanical properties to determine the best-suited application for each alloy. Safety hazards related to handling metal powders and operating the L-PBF printer, Aconity3D, are also examined to understand the best practices for a safe operation. Additionally, we analyze the time series temperature data from the L-PBF printing process using RStudio to gain insight into the printing process. From this research, we aim to understand the properties of metal alloys used in L-PBF, safe operating practices, and the thermal behavior of the printing process.

Faculty Project Mentor: Laura Bruckman, Department of Materials Science and Engineering

Evaluation of Cardiopulmonary Reserve in CKD Using Integrated Cardiometabolic Exercise MRI Protocol (CRUISE-CKD)

Sydney Clemon, Chemical Biology

Dyspnea and exercise intolerance are common in patients with chronic kidney disease (CKD), yet the underlying mechanisms remain poorly understood. Some of the causes of exercise limitation in CKD include: heart failure, vascular stiffness and endothelial dysfunction, sarcopenia, anemia, metabolic acidosis, accumulation of uremic toxins, etc. We aimed to characterize structural and functional cardiac responses during acute exertion in CKD. The CRUISE-CKD study prospectively enrolled 14 patients with CKD stages 3–4 (mean eGFR 32.6±6.7 mL/min/1.73m²), and no heart failure. Participants underwent ECMR-CPT with measurement of ventricular volumes, systolic and diastolic function, pulmonary pressures, and cardiopulmonary metrics (maximum O2 consumption [VO2max], and minute ventilation to CO2 consumption [VE/VCO2]) at rest and immediately post exercise.The mean age of participants was 64±7 years and 71% were women. The mean systolic blood pressure at study enrollment was 137±22 mmHg. With exercise, significant increases were observed in left ventricle (LV) stroke volume (+12.72±14.46 mL), LV ejection fraction (EF) (+6.9±8.2%), cardiac output (+3.1±1.8 L/min), with marked inter-individual variability in ventricular response. Average VO_2max improved by + 6.6 ml/kg/min (mean peak 9.2 ml/kg/min), and the mean VE/VCO_2 slope was 8.2, suggesting impaired ventilatory efficiency. Despite preserved resting EF, a third of participants showed impaired contractile reserve and abnormal pulmonary hemodynamics during stress.Overall, exercise cardiac imaging revealed three distinct phenotypes: (1) preserved ejection fraction with impaired diastolic reserve, (2) RV-pulmonary vascular uncoupling, and (3) skeletal muscle-dominant limitation with preserved cardiac response. Mechanisms beyond reduced GFR contribute to exercise intolerance in CKD. These findings highlight the value of dynamic imaging to reveal cardiac dysfunction not evident at rest, and inform phenotype-guided interventions to improve functional outcomes in CKD.

Faculty Project Mentor: Dr. Mirela Dobre, Department of Nephrology

A transcriptomic approach to identifying potential mechanisms driving psychiatric comorbidity in virologically suppressed people living with HIV

Nathaniel Craun, Nutritional Biochemistry & Metabolism; Banumathi Tamilselvan; Diana Hume-Rivera; Michael Rubsamen, Tulane University; Zoe Rodes; Brian Richardson; Amanda Burger, MetroHealth Medical Center; Mark Cameron; Ann Avery, MetroHealth Medical Center; Corrilynn O Hileman, MetroHealth Medical Center; Cheryl Cameron

People living with HIV (PLWH) often exhibit disproportionately high rates of major depressive disorder (MDD) and/or generalized anxiety disorder (GAD), a phenomenon that remains largely unexplained. These comorbid psychiatric disorders are associated with reduced quality of life and lower adherence to treatment, increasing the risk of viral rebound, drug-resistant HIV strains, progression to AIDS, and the development of additional comorbidities. This study investigates the underlying pathogenesis of mood and anxiety disorders in virologically suppressed PLWH on antiretroviral therapy (ART) using a systems biology approach. A cohort from MetroHealth Medical Center of PLWH virologically suppressed on ART (n = 36) was assembled for the study, with diagnosis of depression and/or anxiety established using the Mini-International Neuropsychiatric Interview (M.I.N.I.) and confirmed by a licensed psychologist. The cohort was followed for 24 weeks, with periodic whole blood collection enabling both cross-sectional and longitudinal analyses.

Comparative transcriptomics and targeted flow cytometry were employed to identify and validate transcriptomic signatures associated with MDD and GAD in PLWH on ART. Bulk RNA sequencing was performed on whole blood collected in Paxgene tubes and peripheral blood mononuclear cells were isolated from blood collected from anticoagulant vacutainers, cryopreserved, and later stained with pathway-specific antibodies selected after running bulk transcriptomic analyses on the samples. Thus far, the study has identified both shared and disorder-specific gene expression signatures that correlate with symptom presence and severity. Notably, discoveries were made in neurotransmitter regulation pathways (e.g. serotonin signaling) and organelle function and cellular stress responses (e.g. mitochondrial function). These findings lay the groundwork for identifying novel therapeutic targets and for future drug repurposing prediction analysis (e.g. dpGSEA, drug perturbation gene set enrichment analysis) to identify potential FDA-approved drugs capable of reversing pathway dysregulation in this population.

Faculty Project Mentor: Dr. Cheryl Cameron, Department of Nutrition, CWRU School of Medicine

Does pre-clinical drug activity predict phase II clinical efficacy in recurrent glioblastoma? A detailed analysis

Elijah Davis, Neuroscience and Economics

Glioblastoma (GBM) is the most common and aggressive primary brain tumor in adults, with median overall survival (OS) of under 15 months and limited treatment options. Despite decades of research, fewer than six FDA-approved therapies exist, and all other tested treatments have failed to show improvement in overall survival compared to established modalities. Novel therapies show preclinical promise but rarely improve outcomes in phase II/III trials. The repeated lack of concordance between preclinical success and clinical efficacy underscores the need to systematically evaluate the translational reliability of these models. We evaluated whether preclinical drug activity predicts phase II clinical outcomes. We systematically reviewed all phase II clinical trials in GBM registered on ClinicalTrials.gov from 1997 up to December 2023. Trials were included if they investigated monotherapy interventions in recurrent GBM. Clinical efficacy outcomes—including overall survival (OS), progression-free survival (PFS), and objective response rate (ORR)—were compared to preclinical endpoints, such as animal survival benefit and tumor volume reduction. Spearman correlation coefficients (ρ) were calculated to assess the strength and direction of association between preclinical and clinical efficacy metrics. Of 660 phase II trials screened, 28 met inclusion criteria. No significant association was found between murine survival benefit and human OS ($\rho = 0.50$, $p = 0.17$), though trends were positive. Likewise, murine survival benefit was not statistically significantly associated with objective response rate in humans, but trended towards a positive association ($\rho = 0.49$, $p = 0.11$). No correlation was found between tumor volume reduction and human OS ($\rho = –0.15$, $p = 0.59$). These findings indicate that conventional preclinical GBM models poorly predict human clinical outcomes, underscoring a need to reevaluate standard preclinical drug development pipelines in GBM. We advocate for stricter preclinical standards and alternative models like organoids or immunocompetent systems to improve translational reliability.

Faculty Project Mentor: Andrew Dhawan, MD, DPhil, Department of Neuro-Oncology, Cleveland Clinic

The Impact of Geospatial Risk Factors in Deprived Rural Areas on Cardiovascular Kidney and Metabolic Mortality: A Socioeconomic and Environmental Study

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Cardiovascular, kidney, and metabolic (CKM) conditions are leading contributors to chronic disease mortality in the US. Understanding what factors influence CKM mortality can inform targeted public health interventions. This study assesses the impact of various environmental and socio-determinants on CKM mortality.

County CKM mortality data were merged with census tract level data from the Environmental Justice Index (EJI), Climate Vulnerability Index (CVI), Social Determinants of Health (SDOH), Normalized Difference Vegetation Index (NDVI), PM2.5 (Particulate Matter), urban/rural classification, and SafeGraph mobility data: Retail Food Availability Index (RFAI), Greenspace and Recreation Time, and Weighted Mobility Index (WMI). Two supervised multivariate analyses were carried out: one by linear multiple modeling and XGBoost machine learning. Additionally, SHAP (SHapley Additive exPlanations) values were used to interpret feature importance. Geospatial mapping was done to visualize outcome patterns across counties.

Census tract-level characteristics were first analyzed by CKM mortality quartiles and urbanity. A strong negative association was found between urbanity and CKM mortality. Several predictors associated with urban life were also significantly negatively associated with CKM mortality, including population density, light and noise pollution, percent black population, SVI, percent without a high school education, unemployment rate, and percent without medical insurance. Additionally, predictors associated with mobility patterns were found to be protective. Conversely, traditional risk factors such as air pollution (PM2.5, Ozone), sleep deprivation, and smoking, as well as Area Deprivation Index (ADI), socioeconomic, infrastructure, and environmental vulnerabilities, were found to be risk factors. Unbiased variable selection by XGBoost will also be presented.

Stratifying by urbanity suggests that living in deprived rural areas presents potentially higher risks for CKM mortality than being socially disadvantaged and living in the city. This raises critical contextual differences that could inform place-based health policies. Future research should explore temporal dynamics and causality using longitudinal data.

Faculty Project Mentor: Sai Rahul Ponnana, Jean-Eudes Dazard, Cardiovascular Research Institute, Case Western Reserve University School of Medicine

The Impact of Particle Bidispersity in Force Chain Formation and Rheology of Dense Suspensions

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Dense suspensions composed of non-Brownian particles dispersed in a Newtonian solvent are widespread in environmental and industrial systems. Their complex, non-Newtonian behavior, such as shear thickening and jamming, arises primarily from the formation and evolution of force chain networks within the suspension. The emergence of these networks is governed by particle-level characteristics, including size, shape, surface roughness, and interfacial chemistry, as well as interparticle forces. While recent studies have deepened our understanding of force chain dynamics in monodisperse systems (where particles are nearly uniform in size), many real-world suspensions involve bidispersity, comprising particles of two distinct sizes. A systematic understanding of how varying degrees of bidispersity influence suspension rheology is therefore critical for bridging the gap between idealized models and complex practical systems. In this work, we employ Lubrication Flow–Discrete Element Method (LF-DEM) simulations, which couple lubrication hydrodynamics with particle-scale contact mechanics, to replicate experimentally observed steady-state rheology in dense suspensions. Our simulations reveal that increasing the degree of bidispersity reshape force chain topology and influence bulk flow behavior across a range of applied shear stress. These results offer new insights into the microstructural origins of rheological transitions and advance predictive modeling of dense suspensions in both engineering and geophysical applications.

Faculty Project Mentor: Abhinendra Singh, Department of Macromolecular Science and Engineering, Case Western Reserve University, Cleveland, Ohio, 44106

Understanding Glucose Monitoring: A Snapshot of AJP Insights

Bodway M. Elama, Saint Martin de Porres High School; Aidan D. Selkirk, Mechanical and Aerospace Engineering; Caroline Kromalic, Materials Science and Engineering; Janet L. Gbur, Materials Science and Engineering

The field of flexible electronics is growing rapidly, especially with their use in healthcare as wearable biosensors. Of particular interest are tools that aid diabetics in monitoring their sugar levels. Glucose biosensors utilize enzymatic reactions to enhance detection sensitivity. Understanding the evolution of sensor technology including key materials such as polymers and conductive inks, along with additive manufacturing methods like aerosol jet printing (AJP), can help in designing low-cost solutions for improving diabetic health. These sensors must be durable and provide accurate, reliable measurements under realistic conditions such as bending and environmental stress testing.

This work focuses on the characterization of an interdigitated capacitor (a circuit component common in biosensors) that was designed with geometric code (G-code) and aerosol jet printed onto a polymethyl methacrylate (PMMA) flexible substrate using a silver ink. Printed parts were imaged with optical microscopy and compared to the intended capacitor design. These images were analyzed to determine the presence of print defects (e.g., cracks, flaking), assess print quality (e.g., overspray, low deposition, poor infill), and measure feature dimensions. Specimens containing printed traces that touched adjacent traces and shorted the circuit were not considered passing. Furthermore, any regions where the printed silver cracked or delaminated from the substrate did not pass. Data collected was reviewed and compared to the G-code and printing parameters to provide information for improving the next iteration of prints. Results suggest there is potential for developing AJP flexible electronics on PMMA, which could transform healthcare by enabling low-cost, more personalized, and responsive solutions for patient needs.

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

Analysis of Activity and Dynamic Balance Measures in a Homegoing Study of a Sensory Neuroprosthesis

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Individuals with lower limb loss rely on prosthetic devices for ambulation but still experience functional deficits partly due to lack of neural connection between the body and the prosthesis. In particular, sensory deficits from the missing limb impair balance, exacerbated by compromised confidence. We examined the effects of restored plantar sensation on dynamic balance and daily activities in a study where an individual with transtibial limb loss wore a Sensory Neuroprosthesis (SNP) at home and the community. The SNP delivers electrical stimulation to the remaining nerves in the posterior leg via nerve cuff electrodes. These stimulations evoke plantar sensations corresponding in intensity and location to prosthesis-floor interactions. The study was divided into pre-active, active, and post-active periods and lasted total of 16 months. A wearable step tracker was used to quantify the daily level of activity by computing step count, distance walked, and calories burned from accelerometer and heart rate data. Linear regression was performed for each study period and 95% confidence intervals for slope were compared. Additionally, the participant visited the lab on regular basis and performed a series of assessments including a Rhythmic Weight Shifting test to assess dynamic standing balance. We analyzed the center of pressure (CoP) location data using a 95% prediction ellipse and examined CoP movements perpendicular to the directed axis of movement. Paired T-tests with Bonferroni correction ($p<0.0083$) were used to analyze the effect of stimulation for the direction and speed. None of the CoP measures showed statistical significance. Lack of statistically significant effects may be due in part to ceiling effects. The participant was highly active (K3+) prior to and during the pre-active period, potentially masking any effects of SNP due to high baseline. The prediction ellipse semiminor axis shows the most promise as additional participants are studied, demonstrating several statistical trends ($p<0.1$).

Faculty Project Mentor: Hamid Charkhkar, Department of Biomedical Engineering

Computational Modeling of Metal Electrodeposition on Electrode Surfaces

Carlos David Escorcia Obando, Chemical Engineering

Electrodeposition is one of the currently preferred methods for the atomically precise monolayer metal coatings. This electrochemical process facilitates the adsorption of selected metallic atoms to a substrate by applying a specific voltage across two electrodes. Therefore, by controlling factors such as the adsorbates and the potential difference, electrodeposition provides a way to build surfaces that exhibit desired properties for various applications, such as electronics and medical devices. Currently, there is a lack of understanding on the mechanisms of certain interactions between adsorbates and substrates, and theoretical models are needed to predict the electrodeposition potentials of metal ions on electrode surfaces. Here, a computational approach that employs the Atomic Simulation Environment (ASE) and density functional theory (DFT) calculations in the Quantum ESPRESSO code is used to model surface–adsorbate interactions in metal electrodeposition. Adsorption energies, Gibbs free energies, and electrodeposition potentials are calculated to determine the stability of different adsorption configurations and to better describe the surface-adsorbate mechanisms. Lead (Pb) deposition on Au(111) is employed as a model system. DFT calculations show that Pb single-atom adsorption to hexagonal closed-packed (hcp) or face-centered cubic (fcc) sites have more energetically favorable structural interactions than other Pb single-atom adsorption configurations. We expect to predict the electrode potentials at which Pb deposits on Au from these energy calculations and to expand this method to other materials in search for structural and electrochemical trends. By developing a theoretical model for these surface-adsorbate interactions, scientific efforts to advance the level of detail and the control of defects in electrochemical coating could obtain a more solid basis for the design of in-lab experiments.

Faculty Project Mentor: Robert E. Warburton, Department of Chemical and Biomolecular Engineering

PM2.5 Exposure Fuels Neurodegeneration and Anxiety-Related Behaviors in Mice

Xiang Fang, Medicine and Cardiology; Armando Vergara-Martel, Medicine and Cardiology; Elaine Ann Ebreo Cara, Medicine and Cardiology; Palanivel Rengasamy, Medicine and Cardiology; Sanjay Rajagopalan, Medicine and Cardiology

Background:
PM2.5 (particulate matter ≤ 2.5μm) is a major air pollutant that can enter the lungs and bloodstream, increasing the risk for diseases like dementia, hypertension, and lung cancer. Beyond physical health, prolonged exposure is linked to neurological and psychiatric outcomes, including anxiety, cognitive impairment, and neurodegeneration. Prior work (Li et al., 2018) shows that PM2.5 exposure induces neuronal death. Growing evidence also associates PM2.5 exposure with anxiety and stress-related behaviors. This study investigates the relationships between PM2.5-induced anxiety and neuronal injury.

C57BL/6 mice were exposed to filtered air (FA) or PM2.5 using a versatile aerosol concentration enrichment system (VACES) for 6 hours/day, 5 days/week, starting at 6 weeks of age. After 71 weeks, open field tests (OFT) and elevated plus maze (EPM) were conducted. Two additional groups were generated: a reversal group (REV), where PM2.5-exposed mice were switched to FA, and a late-exposure group (EXP), where FA mice were switched to PM2.5. Mice remained in their new conditions for 14 weeks before the final behavioral tests. At the end of the study, each group had 6 mice. Afterwards, the mice were euthanized, and brain tissue samples were analyzed for neurofilament light (NEFL), a protein released during neuronal damage.

Results / Expected Results:
PM2.5-exposed mice spent less time in the OFT center and open arms of the EPM than FA controls. Following the reversal timepoint, EXP mice showed reduced OFT center time than FA mice. These results suggest that long-term PM2.5 exposure increases anxiety-like behavior in mice, with partial reversibility. Additionally, decreased NEFL levels are expected in the brain tissue of PM2.5-exposed mice, indicating greater neurodegeneration. These findings may contribute to a deeper understanding of how air pollutants like PM2.5 affect physical, mental, and neurological health.

Faculty Project Mentor: Armando Vergara-Martel, Elaine Ann Ebreo Cara, Palanivel Rengasamy, CWRU, Department of Medicine, Cardiology

Establishment of CRISPR-Cas9 Transcription Factor Screen Workflow in mutant-MYOD1 RMS cell line

Carrietta Farma-Hai, Biochemistry Bhavatharini Udhayakumar, Department of Systems Biology and Bioinformatics

Rhabdomyosarcoma (RMS) is a soft tissue cancer of skeletal muscle lineage that accounts for 3% of all pediatric cancers. Genetic evidence has enabled clear subtyping of RMS into fusion negative-RMS (FN-RMS), fusion positive-RMS (FP-RMS), spindle cell/sclerosing RMS (Sp/Sc RMS) and pleomorphic RMS. Recent studies have discovered a recurrent somatic mutation encoding p.L122R in the myogenic transcription factor MYOD1 in a subset of Sp/Sc RMS. MYOD1, a key transcription factor of muscle development, is the most potent growth dependency factor specific to RMS resulting in a subtype referred to as mutant-MYOD1 RMS (MM-RMS). This subtype is marked by an aggressive course of disease with a high mortality despite multimodal chemotherapy regimens. The L122R mutation occurs within the conserved basic domain and is crucial for DNA binding thus reducing transcriptional activation at MYOD1 sites. This mutation interferes with normal differentiation pathways and underscores MYOD1-L122R's contribution to oncogenesis in skeletal muscle. The main goal of the project is to perform a CRISPR/Cas9 screen in the MM-RMS cell line to identify master transcription factors that contribute to disease pathogenesis, as these factors have not yet been systematically identified and could reveal new therapeutic opportunities. We successfully established wt-Cas9 expression in the MM-RMS cell line and packaged a pooled sgRNA library targeting transcription factors in a lentiviral system. We then performed flow cytometry (FACS) to determine the appropriate amount of virus required for the screen with a MOI target of 0.3–0.5, which is considered optimal for pooled CRISPR screening. Ultimately, we established the CRISPR screening workflow, including successful Cas9 expression, packaging of the transcription factor sgRNA library, and initial viral titration. The current focus is on expanding the PDX-derived MM-RMS cells, which have a relatively slow doubling time, before proceeding with transductions at the determined MOI.

Faculty Project Mentor: Dr Berkley Gryder, Department of Genetics and Genome Sciences

Powering the Future of Transit: A Microgrid Solution for SARTA's Hydrogen Bus Fleet

Abigail Fessel, Physical Science, Anderson University; Dr. Tessa Rosenberger, Energy Policy Center, Cleveland State University; Mark Henning, Energy Policy Center, Cleveland State University; Andrew Thomas, Energy Policy Center, Cleveland State University

This project focuses on the design of a resilient and reliable microgrid for the Stark Area Regional Transit Authority (SARTA) that supports both critical loads and onsite hydrogen production and storage for the support of its hydrogen fuel cell bus fleet and refueling infrastructure. The solution to SARTA's electrical demands will be the implementation of a microgrid that would allow for an islanding-from-the-grid mode to increase resiliency and sustainability efforts through distributed energy resources (DER's). The primary goal of this project is to maximize the use of renewable energy resources to support SARTA's total load independently from the larger electrical grid while replacing current, truck transported, grey hydrogen use with green hydrogen generated onsite through an electrolyzer. Onsite air handlers, data centers, and the electrolyzer require full uptime and the microgrid offers reliable and continuous power to maintain these loads. The design process employed Sandia National Laboratories' Microgrid Design Toolkit (MDT) to model electrical loads and energy generation configurations, and the National Renewable Energy Laboratory's (NREL) System Advisor Model (SAM) to conduct a techno-economic analysis and estimate the system costs. Renewable resource potentials were assessed using PVWatts for solar energy and placement and the NREL Wind Resource Database for wind energy estimates for Canton, OH. The resulting microgrid design considers a combination of rooftop, canopy, and ground-mounted solar installations, paired with battery storage and phosphoric acid fuel cells, that can feasibly supply SARTA's high-capacity campus loads. This microgrid design can serve as a model for other transit authorities looking to increase campus resilience and reliability that supports zero emission bus fleets.

Faculty Project Mentor: Dr. Tessa Rosenberger, Energy Policy Center, Cleveland State University; Mark Henning, Energy Policy Center, Cleveland State University; Andrew Thomas, Energy Policy Center, Cleveland State University

Whole body skin for safe interactive robots

Alisha Fluker, Zach Patterson, Mackenzie Elmer, Susan Schramfield, Denise Huang, Holy Cross College, SouthBend Indiana, Biomedical Engineering, Case Western Reserve University, Cleveland, OH

I have been working on a project under Dr. Zach Patterson that involves developing an artificial skin, enabling machines to sense touch while also controlling impact to help prevent damage. My role has been to assist in developing proofs of concept by creating a version of the skin using sensors and evaluating how well this specific concept performs, which includes identifying areas for improvement. Overall, I am helping Dr. Patterson assesses the strengths of each approach to determine which concept is the most promising. So far, I have created three sensor prototype versions. My most recent prototype consists of a 3x3 grid of six sensors arranged in two overlapping layers. This allows me to detect the specific area on the sensor that it is being touched. After extensive testing to determine which code gave the most accurate outputs, I reached a point where the sensor readings were largely reliable. My next steps involve using a robotic arm to characterize the sensor's properties, including the force applied and the displacement of the artificial skin on the X,Y, and Z axis.

Faculty Project Mentor: Zach Patterson, Assistant Professor in Mechanical and Aerospace Engineering, CWRU

Impact of MDM2 degradation on cytotoxic effects of NSC59984 in endometrial cancer cells

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Introduction: Mutations in TP53 are prevalent in nearly half of all human tumors, with the other half showing disruptions in the p53 signaling pathway. Currently, mutated-p53 endometrial cancers have insufficient treatment options. The compound NSC59984 has previously been shown to induce cytotoxicity in mut-p53 cancer cells. Selective degradation of mut-p53 is one proposed mechanism of NSC59984. This is thought to occur through the normally occurring ubiquitin ligase responsible for p53 degradation, MDM2. The current study investigates whether NSC59984-induced cytotoxicity in endometrial cancer cells is dependent on MDM2.

Methods: Two human endometrial cancer cell lines were used: HEC1B (mut-p53) and JHUEM2 (wt-p53). Cells were treated with NSC59984, KT253 (MDM2 degrader), or both. DMSO served as the control. Effects on cell viability were assessed both qualitatively in 6-well plate assays and quantitatively via high-throughput drug combination assay with Cell Titer Glo luminescent read out. Western blotting was used to confirm MDM2 degradation and determine the impact on p53 and p21.

Results: KT253 effectively degraded MDM2; however, the absence of MDM2 did not significantly reduce NSC59984-induced cytotoxicity. Quantitative and qualitative results demonstrated an additive effect suggesting that NSC59984 acts independently of MDM2. The absence of MDM2; however, demonstrated an increase in p21 suggesting that MDM2 degradation does impact the cytotoxic effect of NSC59984, but does so by potentiating its effect.

Conclusions: Our data suggest that NSC59984 exerts cytotoxic effects in mut-p53 endometrial cancer cells through a mechanism independent of MDM2 degradation. The activity of NSC59984 is not dependent on MDM2 but MDM2 may still play an integral role. These findings reinforce the therapeutic potential of NSC59984 and highlight its alternative proposed mechanism through p73, a paralog of p53, as a key mediator of its anti-tumor effects.

Faculty Project Mentor: Roberto Vargas, epartment of Translation Hematology Oncology Research, Lerner Research Institute, Cleveland Clinic, OH and Division of Gynecologic Oncology, Cleveland Clinic, Cleveland, OH

Fungi-Assisted Bio-Cementation of Lunar Soil

Audrey Gibson, Environmental Studies major, GLWIND REU, from Kenyon

Soil strength is an area of study relevant across disciplines with ever-growing importance as natural disasters are on the rise with the changing climate, for erosion, for landslides, for wind energy, and even nitrogen application on farmlands. A previous study found that adding fungi and wheat bran strengthened soil and improved its ability to hold water (Gou et al. 2025). Another study found that fungi improved the compressive strength of sand (Lim et al. 2020). Past research has not studied fungi in lunar soil, a notoriously weak soil with 0% clay. To investigate the potential of fungi and wheat bran in enhancing the mechanical and erosion-resistant properties of lunar soil simulant, we designed a controlled microcosm experiment using four treatments: (1) lunar soil only (control), (2) lunar soil + wheat bran, (3) lunar soil + fungal inoculum, and (4) lunar soil + wheat bran + fungal inoculum. The fungal cultures were cultivated directly within the lunar soil simulant under controlled laboratory conditions. Wheat bran was used as an organic substrate to promote mycelial growth. To evaluate mechanical improvements, we conducted standardized soil compaction tests to determine compressive strength. Resistance to erosion was assessed using a rain simulator test simulating lunar-resistance to erosion. Surface structure and microbial binding effects were further examined using Scanning Electron Microscopy (SEM). We hypothesize that fungal colonization will significantly increase compressive strength and erosion resistance, with the wheat bran + fungi treatment yielding the most structurally robust and cohesive samples.

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Faculty Project Mentor: Xiong Bill Yu, Department of Civil and Environmental Engineering

Exploring the acute physiological responses and influence of neuromuscular electrical stimulation exercise on cognitive function following spinal cord injury

Taylar Griffith, Kinesiology, Dr. C. Eric Heidorn, Advanced Platform Technology Center, Lisa Lombardo, Advanced Platform Technology Center

Individuals with spinal cord injury (SCI) are at increased risk for secondary health complications including cognitive impairment and cerebrovascular events. Exercise has been shown to improve cognitive function and measures of cerebral health which can be partially attributed to the increases in cardiac output and cerebral perfusion. As volitional exercise intensity increases, cerebral blood flow and tissue oxygenation typically rises, corresponding with greater cortical activity. Neuromuscular electrical stimulation (NMES) is commonly used to improve cardiovascular, bone, and skeletal muscle health outcomes after SCI, however, its acute effects on cerebral tissue oxygenation and cognitive function have not been thoroughly investigated. This preliminary study examined acute physiological and cognitive responses to three NMES exercise modalities in two individuals with SCI. Participants completed one no-exercise condition (baseline cognitive assessment) and three NMES exercise conditions: cycling, rowing, and either standing or stepping, each performed on separate days. Each NMES session consisted of six, five-minute bouts of exercise (totaling 30 minutes of exercise) with 10-minute passive rest periods between bouts. Cognitive function was assessed immediately following each NMES session using the Stroop Task, N-back Task, Trail Making Task, and Rey Auditory Verbal Learning Test. Heart rate (HR) and tissue oxygenation of the prefrontal cortex and quadriceps were continuously monitored during all NMES conditions. Brachial blood pressure (BP), rating of perceived exertion, and performance metrics were recorded for each exercise bout. We hypothesized that NMES exercise would improve cognitive performance compared to baseline, with the greatest improvements following NMES rowing and stepping. We also expected HR, BP, and cerebral oxygenated hemoglobin and total hemoglobin to increase from pre-exercise levels, with the largest changes during NMES rowing and stepping compared to cycling.

Faculty Project Mentor: Lisa Lombardo, Advanced Platform Technology Center

Enhancing Electrode Sensitivity to Reactive Oxygen Species by Electrochemical Deposition of Reduced Graphene Oxide

Andrew Han, Electrical Engineering

Neural probes are invaluable components of brain-machine interfaces for restoring motor and sensory function to individuals recovering from neurological injury or limb loss. Microelectrodes integrated onto the neural probes record activity from the neurons in the brain. However, the probe insertion into the brain causes damage that triggers a neuroinflammatory response and the subsequent release of reactive oxygen species. The resultant oxidative stress causes local neuronal death, damages the implants, and leads to degradation of the overall neural recording quality. Our objective is to use microelectrodes integrated onto the neural probes to electrochemically monitor oxygen species to improve understanding of the time course of the neuroinflammatory response and develop responsive solutions. To effectively detect oxygen species with a microscale electrode size, high sensitivity is required. The sensitivity of electrodes can be improved by modifying the surface with reduced graphene oxide deposition. Reduced graphene oxide improves electrochemical sensing of hydrogen peroxide by providing a high-surface-area, conductive platform that enhances electron transfer and signal sensitivity. In this study, we electrodeposited reduced graphene oxide onto the surface of gold electrodes using cyclic voltammetry (CV). We investigated how the range of potentials used during CV affected electrochemical behavior in a solution of graphene oxide and phosphate-buffered saline, using a gold working electrode and a platinum mesh counter electrode. Running CV on the electrodes led to a decrease in impedance by 60% and an increase in sensitivity to hydrogen peroxide by 153%. As we continue to evaluate the parameter space, we aim to refine our methods to increase electrode sensitivity by at least 200%. The modified electrodes will allow the presence of reactive oxygen species in the brain to be monitored effectively by the microelectrodes on the neural probes so that measures can be taken to track and address neuroinflammation in real time.

Faculty Project Mentor: Dr. Allison Hess-Dunning, Department of Electrical, Computer, and Systems Engineering

The effect of vitamin E on the progression of metabolic dysfunction-associated fatty liver disease (MAFLD).

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Metabolic dysfunction-associated fatty liver disease (MAFLD; formerly known as non-alcoholic fatty liver disease or NAFLD) is a complex, poor-prognosis liver pathology that accompanies metabolic imbalance independent of alcohol intake. MAFLD affects > 25% of the general population and is especially prevalent in patients with obesity and type 2 diabetes. Early stages of MAFLD involve the accumulation of lipid droplets in hepatocytes (hepatosteatosis) that progress to inflammation and fibrosis (scarring) of the liver, culminating in cirrhosis and hepatocellular carcinoma. A key event in this process is the activation of hepatic stellate cells (HSCs), which, upon activation, convert from vitamin A storing cells to fibrogenic myofibroblasts that synthesize and deposit extracellular matrix (ECM). Accumulation of ECM can cause irreversible scarring of the liver (cirrhosis), for which no effective intervention exists except liver transplantation. The molecular mechanisms involved in HSCs activation are poorly understood. It is commonly thought that hepatosteatosis leads to lipid peroxidation, thereby generating reactive oxygen species (ROS) that induce progression of MAFLD to MASH. Vitamin E, as an antioxidant, is hypothesized to reduce the levels of ROS in the body by neutralizing free radicals, therefore reducing oxidative stress and slowing disease progression.

In this study, we used cultured cell models to investigate the nature of the hepatocyte-borne signal that leads to HSC activation, and the ability of vitamin E to attenuate this process. Specifically, we used mono- and co-cultures of hepatocyte (Huh7) and HSCs (LX-2) cell lines to determine the signaling mechanism involved in HSC activation. Ultimately, this study will investigate the ability of Vitamin E to attenuate the progression of MAFLD to MASH and the mechanism through which this occurs.

Faculty Project Mentor: Danny Manor, Department of Nutrition

Fano-Resonant Optical Coating (FROC) for Hybrid Thermal-Electric Power Generation

William Hernandez, Undergraduate Physics Department, Case Western Reserve University

Abstract

This research investigates the fabrication and characterization of two distinct metamaterial structures engineered to exhibit epsilon near-zero (ENZ) or near-zero permittivity behavior within the visible spectrum. ENZ materials are of significant interest in photonics due to their ability to manipulate light propagation, offering promising applications in fields such as lightharvesting and optical sensing for next-generation energy and photodetection technologies. The central goal of this project is to evaluate how differing structural order and fabrication techniques affect the optical properties of materials with identical metal filling fractions. The first structure is a periodic multilayer stack composed of alternating silver (Ag) and silicon dioxide (SiO_2) layers, with a metal filling fraction of approximately 24.6%. The deposition is performed using DC sputtering for Ag and electron-beam evaporation for SiO_2. The second structure, by contrast, is non-periodic using a cross-sputtering method, in which Ag and SiO_2 are co-deposited simultaneously to create a randomized and isotropic distribution where metallicity will be diluted to the same filling fraction. This comparative study draws upon theoretical predictions based on effective medium approximations (EMA) and transfer matrix method (TMM), which predict ENZ response. By fabricating and analyzing both architectures under controlled conditions, this work seeks to explore how structural arrangement influences near-zero index behavior. Although experimental characterization is ongoing, the expected outcomes will provide valuable insight into the tunability of ENZ properties via structural engineering. This work advances photonic metamaterials research by developing scalable, application-specific ENZ materials for visiblelight regimes, with potential impact on renewable energy technologies, particularly in photodetectors for photovoltaic systems.

Faculty Project Mentor: Giuseppe Strangi, Department of Physics

Wide Bandgap Semiconductors - Management, Reliability, and Applications

Jonathan Hsu, Electrical Engineering

Gallium Nitride semiconductors offer significant advantages over traditional silicon devices which makes them increasingly attractive for applications in newer technological ventures such as electric vehicles, aerospace, and high-frequency power systems. However, their long-term reliability under harsh operating conditions remains a key challenge. This project investigates the reliability of GaN-based power devices, focusing on junction temperature rise and other degradation mechanisms. Using MATLAB and Python, I simulate power dissipation and transient thermal behavior.

The simulation framework enables tracking of critical reliability indicators such as junction temperature trends and threshold voltage drift. The results highlight how multiple interacting factors—not just temperature—impact GaN device stability and lifetime. By integrating thermal modeling with degradation tracking, this project provides insight into how GaN devices can be deployed more safely and predictably in demanding environments.

Faculty Project Mentor: Christian Zorman, Department of Electrical, Computer and Systems Engineering

Impact of KDM5B inhibitors on tumor immunosurveillance in triple negative breast cancer

Claire Huang, Solon HS ‘27

Studies have shown that the inhibition of KDM5B resulted in increased expression of T cell markers, cytokines and antigen presentation. KDM5B inhibitors also activate RNA and DNA sensing pathways, resulting in enhanced innate immunity. However, the implications of these findings regarding the suppression of breast tumor growth are not well-defined. MHC class I and II are critical for antigen presentation and adaptive immune responses. MHC-I/II is downregulated in triple negative breast cancer (TNBC) and identified as a targetable vulnerability. Although the expression of MHC-II is normally restricted to professional antigen-presenting cells (dendritic cells, macrophages, and B cells), expression of MHC-II on tumor cells is associated with more potent immune responses. HLA-DR (encoding MHC-II) expression is also significantly higher in the TNBC tumors of patients with long-term disease-free survival when compared to TNBC patients who relapsed. We analyzed the impact of KDM5B inhibitors on tumor immunosurveillance via analyzing MHC II levels, recruitment of CD8+ T cells to mammary tumors, and cytotoxic effect of CD8+ T cells on TNBC cells. We expect that KDM5B inhibitors promote immunosurveillance through increased MHC II expression in TNBC cells, recruitment CD8+ T cells into mammary tumors, and augmentation of the cytotoxic effect of CD8+ T cells on TNBC cells. Our results may inform future avenues of investigation for the development of more effective immunotherapy

Faculty Project Mentor: Monica Montano, Department of Pharmacology

Building Skills in Robotics and Inventory

Denise Huang, Mackenzie Elmer, Susan Schramfield,The Ohio State University, Columbus Ohio, Biomedical Engineering, Case Western Reserve University, Cleveland, Ohio

Over the past two months, I have had the opportunity to work on a variety of projects that have helped me to build both management and technical skills. The focus of my work has been creating and coding touch-sensitive sensors designed to support human interaction. In addition, I have working with Mackenzie Elmer, contributing to a lab inventory project using SharePoint, where I have handled tracking and organization of equipment to improve efficiency across research labs. I worked closely with Mackenzie Elmer on the inventory project, where I have gained hands-on experience navigating SharePoint, identifying the lab tools and equipment, and creating a more cohesive system for researchers. As of lately, I have also started learning how to run a robotic arm, this has helped me grow my knowledge of robotics and the applications in human fusion technology. Moving forward, I plan to continue working on developing my skills in inventory management and the knowledge needed for robotics.

Faculty Project Mentor: Mackenzie Elmer, Vice-President of Research Human Fusions, CWRU

Sepsis Induced Mouse Model Displays Myocardial Fibrosis

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Sepsis and septic shock are life-threatening conditions that result from a dysregulated host immune response to infections. Characterized by acute failure of multiple organs, including cardiovascular collapse, these conditions cause over 11 million deaths worldwide. In sepsis, pro-inflammatory and anti-inflammatory processes lead to the recruitment of inflammatory mediators such as cytokines. Cardiac cytokines promote fibroblast to myofibroblast transition, facilitating fibrosis. However, it is unknown if survivors of sepsis encounter cardiac fibrosis and long-term morbidity. To determine if sepsis causes cardiac fibrosis, C57BL/6 mice (8-10 weeks) were assigned one of two experimental groups: sham and cecal ligation and puncture (CLP), which induces sepsis. While not apparent at 48 hours, by 2 weeks post-CLP, histological analysis revealed increased myocardial fibrosis in the CLP mouse model compared to the sham, primarily in the right ventricle and interventricular septum. These findings remain consistent with the myocardial dysfunction that ventricles exhibit from sepsis. Additionally, immunofluorescence staining expressed ectopic fibrotic and macrophage markers in the CLP-treated myocardium in contrast to the control. Compared to healthy human trial patients, septic patients displayed an increase in macrophage markers, including CD14, CD163 and CD68. Future studies will expand this pilot study to determine the consequences of sepsis on cardiovascular health by testing myocardial function via echocardiogram in mice with CLP. In regards to reducing myocardial fibrosis as a therapeutic strategy, proteases that cleave collagen will be explored and tested as a part of a larger approach to develop therapeutic strategies to reduce the long-term cardiovascular consequences of survivors of sepsis.

Faculty Project Mentor: Dr. Timothy J. Mead, Department of Pediatrics, Case Western Reserve University School of Medicine and University Hospitals Rainbow Babies and Children's Hospital, Cleveland, OH

Endothelial Kruppel-like factor 4 (KLF4) depletion impairs neurovascular function and accelerates age-related cognitive decline

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As we get older, various aspects of our bodies start to decline, including brain function. The mechanisms behind the decline in brain function due to aging are still not well understood. The blood-brain barrier (BBB) is crucial for maintaining brain health and homeostasis across the lifespan by controlling both passive and active exchange of materials between the blood and brain, as well as neurovascular coupling, which is the instantly calibrated delivery of blood to brain regions to precisely match their energy demand. Both aging and neurodegenerative disorders are associated with the deterioration of endothelial cells, the primary component of the BBB. Endothelial cells are highly enriched in the Kruppel-like factor 4 (KLF4) transcription factor, which is reduced in expression with aging. In this study, we report that endothelial-specific KLF4-knockout (KLF4 KO) mice demonstrate accelerated brain aging, including accelerated BBB deterioration, neurodegeneration, and cognitive decline. Single-cell RNA sequencing from brain endothelial cells of endothelial-specific KLF4 KO mice demonstrates aberrantly high expression of adaptive and innate immune response genes, and live animal brain imaging across the lifespan reveals accelerated aging-related BBB deterioration and leakage, decreased blood flow, and impaired neurovascular coupling. Endothelial-specific KLF4 KO mice also show increased neuroinflammation and neutrophil infiltration. Our data suggest that diminished endothelial cell KLF4 signaling with age could be a novel therapeutic target to preserve the health and function of the aging brain.

Faculty Project Mentor: Edwin Vázquez-Rosa, Department of Psychiatry, Case Western Reserve University; Dr. Andrew A. Pieper, Department of Psychiatry, Case Western Reserve University

Integrating Satellite and Ground Data to Extend the Local Spatiotemporal Resolution of Urban Air Phenomena

Nate Jackson, Engineering Physics

As urban areas evolve into smarter, more connected systems, they generate and rely on increasingly diverse streams of environmental data. From satellite-based sensors orbiting the Earth to ground-level monitors in neighborhoods, modern cities produce an unprecedented volume of information. Yet synthesizing these heterogeneous datasets into actionable insights remains a core challenge for renewable energy development, public health, and smart-city decision-making. A critical limitation lies in the spatiotemporal resolution gap between coarse satellite observations and sparse ground-based measurements. Platforms like NASA TEMPO (Tropospheric Emissions: Monitoring of Pollution) and ESA TROPOMI (Sentinel-5P) offer valuable coverage of atmospheric trace gases but at spatial footprints of approximately 3×5 km²—insufficient to resolve block-by-block variations in urban air quality, wind behavior, or heat-island intensity. Local-scale phenomena often demand resolutions on the order of 10–100 m. Moreover, deploying dense sensor networks remains costly, and integrating multi-source data presents significant analytical complexity. To address these challenges, we present a data-driven framework that fuses satellite-derived tropospheric column densities (e.g., NO_2, HCHO, O_3) with ground-level meteorological (temperature, wind speed, wind direction) and air-quality observations from AirNow, Pandora. Case studies in Hampton Roads, VA span a full annual cycle at hourly to daily intervals. Our preprocessing pipeline uses open-source tools—including the Copernicus Data Space Ecosystem, ESA Atmospheric Toolbox, and EPA pyrsig API—to filter, reproject, and align Level 2-3 satellite products onto a unified spatial grid. Python-based workflows with Pandas, NumPy, Matplotlib, and Seaborn enabled time-series plots, correlation heatmaps, and seasonal trend visualizations that highlight pollutant transport and its interplay with meteorology. Although demonstrated for air-quality analysis, this framework is generalizable to other urban environmental phenomena—local wind estimation, heat-island mapping, microclimate modeling—and can inform wind-energy density estimation and turbine siting, thereby bridging environmental monitoring with renewable energy planning in smart cities. Project Mentor: Navid Goudarzi, M³TfluiD Lab, Cleveland State University

Faculty Project Mentor: Navid Goudarzi, Mechanical and Aerospace Engineering

Evaluation of a Train-the-Trainer Model Used to Train Researchers to Implement a Culinary Medicine Intervention for At-Risk Youth with Type 1 Diabetes

Serena Kataria, Nutritional Biochemistry & Metabolism and Psychology

The Train-the-Trainer (TTT) model is a widely used educational framework to train educators not only in content knowledge but also in how to effectively disseminate that knowledge to others. Despite its growing adoption across various healthcare sectors, there remains a limited body of literature evaluating the effectiveness of TTT models, particularly in clinical and public health contexts. Therefore, this study evaluated the effectiveness of a TTT model within the Diabetes Inspired Culinary Education (DICE) study, an innovative, family-centered culinary medicine intervention designed to improve health outcomes among at-risk 8-14-year-old youth with type 1 diabetes (T1D). The DICE TTT model utilized a hybrid multi-component approach as it included online training modules and quizzes as well as in-person demonstrations and role play. Effectiveness of the training was assessed via REDCap surveys completed by RAs at baseline and one-month post-training. Among the 62 RAs, significant improvements in T1D knowledge ($p<0.001$), T1D disparities ($p<0.001$), cultural sensitivity ($p=0.01$), and research methodology & ethics ($p<0.001$) were observed from baseline to post-test. These findings suggest that the TTT approach was successful in preparing RAs to implement the intervention and highlight its potential to serve as a model for training in similar clinical or public health diabetes programs.

Faculty Project Mentor: Dr. Catherine McManus, Department of Nutrition

Spatial Epigenomic Study of the Mouse Brain Following Traumatic Brain Injury-Cell type annotation and neighborhood analysis

Shruti Kelkar, Department of Biochemistry; Ridhima Prasad, Department of Neuroscience; Hui Liu, and Andrew A. Pieper, Louis Stokes Cleveland VA Medical Center; Harrington Discovery Institute, University Hospitals Cleveland; Institute for Transformative Molecular Medicine, School of Medicine; Department of Psychiatry, Case Western Reserve University

Traumatic brain injury (TBI) is a global health crisis affecting 1.7 million people annually and is a common precursor to chronic neurological conditions like Alzheimer's and Parkinson's disease. The diverse nature of TBI currently hinders the identification of specific biomarkers for diagnosis and treatment. Spatial-omic studies are unique as they integrate spatial and molecular information, providing insight for potential biomarkers. Recent advancements in spatial transcriptomics have allowed for mapping neuronal loss and identifying spatial marker genes linked to metabolic changes post-TBI. Our current study utilized spatial ATAC-Seq to investigate the region- and cell type-specific gene accessibility as a function of traumatic brain injury, post-injury time, and the neuroprotective compound P7C3-A20.

A multimodal TBI mouse model, which combines acceleration/deceleration, blast wave, and concussive injuries was used. Mouse brain samples were collected at 24 hours and 3 weeks post-injury, then flash-frozen and sectioned for spatial epigenomic analysis.

Spatial ATAC-seq analysis revealed 19 distinct cell clusters, which were annotated using Allen Brain Cell Atlas as the reference, identifying cell types such as oligodendrocytes, microglia, astrocytes, endothelial cells, and glutamatergic and GABAergic neurons. We observed a decrease in the proportions of glial cells and some subclasses of neurons, as well as an increase in other subclasses of neurons, under TBI conditions. Notably, most of these changes were normalized in samples treated with P7C3-A20. A subsequent neighborhood analysis highlighted altered functional and physical interactions within and between cell clusters in response to TBI and P7C3-A20 treatment.

Data collection and analysis are ongoing. We anticipate this study may offer crucial insights into the molecular mechanisms underlying chronic brain conditions following TBI, ultimately supporting the development of more precise therapeutic strategies.

Faculty Project Mentor: Hui Liu, Department of Psychiatry, CWRU

Regulation of the DDX41–STING Axis by TRIM21 in Podocytes in Diabetic Kidney Disease

Emmeline (Najeong) Kim, Department of Chemistry

Diabetic kidney disease (DKD) affects approximately 35% of patients with type 2 diabetes (T2D) and accounts for up to 50% of end-stage kidney disease (ESKD) cases. Podocyte injury and depletion are key early events in DKD pathogenesis. In T2D, metabolic stress can cause mitochondrial damage and the release of mitochondrial DNA (mtDNA) into the cytoplasm, where it activates innate immune sensors such as STING (stimulator of interferon genes).
A functional protein association network in rats highlights three high-confidence STING-interacting DNA sensors: the canonical cyclic GMP-AMP synthase (cGAS), DEAD-box helicase 41 (DDX41), and interferon gamma inducible protein 16 (IFI16). Our preliminary snRNA-seq data from Control rats showed a distinct distribution of these sensors within glomerular cell types, with DDX41 being the most prominent overall, while Cgas and IFI16 transcripts are mostly restricted to non-epithelial cells. These findings suggest that DDX41 may be the primary DNA sensor initiating STING activation in podocytes under metabolic stress.

Despite its apparent importance, DDX41 regulation in the kidney remains poorly understood. DDX41 activation requires phosphorylation at Y414 by Bruton's Tyrosine Kinase (BTK), while its proteasomal degradation is mediated by the E3 ubiquitin ligase TRIM21. Supporting their regulatory interaction, a functional protein network analysis revealed high-confidence links between TRIM21 and DDX41 in both human and rat datasets. Although abnormal activation of TRIM21 has been reported in T2DM mice, it remains controversial whether TRIM21 activity has protective or harmful effects in the kidney. In our model, high-glucose treatment (30 mM, 24 h) of primary human podocytes led to increased DDX41 expression and STING phosphorylation, supporting a functional DDX41–STING axis. We hypothesize that under metabolic stress, impaired TRIM21-mediated ubiquitination of DDX41 results in sustained STING activation and inflammatory injury in podocytes. Ongoing studies will test this hypothesis by modulating TRIM21 and BTK to regulate DDX41 activity in vitro.

Faculty Project Mentor: Agustin Gonzalez-Vicente, Department of Physiology & Biophysics

Optimizing Transient Selective Neural Inhibition via Photobiomodulation (tSNIP) for Nociceptive Pain

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Chronic pain affects nearly 50 million Americans, with over 20 million experiencing high-impact pain that severely limits daily activities and overall quality of life. Current treatments are often inadequate or unsustainable. Opioids carry significant risks including addiction, overdose, and long-term complications. Other options like nerve blocks or ablation can result in temporary paralysis or irreversible nerve damage. These limitations have prompted growing interest in neuromodulation strategies that offer targeted, reversible pain relief, such as photobiomodulation therapy (PBMT). A specialized form, transient Selective Neural Inhibition via Photobiomodulation (tSNIP), aims to selectively inhibit small-diameter pain fibers while preserving motor and large-fiber sensory function. To optimize tSNIP's physiological effect, the project aimed to record Evoked Compound Action Potentials (ECAPs) from peripheral nerves. However, consistent ECAP acquisition proved technically challenging due to persistent motion artifacts and signal instability, leading to an investigation focused on troubleshooting. Recordings were attempted across multiple anatomical targets, including the saphenous, sciatic, spinal nerves, and dorsal root ganglia. Bipolar cuff electrodes were used for stimulation and needle electrodes for recording. A wide range of experimental manipulations were explored to enhance recording quality, including tendon transection, stereotaxic stabilization, mineral oil coverage, surgical repositioning of nerves, and modifications to stimulation parameters. Each intervention contributed valuable insight into the electrophysiological setup and resulted in incremental improvements in signal quality. However, motion artifacts remained a recurring issue, often correlating with respiratory and muscular reflexes even under deep isoflurane anesthesia. These observations suggest that complete physiological suppression may be required for artifact-free recordings, potentially through the use of paralytics and ventilator-assisted respiration. Importantly, establishing stable ECAP signals represents a critical prerequisite for future investigations into the fiber-specific effects of tSNIP. The troubleshooting strategies and lessons outlined here form a foundational framework to support further development and validation of PBM-based neuromodulation techniques.

Faculty Project Mentor: Dr. Michael Moffitt, Department of Biomedical Engineering, Case Western Reserve University

Optimization of 4R Tau Seed Amplification Assay Conditions

Brian Kong, Biochemistry BS, Heidi Standke, PhD, Department of Pathology.

In recent years, diagnosis of neurodegenerative diseases has made great strides through the development of disease-specific biomarkers, including for Alzheimer's and Parkinson's disease. However, certain neurodegenerative diseases, such as progressive supranuclear palsy (PSP) and corticobasal degeneration (CBD), remain difficult to diagnose early due to the absence of detectable, disease-specific biomarkers. PSP and CBD are 4R tauopathies that are characterized by aggregation of the 4R isoform of the tau protein. The RT-QuIC (real-time quaking-induced conversion) is an in vitro seed amplification assay that selectively detects different types of misfolded proteins via protein-based propagation mechanisms, where misfolded protein "seed" fibril formation of recombinant substrates in vitro through cycles of shaking and incubation with empirically determined reaction conditions comprised of specific buffers, salts, and cofactors. 4R seed amplification assays have historically demonstrated variability in the kinetics of seeded fibril formation, with deviating times to fibril formation, spontaneous nucleation, or heterogeneity in assay outputs. Thus, this study aims to optimize and standardize the kinetics of the 4R RT-QuIC assay by systematically testing buffer compositions, salt concentrations, and polyanionic cofactors that influence seeded fibril formation. To develop an assay with consistent kinetics, RT-QuICs were conducted using replicate wells that would be compared to historical data and contrasted with a new variable, such as varying salt concentrations, utilizing different salts, or changing the assay's incubation temperature. After completing the replicates, the data were analyzed to determine how these variables affected the assay. The 4R RT-QuIC assay is critical for advancing research into tauopathies and other neurodegenerative diseases. By adjusting the conditions that govern fibril formation, this work enables more accurate and specific detection of pathological tau species. In doing so, it contributes to improved diagnostic capabilities, better classification of disease subtypes, and deeper insights into the mechanisms of tau aggregation and propagation.

Faculty Project Mentor: Allison Kraus, Department of Pathology, Case Western Reserve University School of Medicine.

Modeling the Glioblastoma Tumor Microenvironment Using Matrigel-Supported Organoids Containing Immune Cells

Kaylie Lam, Biochemistry; Alexander Crane, Department of Pathology; Sajina Shakya, Department of Biochemistry; Christopher Hubert, Department of Biochemistry, Case Western Reserve University School of Medicine, Case Comprehensive Cancer Center

Glioblastoma (GBM) is the most common and aggressive primary brain tumor, with a median life expectancy of 12-15 months following diagnosis. GBM is challenging to treat with immunotherapy due to its highly heterogeneous nature, immunosuppressive environment imposed by myeloid cells, and low T-cell infiltration. To improve response to immunotherapy, we aim to study immunomodulatory programs in myeloid cells that reside in the tumor microenvironment (TME). The current model our lab uses to study immune cells in the GBM TME is patient-derived GBM organoids (GBOs), which are pieces of resected tissue. However, GBOs have considerable variability in quantity and immunomodulatory state of short-lived immune populations between organoids. Additionally, co-culture experiments with immune cells in GBOs have varying success in immune cell tumor infiltration. This makes it challenging to conduct mechanistic studies, especially given the nonrenewable nature of patient-derived GBOs and the high volume of organoids required. Thus, we sought to make a reproducible immune tumor invasion model that contains a consistent number of myeloid cells within each organoid. To create this model, a highly proliferative GBO line was dissociated into a single-cell suspension along with myeloid cells, placed into a Matrigel mold, and grown in culture. Organoids were then fixed at various time points (1 week, 2 weeks, etc.), frozen in OCT, sectioned, and stained for immunofluorescence to monitor the presence and activity of immune cells. Organoid formation was successful, and immune cells were still present in the tumor by 6 weeks. The organoids also exhibited real tumor characteristics, specifically a hypoxic core, a proliferative periphery, and immune cells that maintained suppressive states. Thus, the use of this model will provide valuable insight into myeloid cell activity in the TME, in addition to providing a more controlled and consistent model to test drugs and immunotherapies for GBM treatment.

Faculty Project Mentor: Dr. Tyler Miller, Department of Pathology

Lifetime And Reliability Assessment of MultiLayer Ceramic Capacitors (MLCCs) Through Highly Accelerated Lifetime Testing (HALT)

Jacob Lample, Department of Materials Science and Engineering; Rishabh Kundu, Department of Materials Science and Engineering; Roger French, Department of Materials Science and Engineering and Department of Computer Science; Alp Sehirlioglu, Department of Materials Science and Engineering

The applications of MLCCs are vast, ranging from cellphones to space shuttles to deep sea communication systems. With the wide variety of applications, the industry generated ~ USD 16 billion in 2023 with a projected CAGR of 4.62%[1] . Reliability of MLCCs is especially important due to the diverse and sometimes critical nature of their applications. Currently, the most widely used method to assess reliability is the Mean Time To Failure (MTTF) test[2]. In this method, a failure leakage current is specified and groups of MLCCs are subjected to HALT experiments. The time at which each MLCC reaches failure is recorded and the average time to failure is recorded. This average time is then deemed to be representative of the lifetime of the population. This method struggles to generate highly accurate predictions and does not appropriately elucidate the reliability and lifetime of a capacitor in operation. MTTF at its best strives to be simplistic estimation of a capacitor's lifetime and involves immense data reduction. Our project\ aims to use the data generated from HALT and dive deeper. Rather than only looking at the failure point and determining an average of when an MLCC will fail, we will analyze an entire stream of data, from the start to the end of the HALT experiments. By collecting and analyzing all of the data produced, the goal is to find potential indicators to gain new insights into when, and ultimately why, an MLCC fails. A primary end-goal is to be able to use data driven models to estimate when a certain MLCC will fail or alternatively, how much it has degraded.

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Faculty Project Mentor: Alp Sehirlioglu, Department of Materials Science and Engineering

Red Cell–Derived Damage-Associated Molecular Patterns Promote Red Blood Cell Adhesion to Human Endothelial Cells: Implications for Hemolytic Conditions in Critical Illness

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Endothelial dysfunction is a key contributor to microvascular impairment in hemolytic conditions frequently seen in sepsis, trauma, sickle cell disease, transfusion of stored red blood cells (RBCs), and other forms of critical illness. Damage-associated molecular patterns (DAMPs) released during hemolysis, including cell-free hemoglobin (CFH) and free heme, promote endothelial activation, oxidative stress, and vascular inflammation. While these DAMPs are known to increase leukocyte and platelet adhesion, their effects on RBC adhesion to the endothelium are less understood. Enhanced RBC-endothelial interactions may drive microvascular occlusion, tissue ischemia, and organ injury across these conditions. We hypothesize that exposure of human endothelial cells to CFH and free heme enhances RBC adhesion which may have associations with oxidative endothelial injury, glycocalyx degradation, and upregulation of adhesion molecules. We performed an in vitro study exposing human aortic endothelial cells (HAECs) to CFH (10 or 20 μM), free heme (1-80 μM), lipopolysaccharide (LPS, positive control), or vehicle control (Media). After exposure, HAECs were incubated with human whole blood (WB) or isolated RBCs. Adherent RBCs were visualized via EVOS M500 microscopy and quantified using MATLAB analysis as adherent RBCs per endothelial nucleus. CFH and free heme exposure significantly increased RBC adhesion relative to vehicle control. In WB, CFH at 10 μM and 20 μM led to 2.4 and 3.3 RBCs per nucleus, respectively versus 1.2 in vehicle controls. Isolated RBCs exhibited similar increases. LPS induced adhesion greater than low-dose CFH around 2.7. Free heme at 10, 40, 80 μM in WB ranged from 2.3-7.7.
These findings suggest that RBC-DAMPs dose-dependently potentiate RBC adhesion to the endothelium through oxidative and inflammatory pathways, contributing to microvascular dysfunction in critical illness. Further studies will clarify the mechanisms involved and guide strategies to mitigate DAMP-induced vascular injury.

Faculty Project Mentor: Dr.Kenneth Remy, Department of Internal Medicine Division of Pulmonary Critical Care and Sleep Medicine, CWRU/UH

Optimization of Formamidine-rich Perovskites via Ligand Passivation

Acadia Lee; Chemistry B.S., Case Western Reserve University

Metal halide perovskites are semiconductor materials that can be utilized in solar cells, light-emitting diodes (LEDs), and lasers. The general molecular structure is ABX_3, where A corresponds to the organic cations, B is a metal, and X is a halide ion. With the change in such ions, their performances vary with different band gaps, fluorescence range, and Goldschmidt tolerance factors. This project focuses on the materials $FAPbBr_3$ and $FAPbI_3$, which have outstanding optoelectrical properties when in an α-phase with a fluorescence of light green and red, respectively. The optimum bandgap of these components allows an increased photocurrent through absorbing and transferring the light photon. The main problem of these materials, however, are its intrinsic instability in ambient atmosphere due to the molecule's polarity that allows moisture to ingress causing phase instability. In order to address this issue, researchers focused on the ways to prevent the phase changes, and several methods were discussed, such as adding small cations to the A site, mixing halides in the X site, as well as passivating ligands to the surface. With the desire to keep the inert structure, ligand passivation is targeted. Hot injection method, separately preparing precursors and injecting the FA-precursor to the Pb precursor, was utilized to synthesize the material. The selected ligands were prepared together with the Pb precursor. When the product is made, the quantum yield (QY) for the level of fluorescence (100% proving all the absorbed photons result in emission), absorbance peaks, and emission peaks will be analyzed to ensure the successful synthesis of the desired perovskite. The main aim for attaching the ligands is to keep or enhance QY, while extending the life time. An enhanced lifetime will prove the effectiveness of the ligands in preventing the moisture from entering the perovskites and degrading their structure.

Faculty Project Mentor: Prof. Clemens Burda, Department of Chemistry

Engineering Novel Approaches to Reclassify VUS

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Variants of Uncertain Significance (VUS) affect 10–40% of patients with gene mutations, complicating clinical decisions and often leading to unnecessary interventions. While relatively common in whole genome sequencing, VUS identified in targeted gene approaches, such as in variants in the fibrillin-1 gene that can predict a diagnosis of Marfan syndrome, creates uncertainty as it raises questions about an individual's genetic risk and future medical plan. Genetic variants can be classified as pathogenic, VUS, or benign. We propose a rapid, translational strategy to functionally reclassify fibrillin-1 VUS using a novel in vitro assay to fulfill an unmet clinical need. De-identified variants were obtained with their classifications hidden. Fibrillin-1 pathogenic and benign variants were cloned and transfected into fibroblast cells to develop a functional assay to note changes in cell behavior such as proliferation, death, and migration. Fibrillin-1 protein quantity and integrity will be determined, in addition to quantifying changes in RNA levels and cell morphology to determine if the pathogenic variants different morphologically from the benign variants. The successful completion of this project not only has the potential for advancement in diagnosis of Marfan syndrome, a connective tissue disease, but could be expanded to VUS in other diseases and disorders. The generation of a functional readout to determine the likelihood of variant causation has the potential for early intervention and could directly impact healthcare outcomes.

Faculty Project Mentor: Timothy Mead, Ph.D., Department of Pediatrics, Case Western Reserve University School of Medicine

Combined Aortic and Coronary Artery Calcifications on CT Calcium Score Scans for improving Prediction of Major Adverse Cardiovascular Events

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Cardiovascular disease (CVD) is the leading cause of mortality in the entire world. Most people are unaware of any heart problems they have until they experience major adverse cardiac events (MACE). Currently, to predict if someone is likely to have a MACE, coronary artery calcium (CAC) scoring is used. However, this does not take into account the calcifications which can be found in the aorta which is increasingly being recognized as another risk factor. This project investigates whether looking at both CAC and aortic calcifications from noncontrast CT calcium scoring (CTCS) can improve early detection of cardiovascular issues. We analyzed data from 764 adults who underwent CTCS. CAC was quantified using the Agatston score while calcifications were automatically detected by TotalSegmentator and looked over manually in 3D-Slicer. Cardiovascular events such as myocardial infarction, stroke, cardiovascular death, and heart failure were looked at over a two year period for the patients who underwent CTCS. We used multivariable models taking into account CAC; calcifications; traditional risk factors such as age, sex, hypertension, smoking, and BMI. Preliminary findings indicate that both CAC and aortic calcifications are associated with cardiovascular events. Our results suggest that using both CAC and calcifications in the aorta offer slightly enhanced risk information and can enhance early risk stratification in many individuals.

Faculty Project Mentor: Ammar Hoori, Department of Biomedical Engineering

Examining Food Resource Management Behaviors by Food Insecurity status and its Associations with Food Resilience in Ohio Adults

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Affiliations: Department of Nutrition, School of Medicine, Case Western Reserve University Department of Agricultural Economics, Purdue University

This project aims to estimate differences in food resource management (FRM) behaviors by food insecurity (FI) status and explore correlations between FRM and food resilience among adults in Cleveland, Ohio.

Food resilience is an emerging concept that describes an individual's ability to utilize food efficiently and overcome unexpected challenges to help their food go farther and meet dietary needs. How this ability differs between food secure and food insecure individuals is not yet understood. Yet, given the relationships between home cooking, ultra-processed foods (UPFs), and chronic disease risk, addressing this gap may improve the current understanding and direction of culinary interventions aimed at reducing health disparities between food secure and food insecure individuals.

This study uses baseline Food, Literacy, Environment, and Waste Assessment data from the first cohort (n=65) of a randomized control trial evaluating a food skills and cooking intervention. Participants self-reported their FI status using the USDA 10-item screener. For FRM behaviors, average scores will be calculated for each behavior. For FI status, the average score will be classified into one of the two categories: food secure or food insecure. Descriptive statistics will be calculated to understand the demographic characteristics of our sample. An independent sample T-test will be used to determine differences between FRM behaviors between food secure participants compared to food insecure participants. Pearson's correlation will be used to explore FRM behaviors' correlations with food resilience.

We hypothesize that food secure individuals will be more likely to read nutrition labels and use a grocery list while shopping, and meal plan more often compared to food insecure individuals. Culinary interventions focused on developing/enhancing food skills and literacy may better reduce household food waste and improve diet quality if they are tailored around developing specific FRM behaviors according to FI status.

Faculty Project Mentor: Melissa Pflugh Prescott, PhD, Nutrition Department

Refining Lower Bounds in Tensor Norm Ratios: Towards Optimal Estimates in Convex Geometry

Lucas Maciel Bueno da Silva, Mathematics and Physics

Abstract:
Using tools from functional analysis and convex geometry, we investigate configurations yielding improved lower bounds for the projective-injective tensor norm ratio $\rho(X,Y)$ for normed spaces X and Y of nontrivial dimension (i.e., at least 2). This ratio represents the universal gap between local and global strategies in the framework of general probabilistic theories, which encompass all physical models whose predictive power obeys minimal consistency requirements. Building on the ideas from a modified version of Auerbach's Lemma introduced in *Universal Gaps for XOR Games from Estimates on Tensor Norm Ratios* (Commun. Math. Phys., 375, 2020), we provide a more detailed derivation of the bound 19/18 obtained in that paper and study configurations yielding a better 8/7 bound that was conjectured there.

Faculty Project Mentor: Stanisław Szarek, Department of Mathematics, Applied Mathematics, and Statistics, Case Western Reserve University

Optimizing T-cell Activation Analysis Through Tissue-Specific Antibody Titration

Ria Makkar - Biochemistry B.S, Filip Goshevski

T Lymphocytes are a type of white blood cell that play a crucial role in generating immune responses. T-cell activation is the process by which mature T-cells become responsive to antigens, leading to T-cell proliferation, cytokine production, and the initiation of immune responses. When activated, T-cells upregulate the expression of CD25, CD44, and CD69 surface antigens. CD69 is found on all activated T-cells within hours of initial stimulation, making it a sensitive marker for recent activation. CD25 is primarily found on activated regulatory and effector T-cells while CD44 is found on memory and effector T-cells, allowing for the discernment between naive cells from antigen-experienced cells. Together, the variety and specificity of these markers provide reliable indicators of the cell's functional state. However, the activation of T-cells and the expression of surface markers are variable throughout different tissues in the body. To optimize staining for flow cytometry and achieve reliable results on T-cell populations across different tissues, we optimized the detection of CD25, CD44, and CD69 in murine bone marrow, lymph nodes, and spleen by performing antibody titrations and maximizing the Staining Index (SI) for each marker. The results indicated tissue-specific differences in signal quality and expression patterns. Using these optimized concentrations, antibody mixes were created for each tissue type, enabling consistent and efficient analysis of T-cell activation in future experiments. This work lays the foundation for the reliable assessment of T-cell activation across diverse immune environments and strengthens our ability to study immune dynamics in disease models frequently used in our lab such as graft-versus-host disease (GVHD), idiopathic pulmonary fibrosis, and chemotherapy-induced neutropenia. Importantly, this project supports our investigations into the immunological impact of 15-hydroxyprostaglandin dehydrogenase (15-PGDH) inhibitors which have shown efficacy in models of hematopoietic recovery, aging and GVHD. We've shown evidence of the connection between PGE2 signaling, which is regulated by 15-PGDH, and T-cell activation but we have not quantified the impact of 15-PGDH inhibition on T-cell activation directly. Through optimizing our staining protocol for T-cell activation, we have laid the groundwork to do so, allowing us to better understand the therapeutic scope of PGDH inhibition.

Faculty Project Mentor: Amar B. Desai, Department of Case Comprehensive Cancer Center

Analyzing Aerosol Jet Printed Circuits with Optical Microscopy

Crystal A. Mangham, Saint Martin de Porres High School; Aidan D. Selkirk, Mechanical and Aerospace Engineering; Caroline Kromalic, Materials Science and Engineering; Janet L. Gbur, Materials Science and Engineering

Optical microscopy is an important technique for analyzing fabricated parts, especially with newer additive manufacturing, direct-write technologies. Data collected helps guide research and confirm quality in commercial settings. Aerosol jet printing (AJP), a direct-write technique, uses focused gas flows that carry a cloud of tiny liquid droplets and deposits them onto a substrate. This process is commonly used to create fine features, intricate patterns, and even functional electronic circuits. Optical microscopy is critical to being able to visually analyze the outcomes of specific AJP printing parameters. For this work, a simple dumbbell-shaped circuit was used for the specimen pattern, and prints were fabricated using silver ink and polyimide thin film. The silver depositions were characterized as successful or unsuccessful prints. Successful prints displayed a clear dumbbell shape with sharp edges and consistent material distribution. In contrast, unsuccessful prints often showed the silver in blobs and contained blurred edges, misalignments, or uneven thicknesses. Unsuccessful prints can be attributed to drift in the system or improper print settings. By comparing these prints using optical microscopy, significant insight is gained into how different variables such as nozzle alignment, ink flow, and environmental stability affect the quality of the printed patterns. This data can be used to improve the reliability and precision of AJP and advance the field of printed electronics.

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

Optimization of Wind Turbine Airfoil Design Using XFOIL and openMDAO

Peter Marinelli, Pure Mathematics, Dept. of Mathematical Sciences, KSU

This project aims to assess the benefits of utilizing openMDAO and XFOIL to optimize wind turbine airfoil design. Traditional optimization methods can become increasingly computationally expensive and inefficient as more parameters from different disciplines are considered. However, openMDAO addresses this challenge by providing an efficient framework for building and solving these multidisciplinary models. In this project, a surrogate model for lift-to-drag (L/D) ratio was developed in openMDAO based on five input parameters: maximum camber, camber position, maximum thickness, Reynolds number, and angle of attack. Within XFOIL, L/D data was collected for different parameter values and used to train the surrogate model. The model was then optimized using the tools and resources provided by openMDAO to identify optimal parameters for the maximum L/D. The resulting optimal design resembled a NACA 2411 airfoil with an 8-degree angle of attack and Reynolds number of 1e6, outputting a maximum L/D ratio of 74. These results demonstrate openMDAO's potential to improve airfoil optimization, allowing for the incorporation of additional parameters and disciplines without overwhelming computational cost.

Faculty Project Mentor: Navid Goudarzi, PhD, Department of Mechanical Engineering, CSU

Nutrient removal of selected Ohio constructed wetlands

Braelyn Marshall, Saint Martin de Porres High School

Wetlands provide essential ecosystem services such as nutrient retention, water filtration, and habitat support for a wide range of species. They play a key role in cycling nitrogen, phosphorus, and carbon, which contributes to improved water quality and biodiversity. During this project, we studied several wetlands in Ohio by collecting and analyzing field data. Key characteristics examined included wetland area, type, sorption capacity, sediment and water nutrient concentrations, nutrient retention per unit area (lb/acre), and species richness. Data were gathered from seven well-monitored constructed wetlands: Brooks Park (BROP), Burntwood-Langerkamp (BWLK), Darby Refugee (DARR), Forder Bridge (FORB), Fruth Wetland (FRUW), and Oakwoods East (OAKE). This research highlights the ecological importance of wetlands and the value of monitoring their functions. Datasets collected from the H2Ohio program were incorporated to enhance our understanding of wetland function and environmental influences. Through this study, we gained insights into the role wetlands play in maintaining ecological health and the importance of protecting and restoring these valuable ecosystems. Importantly, the monitoring data collected in this project can help inform future wetland construction efforts by providing guidance on optimal site selection, expected nutrient retention efficiency, and biodiversity outcomes. Such data-driven insights are essential for designing more effective and sustainable wetland systems.

Faculty Project Mentor: Huichun Zhang, Civil and Environmental Engineering, CWRU

The Role of RGS2 in Spiral and Uterine Artery Remodeling During Pregnancy in mice

Martha Mboowa, Physiology and Neurobiology, Patrick Osei-Owusu, Gagandeep Kaur, and Akua Serwaa-Bonsu

Abstract

Spiral arteries are deeply embedded in the myometrium and, during pregnancy, go through remodeling to enhance uteroplacental blood perfusion. This is essential for delivery of nutrients and oxygen and to remove CO2, metabolites, and wastes from the fetus. Reduced uterine blood flow (UBF) can lead to decreased placental perfusion, affecting fetal growth and uterine health. Uterine circulation is regulated by several mechanisms including G protein signaling. Changes in signaling protein expression can lead to atypical UBF and contribute to pregnancy complications such as uteroplacental insufficiency and/or preeclampsia. One mechanism involved in UBF regulation is the control of G protein signaling by regulator of G protein signaling 2 (RGS2) protein; However, that mechanism is unclear. Here, we determined whether altered RGS2 expression influences the functional and structural properties of the uterine vasculature. We used RGS2-3xFLAG knock-in (Rgs2Flag/Flag), heterozygous knockout (Rgs2Flag/-), and Rgs2Flag/+ mice to isolate the uterus at early pregnancy (pregnancy day 11). Uterine artery (UA) reactivity was assayed using various vasoactive agents, including high potassium (K+) solution, phenylephrine (PE), acetylcholine (ACh), and sodium nitroprusside (SNP). We found that UAs reacted to K+, PE, ACh, and SNP. K+-induced vasoconstriction was reduced in Rgs2FLAG/- UA. Interestingly, basal myogenic tone was elevated in UAs from Rgs2FLAG/- mice compared to those from Rgs2FLAG/FLAG mice, and this effect blunted PE-induced vasoconstriction. ACh-induced vasodilation was markedly impaired in UAs from Rgs2FLAG/- mice relative to all vessels. However, SNP-induced vasodilation was elevated in UAs from Rgs2FLAG/- mice relative to the response in UAs from Rgs2FLAG/FLAG and Rgs2FLAG/+ mice. Our findings suggest that RGS2 deficiency reduces endothelium-dependent vasodilation and enhances basal myogenic tone in uterine arteries during the early stages of pregnancy.

Faculty Project Mentor: Patrick Osei-Owusu, Physiology and Biophysics

Single-Molecule Microscopy and Tracking of Proteins During Electrophoresis in Cellulose-Based Membranes

Owen Minami, Physics and Astronomy

Electrophoresis is the process of separating molecules based primarily on charge and size by applying an electric field through a medium. It is a versatile technique used in many fields with applications such as DNA sequencing, protein analysis, and disease diagnosis. Paper electrophoresis specifically has been of recent interest for requiring little equipment, being relatively inexpensive, and being robust enough for use in point-of-care testing in resource limited and non-standard healthcare settings. Investigating the single-molecule properties of paper-based electrophoresis provides a look into pieces of the process that are impossible to see at the macroscopic level. This project demonstrates the ability to use fluorescence microscopy to observe the molecular dynamics of the protein bovine serum albumin (BSA) during the electrophoretic process in a drop cast cellulose-based membrane, revealing heterogeneity that is lost when looking at averaged data. Single particle tracking of BSA in the cellulose membrane was able to be performed and statistical data of BSA was collected for voltages ranging from 0 V/cm to 50 V/cm. We observed a clear relationship between protein speed and applied voltage and calculated other quantitative data such as mean squared displacement, average jump distance and average jump angle. Our method of observing molecular dynamics will allow the development of practical improvements to paper electrophoresis and further ready it for use in the field of medical diagnostics.

Faculty Project Mentor: Dr. Lydia Kisley, Departments of Physics and Chemistry

The effect of ΔMoRF1 on Drp1 function and mitochondrial fission

Talia Morgenstern, Biology (Westminster College, PA); Anelise Hutson, Department of Pharmacology

Mitochondria are complex organelles involved in regulating a variety of important cell processes. The main functions of mitochondria include regulating cell respiration and ATP synthesis as well as mitigating disease through apoptotic signaling and mitophagy to remove damaged mitochondria. Mitochondrial fission contributes to each of these roles, and the dysregulation of this process is connected to several diseases, including cancer. The key mediator of mitochondrial fission is Drp1 (dynamin-related protein 1), a cytosolic GTPase that is recruited to mitochondria and assembles to form a ring that constricts the organelle to promote scission. Drp1 contains intrinsically disordered regions (IDRs) that regulate self-assembly to build the fission machinery. A conserved stretch of a membrane proximal IDR is predicted to form an α-helix by AlphaFold, and previous studies have designated this region as MoRF1 (Molecular Recognition Feature 1) due to the role it has in mitochondrial membrane association. It remains unclear where or how MoRF1 impacts membrane remodeling and eventual constriction by Drp1. The objective of this research is to investigate the effect of deleting MoRF1 (ΔMoRF1) on Drp1 structure and function and how the loss of this feature impacts mitochondrial fission. To understand the effect of ΔMoRF1 on Drp1, electron microscopy was used to analyze the structure of the protein. In parallel, GTPase assays were performed to evaluate enzymatic activity of the protein in the presence of a lipid template. Understanding the structure and mechanisms of Drp1 will improve the foundational knowledge of mitochondrial dynamics. Future studies will examine this construct in a cellular environment. Collectively, this insight can contribute to the development of targeted therapies that limit excessive fission in cancer progression and similar diseases.

Faculty Project Mentor: Jason Mears, Department of Pharmacology

Development of a Pregnancy-Specific Nutrient Index to Assess Micronutrient Adequacy Across Dietary Interventions During Pregnancy

Aliyah Muhammad, B.S. in Nutrition, Minor in Public Health and Childhood Studies Samantha Bentley, MPH, Department of Nutrition and the Prevention Research Center for Healthy Neighborhoods Joseph Ryan Armstrong, B.S., Department of Nutrition and the Prevention Research Center for Healthy Neighborhoods

Abstract Body:
This research project aims to develop a pregnancy-specific nutrient index to evaluate micronutrient adequacy among pregnant individuals participating in one of three dietary interventions. Dietary quality is typically assessed using 24-hour food recalls, analyzed using Nutrition Data System for Research (NDSR) software. The goal is to identify which nutrients are most critical to assess before and after the interventions to support maternal and infant health outcomes. Although general nutrition guidelines exist, they often lack the specificity needed to tie dietary quality to pregnancy outcomes, such as prematurity. This project seeks to fill that gap by curating a focused set of micronutrients based on evidence from peer-reviewed literature, clinical case studies, and public health research.

Once a comprehensive list was created, we compiled variable codes, nutrient definitions, and food group associations relevant to maternal intake from the NDSR data. Nutrients under consideration include folate, choline, vitamin K, vitamin D, niacin, vitamin B12, potassium, sodium, iodine, iron, calcium, and dietary fiber. Each was reviewed based on its known effects on fetal development, maternal health, and associated birth outcomes. Using pilot data, we explored these nutrients within a sample of 150 pregnant individuals over time to examine sensitivity to a food-based intervention.

The outcome of this project is a curated nutrient set prioritized by relevance to pregnancy. This index will be used in the next research phase to assess whether dietary interventions improve intake of these nutrients among study participants. The project contributes to the broader goals of maternal nutrition monitoring and could inform clinical or community-based dietary guidelines in the future.

Faculty Project Mentor: Elaine Borawski, PhD, Professor, Department of Nutrition, Case Western Reserve University, School of Medicine

Targeting Androgen Receptor Post-Translational Modifications with Chemical Inducers of Proximity

Abbey Murcek, Chemistry, Emily Novak, Department of Pharmacology

Prostate cancer is one of the most common cancers for men in the US, comprising 30% of new cancers diagnosed in men in 2025. High levels of the androgen receptor (AR) are associated with prostate cancer and have become a target of many therapies. However, AR activation is also affected by post-translational modifications, such as acetylation and phosphorylation. In some prostate cancers AR is also activated independently from androgen levels, so post-translational modifications become more central to AR activity. Acetylation of AR has been shown to increase activation of AR, but the exact mechanism of increasing activity is unknown. We developed an strong binder for the AR ligand-binding domain and coupled it with a binder of the bromodomains of CBP/p300. The goal is to use this molecule as a "chemical inducer of proximity", causing recruitment of CBP/p300 to the AR to induce acetylation in a dose and time dependent manner. This would allow further investigation into the effects of acetylation and better understanding of how it participates in prostate cancer cells. As the AR is active in the nucleus and inactive in the cytoplasm, nuclear extraction to separate proteins in the nucleus and cytoplasm, followed by immunoprecipitation and Western blotting, can be used to detect the activity and localization of AR in both locations. We expect AR to be present in both the nuclear and cytoplasmic fractions prior to treatment, with increased localization to the nucleus following drug exposure. Changes in its nuclear abundance or post-translational modifications may indicate altered functional activity (eg, transcriptional output) in response to the compound, and enable precise control of ARs biochemical function.

Faculty Project Mentor: Berkley Gryder, Department of Genetic and Genome Sciences

Geospatial Studies of the Impact of Air Pollution on Lung Cancer Incidents in Ohio

Vanshika S. Myneni, Henry Dirks, Sai Rahul Ponnana, Sanjay Rajagopalan, Erika I. Barcelos

ABSTRACT

This project investigates the potential relationship between ambient air quality, specifically particulate matter (PM2.5) and carbon monoxide (CO) concentrations, and lung cancer incidence across Ohio counties. Environmental factors are increasingly recognized for their impact on public health, making this analysis important for potential interventions. Using lung cancer data from the Ohio Department of Health (2010-2022) and air pollutant data from the Environmental Protection Agency(2018 - 2022), the study utilized R for exploratory data analysis, data processing, and visualizations like county-level case distributions and geospatial mapping of incidence rates. Initial exploratory data analysis demonstrated significant disparities in lung cancer cases, with Cuyahoga County consistently exhibiting the highest total incidence. Moreover, the year 2021 was identified as having the highest average PM2.5 and CO concentrations across Ohio. A critical part of this research involved classifying counties into urban, partially rural, and rural categories to analyze the differences in the impact of air quality. Correlation analyses were then conducted for each county type to further examine the relationships between lung cancer cases, population, and pollutant levels.

Faculty Project Mentor: Erika I. Barcelos, Department of Materials Science and Engineering

Green Shield or Toxic Threat: Investigating the Joint Influence of Air Pollution and Greenness on Cardiometabolic Health in the U.S.

Vanshika S. Myneni, Data Science; Santosh Kumar Sirasapalli, Dr Zhuo Chen, Dr Sanjay Rajagopalan, Cardiovascular Research Institute

Air pollution is a well-established risk factor for cardiovascular and kidney diseases, while green spaces may offer protective health effects by reducing stress, promoting physical activity, and limiting exposure to environmental toxins. However, the joint impact of air pollution and neighborhood greenness on chronic disease outcomes and whether vegetation can buffer pollution effects remains underexplored. This ecological cross-sectional study investigates how air pollutants (PM2.5, PM10, NO_2, and ozone) and greenness, measured by the Normalized Difference Vegetation Index (NDVI), relate to the prevalence of coronary heart disease (CHD), chronic kidney disease (CKD), and stroke at the U.S. census tract level. Health outcome data will be sourced from the CDC PLACES dataset and linked to environmental exposure data. Multivariable linear regression models will estimate associations between pollutant levels, NDVI, and disease prevalence, controlling for potential confounders such as racial/ethnic composition, population density, median income, and the Social Vulnerability Index (SVI). Interaction terms (e.g., PM2.5 × NDVI) will assess whether greenness moderates pollution health effects. Analyses will be stratified by rural vs. urban tracts using Rural-Urban Commuting Area (RUCA) codes, with sensitivity checks excluding outlier regions and assessing geographic consistency. We hypothesize that higher concentrations of PM2.5, PM10, and NO_2 will be positively associated with increased rates of CHD, CKD, and stroke, while NDVI will be inversely associated, indicating a protective effect. Interaction models may reveal that pollution-related health risks are attenuated in greener areas. Stronger associations are expected in urban tracts due to higher pollutant levels and limited vegetation, whereas rural tracts may exhibit weaker or nonsignificant effects. Findings from this study may inform policies promoting urban greening as a public health strategy, emphasizing the value of green infrastructure in mitigating environmental health disparities and reducing the burden of chronic disease in ulnerable communities.

Faculty Project Mentor: Santosh Kumar Sirasapalli, Dr Zhuo Chen, Dr Sanjay Rajagopalan, Cardiovascular Research Institute, CWRU, University Hospitals

Wind Turbine Blade Surface Damage Detection Through Deep Learning Techniques

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Both the efficiency and cost of wind energy generation are considerably dependent on the timely maintenance of wind turbine blades. Turbine blades are essential for electricity generation, yet the effort required to manually inspect them severely impedes their productivity. To address this challenge, this research studies the application of deep learning methods in replacement of manual blade defect detection. The goal is to employ convolutional neural networks to both detect and classify surface damages. Computer vision methods cut the downtime, maintenance needs, and human labor that current inspection techniques require. This study analyzes common blade faults, including cracks, mechanical damage, erosion, scratches, and paint removal. Training is conducted using a supply of drone-acquired images, as well as generated and augmented images to further increase and diversify the dataset. Modern object detection neural networks, YOLO and Faster R-CNN, were the primary models utilized for this purpose. Early results show that, using a combination of real and generated data, YOLOv8L performed well in comparison with the other models, with the highest total mAP50 score of 0.974. Overall, the YOLO models proved better suited for this project than Faster R-CNN, in terms of mAP50 accuracy and speed. Selecting the most appropriate version of YOLO requires inquiry into a variety of architectural parameters. This work intends to improve the economic capacity and timeliness of wind turbine blade inspection by employing deep learning techniques to automate the process.

Faculty Project Mentor: Dr. Xiong (Bill) Yu, Civil and Environmental Engineering, CWRU

The Impact of PFAS Forever Chemicals on Cancer Promotion i Shaped by the Gut Microbiome

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Per-and poly-fluoroalkyl substances (PFAS) or “Forever Chemicals” are synthetic chemical compounds that were developed in the 1940s for their water- and grease-repellent capabilities, leading to their widespread use in non-stick cookware and other industrial applications. Decades of use have made PFAS ubiquitous in our environment, with detectable amounts found in water, air, soil, and the global human population. Due to their excessive use and engineered resistance to degradation, tissue bioaccumulation has become increasingly evident, leading to increased susceptibility to various health issues, including cancer. Recent evidence may suggest that the gut microbiome plays a role in how the host body responds to PFAS exposure, specifically on its impacts to cholesterol circulation and liver toxicity. Here, we directly tested the hypothesis that the gut microbiome modulates PFAS-induced liver toxicity in a rodent model. Briefly, either germ-free (GF) or specific-pathogen-free (SPF) mice were chronically exposed (7-weeks) to control or PFAS-containing water while being maintained on a Western diet. Collected plasma samples were then used in an untargeted mass spectrometry approach to confirm and analyze the presence of PFAS in the designated PFAS cohorts. Harvested liver tissue was utilized in an RNA extraction protocol, followed by necessary cDNA synthesis, and ultimate use in quantitative polymerase chain reaction (qPCR) to measure hepatic gene expression. Interestingly, PFAS exposure dramatically altered the hepatic expression of both cholesterol biosynthetic genes (HMGCS1, PMVK, and MVD) and genes involved in bile acid synthesis (CYP7A1). The resulting data suggest that the gut microbiome plays a role in how the host reacts to PFAS exposure, specifically in the expression of cholesterol and bile acid synthetic genes. Although additional research is needed, the ability of PFAS chemicals to reorganize host cholesterol and bile acid metabolism appears to be modified by the gut microbiome.

Faculty Project Mentor: Dr. J. Mark Brown, Department of Cancer Biology, Cleveland Clinic Lerner Research Institute

Investigating Mechanistic Consequences of GSDMD Assembly at Mitochondria in Models of Alpha-Synucleinopathies

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Parkinson's disease (PD) is a prevalent neurodegenerative disorder characterized by the accumulation of misfolded alpha-synuclein and chronic neuroinflammation. The NLRP3 inflammasome plays a central role in neuroinflammation, with its activation leading to the cleavage of Gasdermin D (GSDMD). Cleaved-GSDMD is an effector protein that forms pores in the membrane that facilitate the release of proinflammatory cytokines. In macrophages, cleaved-GSDMD has been shown to localize to mitochondria, and is capable of forming pores that lead to mitochondrial DNA release and activation of the cGAS/STING pathway. However, this mechanism has not yet been investigated in microglia, the brain's resident immune cells. This project aims to determine whether microglial GSDMD contributes to mitochondrial dysfunction and neuroinflammation in models of PD. To examine inflammasome activation, microglial cells from wild-type and caspase-1 knockout mice have been treated with a known inflammasome activator. Western blotting was used to assess inflammasome activation by detecting markers such as caspase-1 and GSDMD. Moreover, to model PD, primary microglial cells from wild-type and GSDMD deficient mice were treated with α-syn preformed fibrils. We hypothesize that GSDMD deficiency will prevent pore formation at the mitochondria, leading to a decrease in mitochondrial DNA leakage and subsequent cGAS/STING activation. Exploring the consequences of innate immune pathway activation may reveal novel mechanisms by which GSDMD-mediated processes contribute to sterile neuroinflammation in PD. By investigating GSDMD's role in microglial immune signaling, this project seeks to address critical gaps in our understanding of PD pathogenesis and inform future therapeutic strategies targeting neuroinflammation in alpha-synucleinopathies.

Faculty Project Mentor: Nikhil Panicker, Department of Neurosciences

Mechanical Evaluation of Wires used in Biomedical Applications

Kayden G. Parker, Hawken Upper School; Grace W. Anyalisa, Mechanical and Aerospace Engineering; Jerry Yang, Biomedical Engineering and Electrical Engineering; Janet L. Gbur, Materials Science and Engineering

The Cleveland Open Source Modular Implant Innovators Community (COSMIIC) neuroprosthetic platform marks a new era for active implantable devices that provides designs and data for components with the hope that open-source access will lead to improved treatment of life-changing disorders. These complex systems require wires to connect critical components (e.g., power source, electrodes, etc.) of the system in order to deliver the therapy (e.g., electrical muscle or nerve stimulation). Drawn-filled tubes (DFTs) are used in many medical devices and play a crucial role in creating a balance of strength and electrical conductivity. The DFT represents a metallic composite material. The outer sheath uplifts the strength of another material, while the core's function is to enhance electrical conductivity. These metals are drawn together into a wire and in most cases these wires are assembled in different arrangements, then insulated with a polymer. By carefully selecting the materials for the core and the sheath, DFTs can be designed to provide good torsional rigidity, flexural rigidity and tensile strength. In this work, several different architectures of the DFT filars (i.e., wires and outer insulation) were evaluated under tensile load and a worst-case fully-reversed flex bending fatigue minimicking bends anticipated during handling and surgery. Additionally, medical-grade stainless steel wires were evaluated under the same conditions for comparison. For each specimen, the gauge length was imaged pre- and post- test followed by images of the fracture surface. By determining their mechanical properties, we can compare DFT with other standard biomedical wire materials to see the effects of wire dimensions and arrangements. This data will aid in the system design and connectivity of the COSMIIC system.

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

Effects of Complement Protein Receptor Knockout on Inflammation near Intracortical Microelectrodes

Luisa Parker, Chemical Engineering; Francine Graham, Department of Biomedical Engineering

Intracortical microelectrodes (IMEs) are used in brain machine interfaces for recording signals from individual neurons in the brain. These signals can then be used to control prostheses. Upon implantation, inflammation occurs near the IME, degrading the device and surrounding tissue. The inflammation is initiated by a variety of activated immune cells, primarily macrophages. Once macrophages recognize damage, the pattern recognition receptors on their surfaces initiate the release of cytokines that alert other cells to act in a pro-inflammatory manner. Previous studies have shown that the complement cascade is upregulated following IME implantation, indicating the need to further address this inflammatory pathway.

In this study, we targeted C5aR1, a receptor for complement protein C5a. To prevent cultured macrophages from producing C5aR1, we used lipid nanoparticles (LNPs) to deliver small interfering RNA (siRNA) to the cells. The siRNA destroys the messenger RNA (mRNA) that codes for C5aR1, preventing its expression. We analyzed cytokine secretion 24 hours after damage (HSP60)-induced macrophage activation to determine the efficacy of the C5aR1 knockout with and without the presence of anti-HSP60 antibodies.

We found that C5aR1 knockout does not have an impact on the inflammatory response without antibodies. Yet, we observed that the inflammatory response was heightened in the presence of antibodies, and C5aR1 knockout effectively accounted for this increase. This study, combined with previous work performed in the laboratory demonstrating that C5aR1 is upregulated after implantation, suggests that antibodies may enter the brain following implantation, contrary to our initial assumptions. The next steps in this study are to rerun the experiment to validate our findings and to characterize the effects of C5aR1 knockout on the anti-inflammatory response.

Faculty Project Mentor: Dr. Jeffrey Capadona, Department of Biomedical Engineering

Computational Models of TLD1433 Based Photodynamic Therapy Molecules

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Skin cancer is the most common form of cancer in the United States, with 1 out of 5 people contracting it in their lifetime[4]. Inpatient surgeries are limited in their ability to treat widespread cancer and can lead to scarring after treatment[5]. Photodynamic therapy (PDT) is a promising class of cancer treatments that avoids this. PDT drugs, called photosensitizers, are photoexcited when exposed to light, reacting with surrounding oxygen to form reactive oxygen species (ROS), which harm cells. Photosensitizers can be made to bind to cancer, allowing for targeted treatment[1].

Photosensitizers are currently limited in the cases of cancer they can be used for because they are active at blue and green wavelengths, which have low tissue penetration. Additionally, they perform worse in hypoxic environments found in cancer[1]. Photosensitizers that address these limitations are needed to fully harness the benefits of PDT. Previous studies have used computational chemistry to examine existing photosensitizers and their isomers, modeling how they behave[1][2]. Building previous work, this study uses the same computational approaches to identify novel photosensitizers.

To find photosensitizers activated by light wavelengths capable of deeper tissue penetration, derivatives templated on TLD1433—a photosensitizer in clinical trials—were synthesized and optimized using platinum and rhodium, with various tail configurations containing selenium and sulfur [3]. The photodynamic properties of the photosensitizers based on TLD1433 are currently being simulated using ORCA. It is expected that photosensitizers with heavier central atoms will activate at longer wavelengths of light, and photosensitizers with longer tails can be activated better in a hypoxic environment, creating improved photodynamic therapy for photosensitizers based on TLD1433[2].

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Faculty Project Mentor: Dr. Vijay Krishna, Department of Biomedical Engineering, Lerner Research Institute, Hope Zehr, Department of Biomedical Engineering, Lerner Research Institute

Automated Identification of Urological Events via Vesical Pressure Signal Analysis

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Background: Urinary incontinence affects over 25 million people within the United States. Traditionally, urodynamic studies (UDS) is utilized to detect how well the bladder and urethra function in order to assess urinary incontinence. UDS is an invasive procedure requiring the use of two catheters that must be inserted through the urethra causing pain and discomfort for the patient. However, new devices like the urodynamic wireless monitor (UM), which are far less invasive, allow for the assessment of lower urinary tract dysfunctions using vesical pressure data unlike UDS which measures both vesical and abdominal pressure. This reduction in data captured makes event detection difficult. Moreover, manual annotations by urologists can be laborious and error-prone. To overcome these challenges, we developed a machine learning pipeline for automatic classification of urological events.

Methods: 108 annotated UDS traces were analyzed by segmenting vesical pressure into 0.8 segments after being put through an exponential high pass filter. A 5 level discrete wavelet transform was performed on each segment using a Daubechies-2 mother wavelet. For each level, statistical features (mean, variance, standard deviation, etc.) were extracted from the coefficients. This produced a total of 55 features per segment. These features were passed into a two stage neural network with stage 1 detecting whether an event has occurred (None vs Event) and stage 2 classifying each event as either an abdominal event (ABD), a voiding contraction (VOID), or detrusor overactivity (DO).

Results: The stage 1 classifier had a 91% accuracy in determining whether an event occurred while the stage 2 classifier had a 92% accuracy in determining the correct urological event. Sensitivity and specificity for all classes were consistently above 90%, with AUC values exceeding 0.98. Currently, the model architecture is being redesigned for multi-class urological events i.e voiding and abdominal events (VOID + ABD), detrusor overactivity and abdominal events (DO + ABD), etc.

Conclusion: This ML architecture enables real time urological event classification with high accuracy. Further work should utilize this software in real time classification using data collected from the urodynamic wireless monitor in clinical trials.

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

A Cushion for Osteoarthritis: Combining Orthopedic Adjuvants with Stem Cell Therapy

Mayur Patel, Biology and Psychology

Abstract

Osteoarthritis (OA) is the most prevalent joint disorder globally, characterized by progressive degeneration of articular cartilage, inflammation, and impaired chondrocyte function. Despite its high burden on quality of life and healthcare systems, current treatments remain palliative, relying heavily on corticosteroids and hyaluronic acid (HA) injections, which offer temporary symptom relief without modifying disease progression. This project investigates a regenerative approach to OA treatment by exploring how stem cell-based therapies can enhance cartilage repair and reduce inflammation in an OA joint environment.

The primary aim is to evaluate whether human mesenchymal stem cells (hMSCs), when treated with HA, can improve chondrocyte function and secrete anti-inflammatory and regenerative factors under OA-like stress. To simulate the intra-articular stress of OA in vitro, chondrocytes are exposed to granulocyte-macrophage colony-stimulating factor (GM-CSF), a marker cytokine which is elevated in OA joints. Varying doses of HA are then used to precondition MSCs, whose secreted supernatant is collected and analyzed. The effects of untreated MSCs, HA-treated hMSCs, and standard HA treatment alone are then compared and used as treatment for GM-CSF stressed and unstressed chondrocytes. Transcriptional changes in stressed versus unstressed chondrocytes that have and haven't been treated with the hMSC treatments are measured using qPCR, while anti-inflammatory cytokine production is quantified through ELISA and stress-measuring assays.

Although results are pending, the experimental system has successfully replicated an inflamed, chondral-stressed environment using GM-CSF. Current efforts focus on determining how hMSC supernatants, especially those pre-treated with HA, can attenuate inflammation and stress responses in chondrocytes. Findings from this study could inform the development of novel adjuvant therapies aimed at modifying OA progression rather than merely alleviating symptoms. Future directions include further testing various orthopedic adjuvants in combination with hMSCs to optimize therapeutic efficacy.

Faculty Project Mentor: Dr. Tracey Bonfield, Department of Genetics and Genome Sciences, National Center of Regenerative Medicine

Addressing Nutritional Risk and Resource Gaps in Division III Collegiate Athletes: A Pilot Study of Scalable, Team-Specific Nutrition Support Strategies

Lindsey Petersen, Nutritional Biochemistry and Metabolism

Despite growing awareness of the significance of nutrition in athletic performance, NCAA Division III collegiate athletes often lack access to the resources, education, and institutional support available to their Division I counterparts. Underlying challenges include limited nutrition knowledge among student-athletes, insufficient nutrition-related training among coaches, insufficient nutrition staff, and a lack of dedicated funding to support performance nutrition efforts. This study utilized preliminary data from a pilot study conducted with the Case Western Reserve University (CWRU) women's soccer team, surveys, and informal discussions with coaching staff across several CWRU athletic teams to identify the extent of the resource gaps and design potential avenues for improvement. One-third of athletes from the women's soccer pilot study were identified as being at high risk for low energy availability before the season began (LEAF-Q score ≥ 8; $n = 7$). These same athletes showed the greatest significant improvements in grip strength ($P = 0.004$ Pre- vs Post-Season) and skeletal muscle increase ($P = 0.04$ Pre- vs Post-Season) after receiving modest nutrition education and support. Based on these data and subsequent athlete tracking, the proximity of ready to eat food and beverages for athletes was identified as an opportunity for improvement. As such, a proof-of-concept mobile fueling station was developed specifically for the soccer team in order to provide individualized nutrition support to the players. This station included carefully curated, budget friendly fueling options tailored to the specific training demands, preferences, and dietary restrictions. By utilizing athlete data collected over the course of a competitive season, this study demonstrates the ability to address existing challenges in access to nutrition education and resources by creating team-specific, scalable, and low-cost models to improve nutrition support for collegiate athletes. While preliminary, these findings may inform future institutional strategies for broader implementation across collegiate athletics.

Faculty Project Mentor: Kristyen Tomcik, Department of Nutrition; Katie Nabors, Department of Nutrition; Lindsay Malone, Department of Nutrition; Hope Barkoukis, Department of Nutrition; Jacob Mey, Pennington Biomedical Research Center; Clarence Armstrong III, Case Western Reserve University School of Medicine Student

Spatial Epigenomic Study of the Mouse Brain Following Traumatic Brain Injury-Identification of Differentially Regulated Genes and Abnormal Biological Processes

Ridhima Prasad, Department of Neuroscience

Traumatic Brain Injury (TBI) causes long-term neurological impairments and increases the risk of neurodegenerative disorders, such as Alzheimer's and Parkinson's diseases. There are no reliable biomarkers for early diagnosis or treatment of TBI, limiting timely intervention and recovery. Newly developed spatial-omics technologies integrate spatial and molecular information, offering powerful insights for biomarker discovery. Recent spatial-transcriptomic research has revealed region-specific molecular changes following TBI, highlighting novel biomarkers and pathways that may inform future treatments. While spatial transcriptomics maps region-specific gene expression, spatial epigenomics reveals the upstream chromatin accessibility that regulates it. Using a multimodal TBI (mmTBI) mouse model, we applied spatial epigenomic profiling to examine how gene activity varies across brain regions and cell types after injury.

Spatial ATAC-seq was performed via the AtlasXomics platform on TBI and sham mouse brain sections. SnapATAC2 was used for clustering and ArchR for gene score and differential accessibility analysis. Gene Ontology (GO) analysis was performed using Enrichr.

GO analysis of genes upregulated in the TBI 24-hour and TBI 3-week Vehicle groups compared to sham groups revealed impaired axonogenesis and neurogenesis. Downregulated genes for this comparison were involved in mitochondrial function and rRNA processing. Comparing the TBI 3-week Vehicle vs. Sham 3-week Vehicle and TBI 3-week Vehicle vs. TBI 3-week P7C3-A20-treated groups, shared upregulated genes in the TBI 3-week group were associated with extracellular exosome biogenesis and glucocorticoid biosynthesis. Downregulated genes were associated with monoacylglycerol biosynthesis and the fatty acyl-CoA metabolism.

Our data analysis is ongoing. Future directions include motif analysis and validation of marker genes using biochemical methods. This approach may uncover biomarkers for TBI and inform translational strategies for diagnosis and treatment.

Faculty Project Mentor: Andrew Pieper, Department of Psychiatry, CWRU

Ketotifen as a novel strategy to reduce mortality from IPF

Ritisha Rashmil, Systems Biology B.S., Filip Goshevski, Amar B. Desai

Idiopathic pulmonary fibrosis (IPF) is a severe interstitial lung disease with a median survival rate of only 3-5 years. The underlying mechanism of the disease is unknown, but it is thought to be caused by a dysregulated repair mechanism. This causes fibroblast proliferation and differentiation, and increased collagen deposition in the lungs. The deposition causes thickening of the interstitial layer of the lungs, hindering gas exchange and making it harder for the lungs to expand.

Nintedanib and pirfenidone are anti-fibrotic drugs that are used to slow progression, but they are expensive and come with a host of side effects, including gastrointestinal problems and skin reactions. With incidence of the disease rising, an unknown cause, and no known cure, finding cheaper and more cost-effective methods to reduce fibrotic deposition is essential, and would help make treatment more accessible to the public.

Mast cells are immune cells that originate from hematopoietic stem cells. These cells play a role in allergic reaction and defense against pathogens, releasing histamine, cytokines, and chemokines at sites of injury and signs of disease. Within IPF, mast cell numbers were shown to have increased 10-fold in the interstitium, and histamine levels were increased in bronchoalveolar lavage-fluid.

Since mast cells are the main producers of histamine within the body, our lab aims to expand what is known about the role of mast cells within IPF with the use of antihistamines. We hypothesize that ketotifen, an FDA-approved H1R antagonist and mast cell stabilizer, can reduce the fibrotic deposition that results from the disease, thus reducing the mortality from the disease. Results have shown ketotifen reduces mortality and prevents weight loss from the disease to a certain extent. Future directions include analyzing collagen deposition in the lungs, running PCR, and two studies looking at serum histamine levels during disease.

Faculty Project Mentor: Amar B. Desai, Department of Pathology, CWRU School of Medicine

Reducing Solar Panel Damage During Delivery

Conisha Ratcliffe, Department of Material Science and Engineering; **Fathia Ramoni,** Albion College

Abstract

Solar panels are often damaged during shipping, which can be expensive and wasteful. This experiment will be designed to find the best way to package solar panels so they don't break while being transported. We will test several different types of packaging, including bubble wrap, foam, cardboard layers, and combinations of all three. Each package will be dropped and shaken to mimic real shipping conditions, and we will record how much damage each panel has afterward. The goal is to see which packaging will protect the panels the best without making the box too heavy or hard to ship. We expect that using multiple layers, especially foam and strong cardboard, will help protect the panels the most. This project could help companies ship solar panels more safely and reduce how many are thrown away. It could also support clean energy by making solar panels easier to deliver in good condition.

Faculty Project Mentor: Laura Bruckman, Department of Materials Science and Engineering

Characterizing the Molecular Consequences of Human Tau Acetylation at Every Lysine Modified in AD Patients

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Tau is a microtubule-associated protein essential to the proper structure and function of neurons. Multiple neurodegenerative diseases, such as Alzheimer's Disease (AD), are associated with tau pathology, the aggregation of misfolded tau that disrupts neuronal function. Modification of tau, such as phosphorylation, acetylation, and ubiquitination, has been linked to tau pathology. While phosphorylation of tau has been studied for therapeutic purposes, there is little research on the effects of acetylation on tau pathology and brain health. A previous study identified 19 lysines on the tau protein in post-mortem AD brains that exhibit a higher frequency of acetylation as compared to control, but it is underinvestigated how these modifications affect tau pathology. This study aims to identify the effects of acetylation on microtubule binding, tau stability, and neuronal function at each of these sites. The literature shows that tau with a lysine-to-glutamine (K→Q) mutation can mimic acetylated tau (ac-tau). Escherichia coli (E. coli) were transformed with DNA plasmids for each ac-tau mimic and grown on Luria Broth agar plates. Ampicillin resistance was included in the plasmids for artificial selection of transformed bacteria. Individual colonies were picked, bacterial cultures were expanded, glycerol stocks were created, and plasmid DNA was isolated for verification. Once verified, the plasmids will be used to transfect HT22 cells, which are derived from mouse hippocampal neuronal H4 cells. Expression of the ac-tau mimics will be analyzed at 24, 48, and 72 hours post-transfection and detected using Western blot analysis. Experiments are being conducted to identify the optimal conditions for transfection. In the future, possible assays to analyze the effects of acetylation include Thioflavin T aggregation to assess fibrillization propensity, paclitaxel-induced microtubule stabilization to evaluate ac-tau–microtubule interaction, and RT-QuIC (Real-Time Quaking-Induced Conversion) to test seeding and prion-like behavior of ac-tau.

Faculty Project Mentor: Andrew Pieper, MD, PhD; Department of Psychiatry CWRU School of Medicine

Geospatial Analysis of Regional and Commodity-Based Patterns in U.S. Farm Income

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This project analyzes U.S. farm income data to uncover key trends in agricultural revenue across various states and commodities. By cleaning and visualizing the data, the project highlights which crops and regions generate the most income and identifies any anomalies in reported earnings. The goal is to gain a clearer understanding of the financial landscape of American agriculture. The data reveals that farm income across the U.S. is heavily influenced by both geography and the types of crops grown. In the Midwest, states like Iowa, Illinois, and Nebraska generate significant income from staple crops such as corn and soybeans, which are widely grown and supported by strong export demand and domestic processing. These states consistently appear at the top of the income rankings, demonstrating the economic strength of large-scale row crop agriculture.Southern states such as Texas, Georgia, and North Carolina show notable income from cotton, poultry, and cattle, reflecting their historical ties to livestock and fiber production. These regions often show a more diversified income profile, combining crop and animal agriculture. The data also highlights outlier states whose anomalous prices may be caused by specific local conditions, such as a major drought, an unusually large operation, or fluctuations in commodity prices. Identifying these outliers helps reveal where economic performance differs sharply from the national trend and can signal areas needing further investigation or support. Overall, the dataset shows clear patterns of regional specialization and economic disparity in American farming. Some regions rely on large-scale monoculture operations, while others depend on more diverse or niche agricultural products. These insights can support better decision-making in areas such as farm policy, resource allocation, and business investment. Understanding where and how income is generated allows stakeholders to adapt more effectively to changes in markets, climate, and technology, ensuring a more resilient and productive agricultural economy.

Faculty Project Mentor: Erika Barcelos, Department of Material Science

Automated Point-of-Care Bladder Pressure and Volume Measurement Device for Urodynamic Monitoring

Melis Sahin, Biomedical and Electrical Engineering

Neurogenic bladder is a condition that results from most spinal cord injuries (SCI), multiple sclerosis (MS), spina bifida, and more. It can lead to recurrent high bladder pressures, which put patients at an increased risk for severe urinary complications such as kidney damage and autonomic dysreflexia. Treatment often requires catheterization to empty the bladder, and regular monitoring through urodynamic studies (UDS) is recommended. Traditional UDS involves invasive filling techniques, expensive clinical equipment, and can be logistically challenging. The SafeCath system offers an automated point-of-care solution for screening bladder pressures above 40 cm H2O, which is a clinical marker for high risk, by analyzing drainage dynamics during catheter use. The system uses a locking valve to isolate bladder pressure, a high flow sensor to measure pressure, a mounted strain gauge and disposable urine drainage bag to collect volume, and a microcontroller to automate data collection. The device and sensors were calibrated and validated via Bland-Altman analysis, and demonstrated the expected linear relationship between pressure and volume during drainage from a water column. Further work has been done to improve the reliability and consistency of device performance, with features added for troubleshooting, sanitization, simple calibration, and easier user interface for use in an upcoming clinical study. In addition, a bench system, or a "phantom bladder," has been developed to test the system's performance in draining versus filling. The future clinical study is to compare SafeCath performance against UDS, to validate that the necessary 40 cm H2O bladder pressure marker can be representatively determined from the drainage data.

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Image Segmentation with Image

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Aerosol Jet Printing (AJP) is an additive manufacturing technique that commonly employs silver nanoparticle or precursor inks to create conductive prints. Study of the ink through checking for particle agglomeration is important for predicting if there will be clogs during the printing process. Image segmentation is one method for characterizing ink quality for AJP. In particular, it can provide insights into the effects of aging, or alternatively, how separate inks differ. In this work, ImageJ and its Trainable WEKA Segmentation plugin were used to analyze images of silver nanoparticle and precursor inks taken on a transmission-mode scanning electron microscope (T/SEM) to compare particle sizes. One of the silver precursor inks was sampled and imaged a second time six weeks after its initial imaging to monitor for changes. For the analysis, the desired T/SEM image was opened on ImageJ, where the brightness/contrast was adjusted before the Trainable WEKA Segmentation plugin was opened. This plugin was trained to identify what was and was not a particle, and after using filters to smooth, format, and separate the particles, produced a multi-colored overlay image that differentiated and numbered them. The co-generated numerical data detailing particle count and characteristics was used alongside those collected from other images of the same ink to formulate a larger picture of the ink's characteristics. After the completion of these steps for the three inks, they were compared for differences in particle size, and the effects of aging were determined for the one which underwent two imaging sessions. Results showed the average feret sizes of the silver nanoparticle ink to be larger than that of its precursor ink counterparts. Changes observed in the precursor ink over the two imaging sessions were minimal, implying no significant concerns for clogs due to age-related particle agglomeration.

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

Data-Driven Kinematics Error Analysis Framework for Advanced Manufacturing: A Direct Ink Write Case Study

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Direct Ink Writing (DIW) is an extrusion-based advanced manufacturing (AM) technique used to fabricate complex 3D structures. Its versatility and compatibility with a wide range of ink materials, including polymers, metals, and ceramics, make it suitable for numerous applications. However, like its other AM counterparts, DIW has yet to be adopted for large-scale production due to persistent printing process errors. One key limitation is kinematic errors—deviations between the intended and actual movements. These errors compromise the desired properties of printed parts as well as the repeatability of the printing process in fabricating high-quality parts. Herein, we study the kinematic error behavior of the DIW printing process and ultimately develop a transferable, data-driven workflow applicable to other AM kinematic processes.

In this study, we leverage various data-driven methods to quantify kinematic errors and uncover underlying patterns. We established correlations between data-centric observations and domain knowledge by integrating density-based spatial clustering (DBSCAN) with temporal (phase) clustering on the time series data. We used dynamic time warping (DTW) to quantify error variance across different time series. By applying the Fourier Transform to convert time series data into the frequency domain, we identified consistent error patterns across position, velocity, and acceleration. The frequency and amplitude of these patterns correlate with print process parameters, such as velocity and acceleration. By developing this data-driven error analysis framework with DIW as a case study, we aim to provide insights into kinematic error behavior in AM processes.

Faculty Project Mentor: Laura Bruckman, Department of Materials Science and Engineering

The role of hydrogen peroxide and L-lactate in streptococcal fitness in coculture with Aggregatibacter actinomycetemcomitans

Hana Sato, Biochemistry and Political Science; Grace Heine, Department of Molecular Biology and Microbiology; Dr. Gina Lewin, Center for Global Health and Diseases and Department of Pathology.

Diverse bacteria interact with each other in the human oral microbiome, impacting oral health and disease. Streptococcus, the most abundant and diverse genus in the oral cavity, engages in metabolite-mediated interactions with other microbes, such as Aggregatibacter actinomycetemcomitans (Aa), which increases Aa's virulence. In addition, streptococcal fitness (growth) generally increases when cocultured with Aa, but the extent of this effect varies across diverse streptococci, and we do not know the mechanisms driving the changes in streptococcal fitness. We hypothesized that the accumulation of streptococcal metabolites decreases its own fitness in monoculture—hydrogen peroxide (H2O2) through its antimicrobial properties and Llactate via acidification of the environment—but that coculture with Aa mitigates these effects through production of catalase and consumption of lactic acid. To test this hypothesis, we modified our biofilm culture environment to experimentally alter the impact of H2O2 and pH on diverse streptococci in mono- and co-culture with Aa. First, to alter H2O2 levels, we supplemented the chemically defined media (CDM) with catalase, and we assessed the change in fitness by quantifying colony forming units after 23h growth. Of the six streptococci tested, we found that four strains exhibited increased fitness in catalase-supplemented CDM compared to standard CDM, and two strains (S. intermedius and S. mutans) showed no change, likely due to the absence of the spxB gene responsible for H2O2 production. Second, we are currently investigating the role of L-lactate on streptococci by removal of the buffering agent from CDM. Thus far, our results support our hypothesis that H2O2 impacts streptococcal fitness but that the impact of this metabolite varies across streptococcal strains. This project is significant in understanding specific interaction mechanisms between diverse streptococci and Aa, which helps advance our knowledge of periodontitis.

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

Wind Speed Prediction Using Machine Learning Methods Based on Atmospheric Stability and Terrain Type

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As wind energy production increases and wind turbine hub heights continue to rise, accurately extrapolating wind speed to higher altitudes becomes critical for reliably forecasting wind energy production. The power law model has conventionally been used for extrapolating mean wind speed measured at lower levels to the height that is relevant to turbine operation. This project aims to explore machine learning (ML) techniques to capture the dynamics of wind behavior and test ML models for wind speed extrapolation by validation with the established power law model. One year of wind data at multiple levels was collected from a 106-meter meteorological tower in Cedar Rapids, Iowa. Data pre-processing includes outlier removal, identification of failed sensor readings, and data imputation using singular value decomposition (SVD). The surrounding terrain was classified into complex and open types based on surface features and dominant wind directions, and the atmospheric thermal stability was characterized by the bulk Richardson number (Rib). We found that the wind shear exponent varies in the range of 0.12 to 0.40 by atmospheric stability and terrain type, with stable conditions and complex terrain having a higher wind shear exponent on average. Both SVD and Shallow Decoder Network (SDN) methods were used to predict wind speeds at higher altitudes and evaluated with recorded wind speeds. The ongoing work is to calculate wind shear exponents with the wind profiles including predicted wind speed by SVD and SDN and compare their accuracy to the original power law model.

Faculty Project Mentor: Dr. Wei Zhang, Department of Civil, Environmental and Construction Engineering, Texas Tech University; Dr. Longhua Zhao, Department of Mathematics, Applied Mathematics, and Statistics; Dr. Corey Markfort, IIHR, University of Iowa.

Optimizing Process Parameters of Aerosol Jet Printed Circuits

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Aerosol jet printing (AJP) is a direct ink writing method in which conductive ink is aerosolized and deposited onto a substrate to fabricate flexible circuits. Various process parameters, such as gas flows, atomizer voltage, stage speed, and platen temperature, can affect the quality of the print. Bayesian optimization and Taguchi methods are approaches to optimizing process parameters. However, published literature lacks studies determining which of these designs of experiments are most applicable for AJP. In this work, a Bayesian-batch approach used six iterations with five parameters sets across each iteration were aerosol jet printed on polyimide film with a diluted silver nanoparticle ink and thermally cured. Each print was imaged with an optical microscope under identical lighting conditions. Those images were analyzed through a custom MATLAB script which uses a color mask to separate the print and background, and then performs calculations of rectangularity, line edge roughness, average trace width, overspray density, and average overspray distance. Measurements from the MATLAB script were standardized, weighted based on perceived importance to print quality, and compared using a Visual Conformity Grade calculation (VCG). The VCG determined print conformity to the intended design with a higher score indicating greater print quality. Electrical resistance was measured using a four-point probe method, and the conductance of each circuit was calculated. VCG, conductance, and trace width were compared to determine the optimal parameter set from the study. The Bayesian optimization results were compared to a previously completed Taguchi orthogonal array experiment for the same ink and substate, resulting in different optimal process parameter sets that provided similar VCG and conductance. While Bayesian optimization resulted in numerous viable solutions, the Taguchi orthogonal array produced similar results in a more time and material efficient manner.

Faculty Project Mentor: Dr. Janet L. Gbur, Material Science and Engineering

Unequal Burdens: Climate Risk and Chronic Disease in Black vs. White Communities

Zakarias Shishehbor, Data Science; Santosh Kumar Sirasapalli, Dr Zhuo Chen, Dr Sanjay Rajagopalan, Cardiovascular Research Institute

Climate change is an emerging driver of chronic disease, yet its health impacts are shaped by longstanding social and racial inequities, disproportionately burdening historically marginalized communities. Black communities in the United States, in particular, face elevated exposure to climate-related stressors—such as extreme heat, flooding, air pollution, and lack of access to green space—due to a legacy of residential segregation, disinvestment, and environmental injustice. These exposures can contribute to increased risks for chronic diseases, including coronary heart disease (CHD), chronic kidney disease (CKD), and stroke. This cross-sectional study examines and compares the relationship between climate vulnerability and the prevalence of chronic diseases across U.S. census tracts classified as predominantly Black versus predominantly White. Climate vulnerability indices will be constructed using publicly available data on environmental exposures and modeled climate risks. Health outcome data will be drawn from CDC PLACES, and census tract racial composition will be determined using U.S. Census data. Multivariable linear regression models will be used to assess the association between climate vulnerability and disease prevalence, adjusting for socioeconomic and demographic covariates. Interaction terms (Race × Climate Risk) will test whether climate-related health impacts vary by racial composition. Subgroup analyses will further explore disease burden patterns within each racial group. We anticipate that census tracts with greater climate vulnerability will exhibit higher prevalence of chronic disease overall, but that predominantly Black tracts will experience disproportionately greater burdens even at similar levels of climate risk. These disparities are expected to persist after adjusting for other social determinants, suggesting that structural racism may amplify climate-related health harms. Findings will inform equitable climate adaptation strategies, emphasizing the need for targeted investments in healthcare access, environmental infrastructure, and resilience planning in historically underserved communities.

Faculty Project Mentor: Santosh Kumar Sirasapalli, Dr Zhuo Chen, Dr Sanjay Rajagopalan, Cardiovascular Research Institute, CWRU, University Hospitals

Smart Surface Polymer Systems for Cell Capture Microfluidics

Alexey Shorin, Biomedical Engineering

Thermoresponsive polymer brushes coatings allow for selective and reversible cell capture in microfluidic systems. This project targets the synthesis of biocompatible, temperature-sensitive polymer brushes onto thin glass substrates using surface-initiated activator regenerated by electron transfer atom transfer radical polymerization (SI-ARGET ATRP). Due to the physical properties of these brushes they are able to reversibly change confirmation around their lower critical solution temperature (LCST), transitioning from an extended hydrophilic form to a folded hydrophobic structure.

By adjusting the polymer composition, functional groups, and cell-specific ligands, we aim to make a smart surface capable of capturing target cells at physiological temperatures and releasing them at lower temperatures without damaging the cells. The project involves three major steps: (1) preparing glass surfaces using plasma or UV-ozone treatment, (2) attaching initiators to the surface, and (3) growing the polymer brushes via SI-ARGET ATRP. This work has potential applications in diagnostics and therapeutics by allowing an easy, non-invasive capture of target cell populations from complex biological fluids such as blood.

Faculty Project Mentor: Metin Karayilan

The Geography of Inequity: Redlining's Imprint on Cleveland's Health Outcomes

Oluwatoni Shoyinka, Epidemiology, BA

Abstract:
The practice of redlining was introduced in the 1930s as a way for the Home Owners' Loan Corporation (HOLC) to prevent foreclosures on houses during the Great Depression. However, discriminatory appraisal parameters were used to draw lines around neighborhoods, predetermining whether or not people living within them would be approved for mortgages. Neighborhoods outlined in red were hazardous and ruled ineligible for loans.
Although redlining was outlawed by the Fair Housing Act of 1968, its legacy continues to shape life in American cities, including access to healthcare. Despite close proximity to high-quality medical systems like Cleveland Clinic and University Hospitals, Cleveland residents in historically redlined neighborhoods often face barriers to receiving care. This includes structural barriers, such as inadequate transportation infrastructure and housing instability, that prevent them from receiving a range of services (e.g., timely or preventive care). The purpose of this capstone is to examine: how does the legacy of redlining influence health disparities and access to care in Cleveland?
Building on recent scholarship in urban health geography and structural racism in public health, the project combines historical and contemporary data to spatially visualize the relationship between access to care and historic discrimination. Methods include geographic and data analysis from: (1) historical redlining maps of Cuyahoga County, (2) CDC PLACES data visualizing health outcomes like general health and physical distress, (3) transportation access, (4) housing insecurity, and (5) findings from the 2025 Cleveland Health Survey. Health outcomes are compared across historically redlined and non-redlined census tracts, layered with the above data sources.
Results from this study suggest that neighborhoods with a history of disinvestment experience limited access to care, resulting in unmet basic needs and poorer general health outcomes—demonstrating the need for systems that assist in navigation of structural barriers or the removal of barriers entirely.

Faculty Project Mentor: Dr. Catherine Stein, Department of Population and Quantitative Health Sciences, CWRU

Repurposing water treatment byproducts as a sustainable alternative in concrete production

Lindsay Siu, Applied Math, **Kennedy Bright**, Physics

Concrete is made of 3 main ingredients: cement, aggregate (usually sand and/or gravel), and water. Since concrete is a vital building material, high amounts of these ingredients are needed. However these ingredients may be substituted while still creating a concrete of similar quality. In this project, concrete made with ash byproducts of water treatment plants will be tested as a substitute for cement and aggregate. If the ashes prove a viable alternative, then the resulting concrete will provide a sustainable option that repurposes a material that would otherwise be unused. In order to test if the ashes are able to act as a substitute, 2 types of concrete will be casted and tested against a control concrete. One batch will have 10% of cement replaced with ash (batch A) and the other will have 10% of sand replaced with ash (batch B). The control concrete will have no ashes added (batch C). All concrete batches will be cast into 2 inch cubes, and will be tested after curing for 14 and 28 days. To test the maximum compressive strength of each concrete type, the specimens will be crushed with a hydraulic press and the peak load before failure will be recorded.

Currently, all specimens have been tested at 14 and 28 days, and the batch strengths from weakest to strongest were A C B. Because of these results, additional batch B and C concrete will be mixed for cylindrical specimens. These specimens are currently curing, however, during demolding, it appeared that the specimens were improperly cast and may require additional samples to be made upon observation by Dr. Carloni. The compressive strength of the original cylinder specimens will be tested once they have cured for 28 days.

Faculty Project Mentor: Christian Carloni, CWRU Department of Civil Engineering

Performance Prediction of Convolutional Neural Networks on Heterogeneous Platforms

Wiam Skakri, Computer Science

Convolutional Neural Networks (CNNs) are at the core of many modern AI applications, from image recognition to autonomous systems. However, their deployment efficiency is highly influenced by factors such as layer dimensionality, the choice of convolution algorithm, and the hardware platform. This research addresses the increasing complexity of CNN deployment by developing predictive models that estimate execution time across heterogeneous computing platforms, specifically CPUs and GPUs. We generated a dataset using four distinct convolution algorithms applied to 100 commonly used layer dimensions on both platforms, collecting execution time as the primary performance metric. These data were used to train a Multilayer Perceptron Regression model and a Random Forest Regression model using cuML, both capable of predicting CNN performance for previously unseen configurations. Our approach leverages tools such as PyTorch, Scikit-learn, and cuML, and incorporates hardware-specific parameters to improve predictive accuracy. The resulting models provide a practical means for selecting optimal CNN configurations, reducing computational overhead and environmental impact. More broadly, this research enhances accessibility to AI, supports sustainable computing practices, and enables innovation in performance-critical fields such as healthcare and autonomous systems.

Faculty Project Mentor: Dr. Sanmukh Kuppannagari, Department of Computer and Data Sciences

Nicotinamide Adenine Dinucleotide Precursors delay Pancreatic cancer progression

Desiree Smith, Faith Nakazzi, Dr. Jordan Winter

Background: Pancreatic ductal adenocarcinoma (PDAC) is one of the most aggressive malignancies, with a poor prognosis due to its late-stage diagnosis and rapid progression. Cellular stress, mitochondrial dysfunction, accumulation of reactive oxygen, and genomic instability contribute to the initiation and progression of PDAC. Nicotinamide adenine dinucleotide (NAD^+) plays a critical role in maintaining redox balance, facilitating DNA repair, and regulating cellular metabolism. Because NAD^+ precursors like Nicotinamide mononucleotide (NMN) and nicotinamide (NAM) are protective to cells, they show promise in alleviating aging-related metabolic, cardiac, and neurological dysfunction; however, their potential as cancer preventative alternatives, especially for aggressive cancers like PDAC, has not been explored. Aim: To determine whether NAD^+ precursor supplementation delays PDAC progression in LSL-KRASG12D; Pdx-cre mice. This is an autochthonous mouse model that develops PDAC between 8 and 12 months and recapitulates PDAC progression in humans. Approach: LSL-KRASG12D; Pdx-Cre mice were divided into two groups. One group was treated with nicotinamide (NAM) at 400 mg/kg in drinking water starting at 5 weeks of age until the end of the experiment. The control group received only the vehicle. Age-matched P48-Cre mice served as negative controls. At 6 months, mice were sacrificed, and pancreatic tissues were collected. Hematoxylin and eosin (H&E) staining was used to assess the pancreatic intraepithelial neoplasia (PanIN) lesion grade. Immunohistochemistry and western blotting were performed to evaluate expression of PanIN progression markers; cytokeratin (CK)-19 (ductal cell marker), Amylase (acinar cell marker), and PCNA (proliferation marker), Protein was extracted from pancreatic tissue and western blot analysis performed for gamma-H2AX (DNA damage marker), and PAR (DNA repair marker). Results: NAM treatment slowed the progression of precancerous PanIN lesions in mice, as evidenced by lower-grade PanIN grades, reduced expression of cytokeratin 19 (CK-19), and PCNA in NAM-treated mice compared to controls. NAM treatment also increased PARylation and reduced DNA damage.. Conclusions: NAD^+ precursor supplementation delays PDAC progression in LSL-KRASG12D; Pdx-Cre by enhancing DNA repair.

Faculty Project Mentor: Faith Nakazzi, Case Comprehensive Cancer Center

Systematic Functional Characterization of SAVI-Associated STING Variants

Anish Sriram, Biochemistry; Lane Pierson, Department of Molecular Biology and Microbiology; Kenneth Matreyek, Department of Pathology,

Inborn errors of immunity are mutations to key proteins involved in host-defense resulting in dysregulation and immune mediated pathogenesis. One such example involves dysregulation of the innate immune protein STING. Gain-of-function mutations in STING cause the autoinflammatory disease known as STING-Associated Vasculopathy with onset in Infancy (SAVI). SAVI-associated mutations cause constitutive activation of STING and its downstream pathways, resulting in chronic inflammation, interstitial lung disease, fevers, among other symptoms. Current treatment options mainly targeting interferon (IFN) signaling are limited in both availability and effectiveness, suggesting that other STING functions may be involved in disease progression. To date, there have been 22 confirmed pathogenic STING variants that cause SAVI, as well as hundreds of variants of uncertain significance (VUS). While some variants have been studied in both a clinical and laboratory setting, many remain largely uncharacterized. In addition, those that have been studied are usually only assessed for one of STING's functions, Type I IFN production, providing an incomplete picture of the mechanism of disease of these variants. In this pilot study, we functionally characterized four known SAVI variants for their IRF3 and NF-κB transcriptional activity, autophagosome formation, and cell death induction. We found that all four variants upregulate both IRF3 and NF-κB activity, as well as autophagy at basal levels, with R284S unable to be induced further through any of these pathways. Interestingly, we also found that R284S shows minimal induced cell death, while the other three tested variants showed similar levels of death to wild-type human STING. By systematically characterizing these variants, we aim to better understand the molecular pathways influenced by these mutations, and guide the clinical assessment and treatment development for SAVI patients.

Faculty Project Mentor: Anna Bruchez, Department of Pathology

Downregulation of Prostate Tumor Angiogenesis and Upregulation of Tumor Immunosurveillance by Inhibitors of the Histone Demethylase KDM5B

Joseph Stinson, Department of Neuroscience

Prostate cancer is a common, but typically slow-growing malignancy in older men. While it is often curable when detected early, the mechanisms driving continued tumor growth remain poorly understood. One protein of interest is hexamethylene bis-acetamide inducible 1 (HEXIM1), a known tumor suppressor that has been found to be significantly downregulated in prostate cancer tissues and models. This observation has led to the hypothesis that increasing HEXIM1 levels may halt or even reverse tumor progression. One strategy to achieve this involves inhibiting KDM5B, a histone demethylase that suppresses HEXIM1 expression by limiting transcription of its gene. Inhibition of KDM5B could, therefore, restore HEXIM1 levels and potentially suppress tumor growth.

A key area of ongoing research is understanding how increased HEXIM1 may affect tumor angiogenesis. Angiogenesis is the formation of new blood vessels that supply tumors with essential oxygen and nutrients. Tumors typically promote angiogenesis by secreting factors such as vascular endothelial growth factor (VEGF). By increasing HEXIM1 through KDM5B inhibition, we aim to determine whether this pathway also disrupts angiogenesis, thereby cutting off the tumor's blood supply and stalling its growth. This approach could offer a promising therapeutic avenue for prostate cancer treatment.

HEXIM1 and KDM5B inhibitors may contribute to the regression of prostate tumors through alternative mechanisms. This study also investigated their potential roles in activating the innate immune system by measuring levels of type I interferon (IFN-β) and its transcriptional regulator, interferon regulatory factor – 7 (IRF7). Elevated levels of IFN-β and IRF7 suggest that these inhibitors may help convert immunologically "cold" tumors into "hot" tumors. This conversion is an important shift associated with improved prognosis due to enhanced T cell activation.

Faculty Project Mentor: Monica Montano Department of Pharmacology

Diffusion of Biomacromolecules in Solution and Porous Hydrogels

Sneha Suresh (Biomedical Engineering), Mario Tsai, Deborah Adedeji, Svetlana Morozova

Abstract
In the extracellular matrix of articular joints, collagen type II is self-assembled in a distinct hierarchical way to provide strength to the tissues. To recreate anisotropic and aligned self-assembly from the bottom-up in engineered therapeutic cartilage replacements, we have investigated the fibril formation in directionally structured pores in polyacrylamide networks. First, the pores are synthesized by polymerizing the network around ordered disodium cromoglycate liquid crystal phases. Then, we study the diffusion and assembly of collagen type II in the networks based on the structure of the pores. Differential dynamic microscopy (DDM) is used to measure dynamics. Diffusion coefficients are found to change depending on the size and shape of the pores in the anisotropic gel. Understanding the patterns of diffusion in hierarchal structures is essential since the mechanisms governing collagen organization in the extracellular matrix remain unclear and this approach could have applications in biomaterials and tissue engineering.

Faculty Project Mentor: Svetlana Morozova, Department of Macromolecular Science and Engineering, Case Western Reserve University

Rotenone induces NLRP3 inflammasome activation in microglia, contributing to neuroinflammation in Parkinson's disease

Shreya Swamy, Department of Cognitive Science, CWRU; Kamya Lapsley, Department of Neurosciences, Cleveland Clinic Lerner Research Institute

Abstract:
Parkinson's disease (PD) is a neurodegenerative disorder characterized by dopaminergic neuron loss and progressive aggregation of the protein α-synuclein. Neuroinflammation, driven by microglial (brain-resident immune cells), plays a significant role in PD pathogenesis (1). The Nod-like-receptor protein-3 (NLRP3) inflammasome is a multiprotein complex consisting of NLRP3, the adaptor protein, Apoptosis-associated speck-like protein containing a Caspase-recruitment domain (ASC), and the effector protein, Caspase-1. When activated in response to cellular stressors, the NLRP3 inflammasome is a key mediator of microglial-induced neuroinflammation which results in the cleavage and secretion of the pro-inflammatory cytokine interleukin-1β (pro-IL-1β) (2). Mitochondrial dysfunction is a key feature of PD, consistently appearing in postmortem brain samples and contributing to neuroinflammation (1). Mitochondrial dysfunction has largely been investigated in dying dopaminergic neurons. Our work begins to investigate the role of rotenone, a naturally occurring pesticide and mitochondrial complex I inhibitor, as an activator of the microglial NLRP3 inflammasome. We show that microglial NLRP3 responses contribute to α-synuclein aggregation in PD. Western blot analysis revealed that rotenone facilitates inflammasome activation in LPS-primed microglia, as evidenced by increased caspase-1 cleavage. Rotenone induced the release of ASC, the inflammasome adaptor protein, in a time-dependent manner, further supporting inflammasome assembly and activity. This release of ASC may facilitate α-synuclein aggregation, making it a potential model for studying the link between inflammation and α-synuclein pathology in PD. NLRP3 Inflammasome activation is a two-step process, requiring two steps: Step-1/priming entails the induction of NLRP3 and Step-2 involves assembly of the Inflammasome into a functional complex. Quantitative PCR (qPCR) analysis revealed that while rotenone is an effective activator of the NLRP3 Inflammasome, it cannot prime the NLRP3 inflammasome. Overall, our findings suggest that rotenone-mediated inflammasome activation may exacerbate neuroinflammation, contributing to PD symptoms.

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Faculty Project Mentor: Dr. Nikhil Panicker, Department of Neurosciences, Cleveland Clinic Lerner Research Institute

Design of a Damage-Sensing, Self-Healing Electronic Skin Based on Dynamic Polymer Composites

Trevor Swan, Department of Chemical Engineering, **Kianna Verdugo**, Department of Biomedical Engineering, Roberto Obregon, Department of Macromolecular Science and Engineering, Jiahao Huang, Department of Macromolecular Science and Engineering, Samuel Root, Department of Macromolecular Science and Engineering, CWRU

Damage detection capabilities in soft materials have far-reaching implications such as creating anatomically realistic simulation mannequins for training surgeons, both human and robotic. Several strategies have been introduced with non-self-healing polymers, including thermoset elastomeric silicone composites containing microscale droplets of liquid metal, which trigger conductive pathway formation1. However, such devices cannot repair from damage limiting them to single use applications. Concurrently, over the past two decades, there have been rapid advances in the molecular and material design of dynamic polymer composites with useful properties and processing characteristics. Such materials have only recently been applied toward damage sensing systems, including sophisticated multilayer devices capable of sensing damage in three dimensions with millimeter resolution2. This approach employs alternating layers of composites with copolymer matrices of bisurea-based hydrogen bonding units linked by immiscible poly (dimethyl siloxane) and polypropylene glycol backbones3. These naturally electrically insulative polymers are loaded with embedded percolated networks of dielectric $SrTiO_3$, resistive carbon black, and conductive Ag micro-flake fillers and are fine-tuned to achieve the desired balance between mechanical and electrical functionality. Such adhesive yet immiscible self-healing composites achieve a skin-like texture suitable for surgical applications and are capable of autonomously realigning from damage in multilayered systems. Through synthetic modification of the base polymer materials, composite formulation including loading of functional materials, characterization of material properties including 4-point probe measurement and tensile testing, and optimizations of multilayer fabrication processes, we are working towards iteratively modifying the materials and processes towards the goal of improving device functionality and reusability of these damage sensing devices.

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Faculty Project Mentor: Dr. Samuel Root, Ph.D., Department of Macromolecular Science and Engineering, CWRU

Synthesis and Characterization of Enzyme-Mimicking Nanoparticles for Healthspan Extension

Koki Takizawa, Biomedical Engineering

Aging induces a decline in metabolic enzyme activity in the human body. This can lead to an increased risk of cardiovascular, neurodegenerative, and metabolic diseases, thus decreasing healthspan. To combat this, scientists have been trying to develop enzyme mimickers that promote sulphur metabolism, a process known to have many positive effects on human health. One potential enzyme mimicker is nanoparticles, which have recently attracted substantial interest in the medical field. We want to synthesize nanoparticles that are effective in mimicking enzymes in the human body and investigate potential side effects that come with them.

In this study, we synthesized five new bimetallic nanoparticles and tested their absorbance and hydrodynamic diameter using UV-Vis and DLS, respectively. The nanoparticles were synthesized using half volume of POF solution with two quarter volumes of individual metal salt solutions. They were titrated to a certain pH, stirred for 5 days, and lastly centrifuged. Out of all of the nanoparticles that we synthesized, results show that gold iridium and gold rhodium nanoparticles are the most stable. No identifiable peak from the UV-Vis indicates that these nanoparticles could have a true diameter less than 5 nm, which would make them preferable over larger nanoparticles as drugs. Next, we will react these stable nanoparticles with cysteine as well as other proteinogenic amino acids. From this data, we intend to explore the therapeutic potential of gold iridium and gold rhodium nanoparticles.

Faculty Project Mentor: Dr. Vijay Krishna, Department of Biomedical Engineering, Cleveland Clinic Lerner Research Institute

Cancer Risk and How it Interacts with Air Toxics and Cardiovascular Disease Risk on a Census Tract Level

Samir Taliwal, Data Science

Cardiovascular disease (CVD) covers a variety of conditions affecting the heart, making it a leading cause of death. In 2019, around 18 million people died from CVD, 32% of global deaths. However, one's risk for contracting CVD related ailments are not limited to genetic predispositions. For example, one's socioeconomic status (SES) could have a direct impact on disease incidence; lower income neighborhoods have poor access to healthy food, exercise spaces, and healthcare sites, which in turn could worsen health. Areas associated with lower SES also have more long-term exposure to air toxics, since these communities are more likely to live near highways, factories, or industrial areas. These toxins also increase cancer risk through chronic inflammation and oxidative stress. When these neighborhood health risks combine with environmental cancer hazards, they can worsen existing disparities and lead to higher rates of cardiovascular disease in already vulnerable populations. The purpose of this project is to examine how these SES factors relate to one's CVD risk across these urban and rural census tracts, while examining how cancer risk interacts with these terms. CVD prevalence was measured through Coronary Heart Disease (CHD) prevalence. Given cancer risk data from the EPA based on air toxin concentrations, we will use multivariable regressions to see significant associations between CHD prevalence and SES variables. We used variables from the Social Vulnerability Index (age, sex, education, income, insurance, etc) to quantify SES. We will also use cancer risk as an interaction term to see if the relationship varies based on cancer risk. We expect to see many significant associations between these SES variables and CHD prevalence in both urban and rural settings. However, we hypothesize that only urban census tracts will see significant interactions between cancer and SES/CHD prevalence because of the higher likelihood of exposure to air toxins.

Faculty Project Mentor: Dr. Sanjay Rajagopalan, Niketh Surya, Feriel Presswalla, Cardiovascular Research Institute, Case Western Reserve University, University Hospitals

Cereblon Regulation of Mitochondrial Homeostasis

Phoebe Templin, B.A. in Biology, Case Western Reserve University

Cereblon (CRBN) is a protein that acts as a substrate receptor for an E3 ubiquitin ligase complex, which plays a critical role in maintaining mitochondrial homeostasis. Research has shown that CRBN increases within the parietal cortex after a Traumatic Brain Injury (TBI) in humans.

In this lab we used a jet-flow overpressure chamber (OPC) on mice to model a blast-meditated traumatic brain injury (bTBI). Using this model we observed that CRBN increases a year post injury in the cortex. To relate this to mitochondrial expression, we explored human databases and saw that as CRBN expression increases, so did Mitochondrial fission 1 protein (FIS1), which is a protein involved in the process of mitochondrial fission. This process is normal; however, excessive fission is associated with functional defects and can be implicated in many diseases.

We generated knock-n (KI) and knock-out (KO) cells (Hippocampal HT22) in order to conduct a Seahorse experiment to measure the metabolism of live cells. This experiment specifically measures the oxygen consumption rate (OCR) to effectively assess cellular respiration. When CRBN was over expressed (KI cell line), we observed an increase in the OCR. When CRBN expression was reduced (KO cell line), we observed decreased OCR. A low OCR indicates that these cells are not as efficiently taking in and using oxygen to produce energy, increasing the risk of cellular issues.

In recent clinical trials, thalidomide has been used to bind and block CRBN to inhibit its function, essentially mimicking a KO cell line. Given the success in these clinical trials, we hypothesize that the therapeutic benefit of thalidomide is due to the reduction in OCR. Future direction involves treating the HT22 cells with thalidomide to determine at which specific concentration OCR can be reduced, without it being detrimental to the cell's health.

Faculty Project Mentor: 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

Land Cover Associations with Headwater Fish in a Developed Metropolitan Area

Alexander Teresi, Departments of Evolutionary Biology and Geology

Headwater streams, streams with watersheds of twenty square miles or less, are the smallest river network tributaries, conveying water into ponds, aquifers, larger streams and rivers. Headwater streams contribute to stream network health and biodiversity by delivering water, sediments, and nutrients downstream, providing habitats, and offering organisms protection from predation, competition, temperature extremes, and high flows. Headwater streams are vulnerable to urbanization; urban development often coincides with loss of headwater stream branches, stream length, water clarity, and biodiversity. One method to assess headwater stream health is to identify and track indicator species, whose presence, absence or abundance reflects damaged or undamaged stream conditions. This research examines the use of headwater fish as indicator species along gradients of landscape development by comparing fish abundance across stream sites with traditional fish tolerance rankings within Cleveland Metroparks. Data were sourced from fish surveys conducted from 2013 to 2022 by Cleveland Metroparks' aquatic research staff. Development and other factors, including open water proximity and local habitat type, were quantified using National Land Cover Data. We then used two R-based mathematical models, quasipoisson regression and segmented regression, to quantify land cover associations and identify condition break-points for 31 native fish species. Abundances of 14 species held net positive associations with development. Abundances of 17 fish species held net negative associations with development. Several common indicator species fish showed unexpected relationships with development, including bluegill Lepomis macrochirus and green sunfish Lepomis cyanellus, sharing similar break-points and negative model coefficients despite differing conventional tolerance rankings. These results suggest that fish species tolerances to development-related stream damage may be more malleable and habitat-dependent than previously proposed. This study may support conservation efforts within Cleveland Metroparks by providing a framework for indicator species as a metric for headwater stream health.

Project Supervisor: Dr. Nathan Byer, Research and Database Manager, Cleveland Metroparks

Faculty Advisor: Dr. Ronald Oldfield, Department of Biology, CWRU

Cleveland Metroparks Data/Resources Provided by: Mike Durkalec, Aquatic Biologist and Claire Weldon, Aquatic Research Coordinator

Game Controller Input for Ultrasonic Tibial Nerve Stimulator

Amit Thusay, Electrical Engineering; Michael Sobota, Electrical Engineering; Dr. Steve Majerus, Department of Electrical, Computer, and Systems Engineering

Peripheral neuromodulation is used to treat symptoms of conditions like peripheral and diabetic neuropathy, migraines, overactive bladder syndrome, and chronic pain. The least invasive route for neuromodulation is TENS or transcutaneous electrical nerve stimulation; however, it can accidentally stimulate normal nerves. An emerging alternative to conventional electrical neuromodulation is the use of low intensity focused ultrasound (LIFU); this method uses ultrasonic modulation to reduce the activation threshold for peripheral nerves. A device that uses this method of neuromodulation is the Steerable Ultrasonic Nerve Stimulator (SUNS). We believed that combining the LIFU stimulation, from the device, with TENS stimulation would yield unique results for feasibility testing in animals or humans. This project focused on improving the device's current platform and adding TENS stimulation. To improve the device's ease-of-use and experimental control, an Xbox controller was adapted to enable real-time control over and refocusing of an ultrasonic beam, and 2 PCB prototypes were developed to improve the form factor, hardware tuning, efficiency, and signal integrity of the current device's PCB. The significant change made in the prototypes was the use of an analog gate driver that had integrated dead-time control; this removed the need for the digital chips on the existing board and reduced its size significantly. Based on LTSpice simulations of the current benchtop design, important discrete components that would need to be tuned in a benchtop setting were identified; this information was used as a guide for the general layout of the second PCB prototype. Using the achieved real-time control, we plan on pairing a clinical grade electrical stimulator to work synchronously with the device's ultrasonic pulses. To test the effectiveness of this setup and to design an optimal mechanical enclosure for the devices, we plan on using an agarose gel phantom media with embedded sensors.

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

The Ethics and Effectiveness of Short-Term Medical Brigades

Amanda Tian, (Biology and English)

In recent years, there has been a growth in the number of short-term medical missions, prompting questions about ethics and effectiveness when administered in underresourced populations. While this expansion suggests a desire to address global health disparities, many socioeconomic and cultural factors complicate their ethical foundation. These initiatives are often presented as mutually beneficial for those served and those serving, addressing global health disparities while providing educational opportunities for volunteers. Yet, the relationship between the needs of volunteers versus host communities is found to be ambiguous and uneven. The desire for experiential learning, combined with narratives of saviorism and voluntourism, creates a conflicted basis for these programs. Previous research reports perceived benefits for volunteers, such as increased empathy, cross-cultural awareness, and professional development. However, studies have also found that these programs can undermine local healthcare delivery due to insufficient training, cultural insensitivity, and limited sustainability. The inevitable charity-based mindset, rather than an equitable partnership, leads to a risk of dependency and overlook of the systemic causes for such disparities. Much of the existing literature faces shortcomings due to reliance on self-reports and a lack of observational longevity. Another difficulty arises due to limitations in gathering quantifiable health outcomes from these programs. Recent studies incorporating host viewpoints and program evaluation tools reveal a more complex perspective. Rather than the elimination of these brigades, there is emphasis on a need for ethically accountable and collaborative models that prioritize cultural humility, reciprocity, and long-term sustainability.

Faculty Project Mentor: Robert Ward, Department of Biology

Linking Air Pollution to Atherosclerosis: Endothelial Cell-Specific Transcriptional Responses to Chronic Air Pollution in Atherosclerosis

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Background: Air pollution is the world's leading environmental risk factor for atherosclerotic cardiovascular disease (ASCVD), a major global cause of morbidity and mortality. Ambient air pollution (PM2.5) consists of particles with diameters less than 2.5μm that can penetrate deep into the lungs and enter the bloodstream, leading to systemic inflammation and oxidative stress, negatively affecting vascular function. Endothelial cells, which form the inner lining of blood vessels, are key regulators of vascular tone and barrier integrity and are particularly vulnerable to PM2.5-induced injury. However, the transcriptional changes in endothelial cells with air pollution exposure remain uncharacterized.
Goals: This study aims to assess how chronic PM2.5 exposure affects vascular function in apolipoprotein E-deficient (ApoE-/-) mice and to identify transcriptional mechanisms driving vascular dysfunction.
Methods: Male ApoE-/- mice were inhalationally exposed to either concentrated PM2.5 or filtered air (FA, controls) using a Versatile Aerosol Concentration Enrichment System (VACES, 5–6 h/day, 5 d/week for 36 weeks). Aortas were collected for vascular reactivity studies and single-cell RNA sequencing (scRNA-seq) using the 10X Genomics platform. Cell clustering, principal component analysis (PCA), and Uniform Manifold Approximation and Projection (UMAP) were performed. Differentially expressed genes were analyzed using Gene Ontology (GO) and KEGG pathway enrichment to identify mechanisms underlying PM2.5-induced vascular dysfunction.
Results: PM2.5-exposed mice showed impaired aortic relaxation to acetylcholine, but not sodium nitroprusside, indicating endothelial dysfunction. scRNA-seq identified 397 DEGs in endothelial cells. GO and KEGG pathway analysis are ongoing.
Conclusion: Chronic exposure to PM2.5 induces endothelial dysfunction in ApoE-/- mice. We anticipate that ongoing transcriptional analysis will reveal activation of inflammatory and oxidative stress pathways. These findings may help clarify how air pollution contributes to ASCVD pathogenesis and identify novel molecular targets for intervention.

Faculty Project Mentor: Sanjay Rajagopalan, Cardiovascular Research Institute, Case Western Reserve University School of Medicine

Novel Mouse Model for Cardiac Valvular Ehlers Danlos Syndrome Demonstrates Enlarged Heart Valves

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Ehlers Danlos Syndrome (EDS) is a hereditary connective tissue disorder that primarily affects the skin, blood vessels and joints. Clinical features include joint hypermobility, joint dislocation, skin hyperextensibility, and tissue fragility. Cardiac valvular Ehlers Danlos Syndrome (cvEDS), resulting in mutations in COL1a2, is an especially rare form of EDS and causes severe heart valve problems including aortic, mitral, and tricuspid valve regurgitation along with other common features. Unlike other EDS forms, cvEDS follows an autosomal recessive inheritance pattern with few recorded cases and affects less than one in a million people. Because there are no current model systems and limited research for this rare connective tissue disorder, a novel mouse model was generated.

Normal Type 1 collagen consists of two chains of pro-α2(I) and one chain of pro-α1(I). Without proper form, the collagen leads to weak function of connective tissues, such as cartilage, tendons, and skin. cvEDS is caused by mutations in both copies of the COL1A2 gene (at E1207) leading to a premature termination codon. The resulting Col1a2 E1207*/E1207* (termed cvEDS KO) embryos were recovered at a lower Mendelian ratio (7/45; 15% (expected 25%) with a lower litter size of 6.4 as compared to standard of 8, in 7 litters). At postnatal day 7, there is a decrease in the number of expected cvEDS mice (6/53; 11% (expected 25%) with a lower litter size of 6.6 in 8 litters). The cvEDS KO embryos have enlarged cardiac valves, particularly the aortic and mitral valves, with an increase in proteoglycans and disorganized collagen. A similar pattern is observed in cvEDS KO adult (1M) heart valves. While there are no apparent embryonic joint malformations, investigation of adult joints, as well as embryonic and adult skin, is ongoing.

Faculty Project Mentor: Timothy J. Mead, PhD Department of Pediatrics

Designing Anisotropic Polyacrylamide Scaffolds for Collagen Fiber Alignment

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Hierarchical structures commonly found in natural biomaterials impart unique mechanical and functional properties across multiple length scales. However, current microfabrication methods for hierarchical architectures often lack sufficient spatial resolution and material compatibility, limiting their ability to replicate these complex structures. Inspired by the phase behavior of liquid crystals, we utilized liquid crystals as templates to generate anisotropic, elongated pores within a polyacrylamide matrix. This porous
polyacrylamide scaffold was subsequently used to guide the alignment of collagen fibers, successfully mimicking the hierarchical organization characteristic of native extracellular matrix (ECM) structures.

In this work, we used polyacrylamide gels with different crosslinking densities to create scaffolds with different Young's Modulus. Disodium cromoglycate (DSCG) served as the liquid crystal, forming stripe-like structures within the gel. To facilitate alignment, the liquid crystal was oriented using a carved glass surface as a template. The resulting network was then swollen in a 1 mg/mL collagen solution prepared in 0.12 M HCl before being transitioned to a neutral pH buffer. This step promoted collagen diffusion into the pores, followed by incubation in PBS to trigger collagen fiber formation.

This work presents a method for creating self-assembled hierarchical structures and explores both the behavior of liquid crystals within polyacrylamide gels and the diffusion of collagen through the porous network. The resulting materials show strong potential for applications in tissue engineering, regenerative medicine, and biomaterial design by offering new strategies to guide cellular behavior and support tissue regeneration.

Faculty Project Mentor: Sveta Morozova, Department of Macromolecular Science and Engineering

Understanding Integrin Subunit Alpha V (ITGAV)'s role in Signet Ring Cell Carcinoma (SRCC)

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Signet Ring Cell Carcinoma (SRCC) is a rare form of colorectal cancer (CRC) that accounts for approximately 1% of all CRC cases. SRCC is difficult to detect, has a poor prognosis, and onset is associated with younger patients – with some cases in their early teens.

Current treatment for SRCC is the same as for an aggressive Adenocarcinoma (ACC), the most prevalent form of CRC. Recent research demonstrates that SRCC and ACC differ in mutations detected, signaling pathway activities, and metastasis patterns resulting in current SRCC treatments having limited effect. Therefore, SRCC-specific therapies would significantly improve patient survival.

Recently, Dr. Fink and the Markowitz lab DNA sequenced SRCC, ACC, and healthy patient colon samples and discovered that Integrin Subunit Alpha V (ITGAV) is mutated in ~10% of SRCC, but not ACC or healthy, patients. Understanding how ITGAV mutations contribute to SRCC development could open new avenues for SRCC-specific therapies. We hypothesize that ITGAV inactivating mutations block conversion of Transforming Growth Factor Beta (TGF-B) from its latent to active form. This results in the loss of a tumor suppressor signaling pathway important in the regulation of colon epithelia growth.

This summer, I started testing this hypothesis in-vitro. I confirmed ITGAV protein expression in four TGF-B sensitive cell lines, optimized siRNA transfection conditions to knockdown ITGAV in these cells, and confirmed these four cell lines are TGF-B sensitive. Future directions include using these transfection conditions to determine if ITGAV knockdown results in loss of TGF-B sensitivity when treated with latent TGF-B.

These in-vitro experiments will help shed light on the role of ITGAV inactivating mutations as potential drivers of SRCC and open up new avenues for the development of SRCC-specific therapies.

Faculty Project Mentor: Dr. Stephen Fink, Case Comprehensive Cancer Center

Investigating T cell associations with the cervicovaginal environment in women with abnormal pap smears.

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In 2025 13,360 new cases of invasive cervical cancer are estimated to occur in the United States alone— of these women, 4,320 are predicted to die due to the cancer. Cervical cancer is the most common cause of cancer related deaths for women. 90% of all cases of cervical cancer are directly caused due to the persistence of the Human Papillomavirus (HPV). This can lead to the development of high-grade lesions by disrupting division, replication, and communication of cervical cells which are more prone to mutations and developing into cancerous lesions. This project is investigating cervical immunity during HPV infection to better understand factors underlying HPV persistence. This study is enrolling female participants with abnormal PAP smears or high-risk HPV (hrHPV) into a longitudinal cohort, with biospecimen collected every 6-12 months for up to 3 years. Cervical immune cells are collected by cytobrush and analyzed by flow cytometry to identify cervical T cell subsets. HPV status and cervical pathology have been determined as part of routine clinical care and 16S rRNA sequencing has been used to profile the microbiome. We performed flow cytometry analysis of cervical T cells from 50 participants. 27 of those participants had hrHPV which has a higher likelihood of persistence. Markers with increased expression in hrHPV are CD8+CD69+ and CD4+CD25+ (p-values: 0.023, 0.035). These markers are associated with cytotoxic T cell activation and regulatory T cells respectively. An average of 42.4% and 10.4% of CD8+ and CD4+ cells are CD8+CD69+ and CD4+CD25+ with a range of 0-100%. Regulatory T cells play a role in suppressing the immune system and a higher amount of activation suggests an increase in inflammation in hrHPV. Further analysis must be done to confirm these findings and identify other diUerences in sample populations.

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Modeling a High Density Nerve Cuff Electrode

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For decades, prosthetic limbs have helped amputees across the world live fuller lives. While these prosthetics greatly expand mobility for patients, commercial devices are yet to provide ways to restore one's sensation. Electrical stimulation can be used to address this roadblock. Delivered through nerve cuff electrodes, stimulation can restore sensation to an amputee. These cuffs consist of multiple contacts that surround a nerve; each one is calibrated to release a certain current in order to stimulate certain axons in a nerve. One must consider the exact current magnitude and contact location when designing the cuffs to deliver optimal sensory restoration.Current nerve cuffs aren't selective enough to produce the most optimal sensory reaction; modern electrical stimulation can leave patients with an unnatural sensation of touch or stimulate unwanted axon clusters. So, our research is working to optimize the placement of electrode contacts in order to deliver the most selective stimulation to the nerve. However, testing these highly-advanced technologies in living organisms poses a problem. The cost and time of manufacturing electrode cuffs, implanting them in an organism, and studying their behavior are expensive and time-consuming. Instead, models can be used to replicate the different scenarios a physical electrode cuff may face. Using a multiphysics FEM simulation software, COMSOL, I have created multiple different models of electrode cuffs and tested them under various circumstances, observing how the contacts on the cuff affected electrical stimulation. This has allowed us to make modifications to the model in order to reach the most optimal design parameters. This model will be used in the future to optimize electrode contact placements to deliver selective stimulation with novel, algorithmically determined contact Placements.

Project Mentors: Dustin Tyler, Department of Biomedical Engineering

Measuring Falling Impact Forces Using IMUs in an Anthropometric Crash Test Dummy

Elizabeth Walther, Department of Mechanical Engineering, Vanderbilt University School of Engineering

Powered exoskeletons are wearable robotic devices with actuated joints that enable individuals with lower-limb paralysis to walk. However, commercial exoskeletons lack fall prevention features. These devices monitor trunk angular velocity, and when a threshold is exceeded, they either lock the hip or knee joints, or adopt a highly-damped “slow fall” mode. Despite the inclusion of more robust fall prevention controllers, falls may still occur. This project aimed to measure impact forces during simulated falls using an anthropometric crash test dummy. Local accelerations at the head, shoulder, sternum, hips, and knees were recorded via inertial measurement units (IMUs) and used to calculate impact forces. Joint kinematics were captured using VICON motion capture with a full-body marker set. Fall scenarios included 1) forwards and 2) backwards falls from a standing, double-support pose, and 3) split-stance forwards falls to simulate walking. Ten trials each of uncorrected and corrected postures were conducted, totaling 60 trials. Impact forces were compared using Wilcoxon Rank-Sum Tests with Bonferroni corrections. Results for the backwards falls showed significant reductions in impact force at the head, shoulders, sternum, and hips, particularly at the sternum ($p = 0.0002$) and right hip ($p = 0.0002$). Notably, the corrected positioning lowered the impact force below the pelvic fracture threshold for osteoporotic bone (1479 N), indicating that this posture could help prevent injury in high-risk individuals. Forwards falls showed a significant reduction only at the knees ($p = 0.0023$). For the split-stance falls, preliminary results suggest a significant reduction in impact force at the hips and knees. These findings suggest that lowering the center of mass is crucial for reducing impact forces, and repositioning the arms alone may not be enough to prevent injury. Future work should incorporate biomechanical modeling to optimize impact force mitigation, providing clearer guidance for developing active limb repositioning controllers.

Faculty Project Mentor: Dr. Sandra Hnat, Department of Biomedical Engineering, Case Western Reserve University School of Medicine

Isoxanthohumol inhibited MRGPRX2-mediated mast cells activation to reduce inflammation in rosacea

Kathy Wang, Biochemistry; Dr. Tao Jia, Yifan Xia, Mengyao Yi, Ruiqi Li, Dr. Yi Zheng, Dr. Xinyue Zhang

Rosacea is a chronic inflammatory skin disease shown as facial erythema, papules, etc., which can affect the quality of patients' lives. The mechanism of rosacea is complex, and one explanation to the mechanism of rosacea occurrence and development focuses on the abnormal immune response. The latest research confirms Mas-related G-protein coupled receptor X2 (MRGPRX2), which mediated mast cell (MC) activation is a key receptor to regulate the inflammation of rosacea. There is a lack of targeted drugs in the clinical treatment of rosacea. Isoxanthohumol (IXN) is a prenylated flavonoid primarily derived from hops and showed anti-inflammation effect. However, whether IXN inhibits MRGPRX2 and reduced inflammation of rosacea is still unknown. In our study, LL-37-induced rosacea mouse model was used to evaluate the effect of IXN on the inflammation of rosacea. Pathological change was evaluated by H&E. And MCs, CD4+ T cells and neutrophil were marked. The inflammatory mediators were analyzed by ELISA. The effect of IXN on rosacea was analyzed by RNA sequence. MRGPRX2-mediated MC degranulation reaction model was used to evaluate the inhibition effect of IXN in vitro. Molecular docking analysis, molecular dynamics simulation, and surface plasmon resonance (SPR) were used to evaluate the binding action of IXN and MRGPRX2. We found that IXN reduced inflammatory cells infiltration and inflammatory mediators release by inhibiting MCs activation in vivo. IXN could effect on NF-κB and toll-like receptor signal pathway analyzed by RNA-seq. In vitro, IXN inhibited LL-37-induced MCs activation and inflammatory mediators' release. In addition, IXN showed a good binding effect with MRGPRX2. Our study showed IXN reduced the inflammation of rosacea as a MRGPRX2 antagonist, which provides a new idea for the treatment of rosacea.

Faculty Project Mentor: Dr. Delu Che, Department of Dermatology, Northwest Hospital, The Second Hospital Affiliated to Xi'an Jiaotong University

15-PGDH inhibition Accelerates Recovery From Radiation Induced Leukopenia

Sofia Wilhelm (Neuroscience), Bailey Klein (Biomedical Engineering), Filip Goshevski (Biomedical Engineering), Ritisha Rashmil (Systems Biology), Mia Kim (Biology), Ria Makkar (Biochemistry)

Abstract:
Hematopoietic stem and progenitor cells (HSPCs) are essential for maintaining blood and immune cell production under normal conditions and for regenerating the hematopoietic system following cytotoxic injury. Treatments such as chemotherapy or ionizing radiation can severely deplete HSPCs leading to neutropenia, anemia, and increased risk of infection. Despite this clinical challenge, therapeutic strategies to enhance hematopoietic recovery remain limited, particularly in the aging population where regenerative capacity is diminished. Our lab previously demonstrated that pharmacologic inhibition of 15-hydroxyprostaglandin dehydrogenase (15-PGDH) using the small molecule SW033291 (PGDHi) elevates prostaglandin E2 (PGE2) levels and, enhances HSPC function following stem cell transplantation. In this study, we investigated the therapeutic potential of PGDHi in 12-month-old male C57BL/6 mice subjected to sublethal total body irradiation. Mice were treated with PGDHi or vehicle control twice daily for 21 days post-irradiation. Peripheral blood was collected at intervals to track blood cell recovery, and bone marrow and spleen were analyzed on day 21 for HSPC content by flow cytometry. Our results show that PGDHi significantly accelerates neutrophil and red blood cell recovery compared to vehicle-treated controls. These findings support 15-PGDH inhibition as a promising therapeutic strategy to mitigate therapy-induced cytopenias and enhance hematopoietic regeneration following radiation or chemotherapy exposure.

Faculty Project Mentor: Amar Desai, Case Comprehensive Cancer Center

Ethics In the Weeds: Fraud in the Legal Psychoactive Substance Market

Autumn Wolf, Undergraduate in Medical Anthropology

Since the 2018 U.S. Farm Bill, which legalized the industrial production of hemp, the prevalence of intoxicating hemp products available in brick-and-mortar and online retail has grown significantly in the past seven years against a backdrop of an increasingly complex web of social, commercial, and legislative environments. With an influx of entities seeking to cash in on an emerging industry, a troubling yet familiar pattern of deceptive business practices has emerged. The purpose of this study was to examine the prevalence of deceptive business practices in his new industry, looking specifically at their disclosure of intoxicating substances through certificates of analysis (COAs). This study examined 20 online retailers with available COAs, which were extracted between May and June 2025. Microsoft Copilot was used to extract information from each COA. COAs were examined for inconsistencies with respect to testing identification numbers for each product as well as indicators that a COA had been manipulated. Across COAs (n=2942), there were 52 distinct brands, and 40 laboratories listed. A total of 6.0% of COAs were flagged for inconsistencies including having the same test ID number but listing a different product (94.5%) or having evidence of manipulation (e.g., mismatched fonts, variable image resolutions, or having information visibly cut off) (19.3%). A total of 13 different brands of 52 were associated (25%) had at least one or more flagged COA but more than half of the flagged COAs (55.1%) could be attributed to three companies and three distinct testing laboratories representing California, Florida, and Wisconsin. These findings provide preliminary evidence which suggests a concentrated effort to mislead consumers that may be specific to a cluster of companies operating across state borders. Additional research is necessary to examine broader engagement into deceptive practices to fully understand the risks to consumer safety and public health.

Faculty Project Mentor: Stephanie Pike Moore, Department of Population and Quantitative Health Sciences

Investigating the Role of Propanol and Nafion in Cracking Reaction

Rihanna Wright, Saint Martin, **Prateek Dwivedi, and Christopher Wirth,** Chemical and Biomolecular Engineering, CWRU.

Colloidal suspension-based coatings are widely employed in applications such as functional films and catalyst layers. However, these coatings are prone to cracking during the drying process, which compromises their structural integrity. In this study, we experimentally investigate the influence of solvent composition on crack morphology in model colloid–polymer films comprising fumed silica, Nafion, and a binary solvent mixture of water and 1-propanol. Films were fabricated using the doctor blade technique, with the propanol-to-water ratio systematically varied from 0.40 to 2.45. Our qualitative observations indicate that increasing the proportion of propanol leads to a noticeable reduction in crack width in the dried films. These preliminary results underscore the importance of solvent composition in dictating crack behavior and suggest that solvent tuning can be an effective strategy to improve film uniformity particularly relevant for coatings in energy and electronic applications.

Faculty Mentor:Christopher Wirth, Department of Chemical and Biomolecular Engineering

Analysis of beam line X-ray Diffraction & Scattering of SS and Ti Wire Arc Additive Manufacturing

Jiani Xu, Noah Lee, High School Interns studying Material Science and Engineering

Amorphous materials are challenging to study due to their lack of long-range atomic order, which makes them behave very differently from crystalline solids. Unlike crystalline alloys, amorphous metallic alloys, such as TiNb, do not exhibit a regular and repeating atomic structure. This makes it difficult to analyze them using traditional methods. In this project, X-ray diffraction data was collected for a TiNb alloy in its amorphous phase during solidification. The goal was to create an atomic model that could represent and help interpret the short-range structure of the amorphous phase. Using the experimental diffraction data, an atomic simulation box was refined until it matched the experimental data. Furthermore, computational methods were applied to analyze the local atomic structure from this model. Techniques such as Voronoi cell analysis and Delaunay triangulation were applied to study short-range atomic order and how the atoms were arranged with their nearest neighbor. Although amorphous materials do not obtain a highly repetitive pattern as metallic crystallines do, the models did show that some local ordering does exist within the structure. These findings suggest that even in an amorphous phase, there are certain underlying patterns, though not as stable as that of liquid or solid phase, may help show how the material transitions from liquid to solid as it cools. This study provides a way to better understand materials that do not conform to traditional crystalline structures.

Faculty Project Mentor: Roger H. French, Jonah Bachman, Mohammad Redad Mehdi - Material Science and Engineering

Functional Reliability of High-Density In-Line Implantable Connector

Jerry Yang, Biomedical Engineering and Electrical Engineering; Wenfei Zhao, Biomedical Engineering; Grace W. Anyalisa, Mechanical and Aerospace Engineering; Douglas B. Shire, Advanced Platform Technology Center, VA Northeast Ohio Healthcare System; Janet L. Gbur, Materials Science and Engineering

Nervous system disorders (e.g. spinal cord injury) can be treated using implantable neurostimulation systems. Using several wire channels, these systems both provide electrical stimulation to muscle groups and record electrical pulses from sensory receptors, allowing for a restoration of nervous system function. Greater channel counts allow for the transduction of more complex sensations and movements. The development of a High-Density (HD) In-Line Connector allows for a high channel count while minimizing implanted volume within the body.
Improving current 6- and 8-channel systems, a 32-channel HD In-Line Connector was developed, consisting of two halves. Each consists of a titanium package filled with silicone, containing 32 filars (35N LT drawn-filled tubes) terminated in stainless steel ferrules. To assemble the device, the two halves were attached using two set screws. During assembly, the stainless steel ferrules are aligned and form electrical connection. In this work, 6 of these 32 channels were arranged to represent a worst-case scenario for channels most likely to fail. These filars were routed out of the package and through strain relief into a silicone jacket.
To simulate conditions during fabrication, implantation, and surgery, the devices were evaluated under similar loading conditions. Electrical resistances of the as-received specimens averaged 12.7 ± 7.4 Ω. Next, specimens were soaked in a phosphate-buffered saline solution for 10 days at 37°C to simulate body conditions, and electrical resistances were measured upon removal (14.0 ± 6.6 Ω). To simulate worst-case axial loading, specimens were stretched to a 5 N load and held for one minute. Consistent resistances of the HD In-Line Connectors indicate the design is appropriate and functionally reliable.

Faculty Project Mentor: Dr. Douglas B. Shire, Advanced Platform Technology Center, VA Northeast Ohio Healthcare System; Dr. Janet L. Gbur, Materials Science and Engineering, Advanced Platform Technology Center, VA Northeast Ohio Healthcare System

Single-Nucleus RNA Sequencing Reveals Enteric Glial Cell Transcriptional Signatures in the Early Stage of Parkinson's Disease in Mouse Colon

Liwen Zhu, Neuroscience, Case Western Reserve University, The Scavuzzo Lab

Abstract:
Parkinson's disease (PD) is a neurodegenerative disorder affecting over 10 million people worldwide. While traditionally characterized by motor symptoms from dopaminergic neuron loss, growing evidence shows PD pathology extends beyond the central nervous system to include significant gastrointestinal involvement. Gastrointestinal symptoms such as constipation and delayed gastric emptying affect approximately 80% of PD patients and often precede motor symptoms by years or decades, suggesting the gut may be an early site of pathology. Enteric glial cells (EGCs) serve vital functions in maintaining gastrointestinal physiology and may participate in the early onset of PD pathogenesis through the gut-brain axis. In previous studies, PD enteric glial cells display a reactive phenotype characterized by altered morphology and upregulation of reactive glial cell markers such as GFAP and SOX10. However, the specific transcriptional changes in EGCs during early PD and how these cellular alterations lead to intestinal dysfunction remain poorly understood. This study investigated transcriptomic alterations in enteric glial cells from colon tissue of α-synuclein A53T transgenic PD mouse models using single-nucleus RNA sequencing (snRNA-seq). Nuclei were isolated and processed using the 10x Genomics platform, followed by computational analysis including quality control, normalization, and differential gene expression analysis. The snRNA-seq data included four samples: two PD mouse models and two control mouse models, with one male and one female in each condition. Transcriptomic results identified downregulation of protective mucosal factors (Agr2, Muc2) and neuronal-related factors (Nrxn1, Foxa2), alongside upregulation of PD-associated gene (Lrrk2) and neuronal excitability factors (Kcnip1). These findings provide molecular evidence for intestinal pathology in early PD and support the gut-brain axis hypothesis, potentially identifying biomarkers for early disease detection and novel therapeutic targets.

Faculty Project Mentor: Marissa Scavuzzo, Genetics and Genome Sciences, School of Medicine
Capstone Instructor: Jon Niemi, Neurosciences, School of Medicine

Cutting Edge Gets Smaller: Downsizing Mechanically-Adaptive, Microfluidic, Intracortical Microelectrodes

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Intracortical microelectrodes, or IME probes, are microscale implantable devices designed to stimulate or record from the cerebral cortex of the brain. By directly recording neural electrical signals from local neurons, these probes provide critical information for neurorehabilitation therapies. The detected neuronal signals can be translated into control signals to restore motor function in individuals with motor dysfunction or limb loss . Despite their potential, IME probes often fail over time, limiting long-term utility. This failure is primarily due to a neuroinflammatory response triggered by implantation, which disrupts the blood-brain barrier and damages surrounding brain tissue. Consequently, the immune system activates, glial scarring forms, and neurons retract from the implant site, leading to reduced recording performance.

To promote biointegration and device functionality, several strategies have been explored to reduce neuroinflammation, including local drug delivery, softer materials, and modification of device architecture/design. To improve long-term performance, we developed probes combining mechanically-adaptive materials with continuous, localized microfluidic drug delivery. This design minimizes mechanical mismatch and enables targeted therapy, offering advantages over rigid silicon probes and conventional delivery methods. To reduce the damage caused by device insertion, we aimed to reduce the cross-sectional area of the probe. We used guidance from Euler's buckling formula to design probes of varying widths to determine the extent to which the cross-sectional area could be reduced while retaining microfluidic probe functionality. Fabrication required micron-scale laser cutting with coordinate system fiducials and draft scaling for precise alignment. Probes were then subjected to mechanical buckling and flow tests to evaluate performance across widths. Testing the boundaries of the cross-sections of mechanically adaptive microfluidic probes advances design refinement and damage mitigation. Better device integration with surrounding brain tissue ultimately supports longer-functioning and more reliable neurorehabilitation implants for patients with motor impairments.

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