Graduate Research Colloquium Abstract Booklet

Sponsored by the Graduate Student Government

29th – 30th March 2023

Welcome

The GRC provides graduate students with a great opportunity to practice their oral or poster presentations in a friendly environment that prepares them for major national and international conferences. The GRC environment helps students improve their skills and judges also provide valuable feedback for each presentation that can improve a participant's research. Presenters receive feedback from judges with expertise in similar fields. These factors, taken together, are an important step for graduate students as they progress towards their degree.

The GRC is organized by the Graduate Student Government and is open to all graduate students at Michigan Tech. Graduate student researchers may participate through oral presentations, poster presentations, or both. Cash prizes are awarded to the top 3 presenters in each category. All graduate students are highly encouraged to participate to present their research and use GRC as the platform for their presentation.

This year, both the formats will be held in person. Judges will score all the presentations. They will provide valuable insight and feedback on how the students can improve their presentations. The presenters will be grouped into different technical sessions, according to their discipline of study. Poster Presentations will occur on **Wednesday, March 29** at the Rosza Lobby**, 5-8 pm**. GSG has printed all the posters with their newly acquired poster printers. The oral presentations will be held at the Alumni Lounge on the 29th from 12-5 pm and Admin 404 on 30th March from 10 – 3 pm respectively. Each oral presentation will be 10-12 minutes, followed by a brief Q&A session.

The GRC event will culminate with the annual GRC Awards Banquet. All participants and judges are invited to attend. The banquet will be held on **Thursday, March 30** at the Rosza Lobby, **5-8 pm**.

Full information can be found on our event website.

Table 1: Poster Presentation Schedule (March 29th)

5:00 – 6:00 PM	5:00 – 6:00 PM	6:00 – 7:00 PM
Abel Reyes	Nishat Binte Alam	Akash Kumar
Abhishek Patil	Michelle Bollini	Ayush Chutani
Cassandra Reed-VanDam	Mitch Kehne	Divya Pandya
Catherine Rono	Pradnya Pendse	Ian Norwood
Eleanor Serocki	Samuel Hervey	Iman Najafipour
Hossein Tavakoli Dastjerdi	Soheil Sepahyar	Grace Dykstra
Lauren Sprague	Seyedmostafa Rezaeitaleshmahalleh	Jordan Ewing
Lirong Zhu	Swapan Chakrabarty	Manpreet Boora
Jenna Disser	Vaishali Sharma	
John McCall	Xinqian Chen	Roya Bagheri
Katy Matson	Zonghan Lyu	Shreya Joshi
		Shashank Pathrudkar
		Susan Mathai
		Tania Demonte Gonzalez
		Vasu Bhardwaj
		Zachary Olson
		Zaid Bakri

Table 2: Oral Presentation Schedule

29th March				
12:00 – 1:00 PM	**1:00 – 2:00 PM**	**2:00 – 3:00 PM**	**3:00 – 4:00 PM**	**4:00 – 5:00 PM**
Hossein Tavakoli Dastjerdi	Adelina Oronova	Alexander Apostle	Benjamin Barrios	Akash Kumar
Jordan Ewing	Anne Inger Mortvedt	Divya Pandya	Courtney Archambeau	Fangyao Zhu
Shashank Pathrudkar	Brennan Vogl	Komal Chillar	Eric Boyer-Cole	Hrishikesh Gosavi
Swapan Chakrabarty	Isaac Flint	Neha Sharma	Katherine Higdon	
Zaid Bakri	Katy Matson	Udit Sharma	Paola Rivera Gonzalez	
Zonghan Lyu	Lauren Sprague	Utkarsh Chaudhari	Sarvada Chipkar	
	Xinqian Chen	Vasu Bhardwaj	Thi Mai Anh Tran	

30th March		
10:00 – 11:00 AM	**1:00 – 2:00 PM**	**2:00 – 3:00 PM**
Catherine Cono	Anna Li Holey	Abhishek Patil
Greg Miodonski	Austin Depottey	Genius Amaraizu
Hailee Petosky	Tania Demonte Gonzalez	Kendall Belopavlovich
Roya Bagheri	Zachary Olson	

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1 Poster Abstracts

1.1 Biology and Biomedical Engineering

Biological Sciences

1 STK11/LKB1 Inactivation Sensitizes Cancer Cells to PDE3A Modulators

Author: Catherine Rono

Liver Kinase B1 (LKB1) is known as a serine/threonine kinase (STK11) and plays diverse roles in organisms. The functions of LKB1 mainly depend on phosphorylation and activation of various downstream kinases within the superfamily of AMP-activated protein kinases. Particularly, LKB1 functions as a pivotal tumor suppressor in humans and its loss contributes to tumorigenesis. In non-small cell lung cancer (NSCLC), LKB1 ranks as the third most commonly mutated gene. Metabolic regulation of LKB1 exhibits an essential role in this context, but most of the relevant mechanisms are undetermined. Here, we performed the transcriptomic profiling analysis and identified LKB1-dependent suppression of phosphodiesterases (PDE), which reveals a novel role of LKB1 in cyclic monophosphate metabolism.

Specifically, LKB1 suppresses PDE3A expression through activation of the downstream salt inducible kinase (SIK). Early evidence suggested that PDE3A modulators, such as anagrelide and estradiol, kill PDE3A-positive tumor cells via formation of PDE3A-SLFN12 complex. We uncovered that PDE3A modulators can selectively eliminate LKB1-deficient tumor cells, but not LKB1-intact cells. However, some of LKB1 deficient tumor cells, even with high PDE3A expression, were exceptionally resistant to PDE3A modulators. Resistance appears because SLFN12 is epigenetically silenced in those cells.

We found that expression of SLFN12 can be induced by either forced elevation of cAMP or epigenetic inhibitors, by which the resistance can be abolished. Overall, our findings not only reveal a new role of LKB1 in regulation of cAMP metabolism, but also suggest a novel targeted therapy for LKB1-deficient cancers.

2 MicroRNA-483 Deficiency in Pancreatic β-cells Stimulates Stress-Induced β-cell De-differentiation

Author: Katy Matson

MicroRNAs (miRNA) are a group of small non-coding RNAs that negatively regulate target gene expression in response to metabolic changes in pancreatic islets. Dysregulation of miRNAs plays a crucial role in controlling the pathogenesis of diabetes. Our previous studies have identified higher expression of miR-483 in β-cells compared to α-cells. Mice with β-cell specific deletion of miR-483 (miR483-/-) exhibited high fat diet (HFD)-induced hyperglycemia and reduced glucose tolerance by the diminishing release of insulin. During the development of type 2 diabetes (T2D), β-cell dedifferentiation, or reversion, has been discovered to be a pathological mechanism for β-cell loss and dysfunction. Dedifferentiated β-cells transform to progenitor-like cells or transdifferentiate, or convert, to other endocrine cell types, like α-cells. However, the specific processes involved in these cell conversions are still under investigation. Notably, after HFD feeding the islets of miR483-/- mice showed elevated expression of aldehyde dehydrogenase family 1, subfamily A3 (Aldh1a3), a marker of β-cell dedifferentiation and a direct target of miR-483.

In this study, we induced diabetes with HFD and/or treatments of streptozotocin (STZ) and identified that a higher proportion of ALDH1A3-positive β-cells were colocalized with glucagon in miR483-/- mice compared to the control mice. Further confirmation of increased glucagon contents was shown in miR483-/- islets and miR483-deleted MIN6 cell line cells when treated with palmitate or STZ.

In addition, the loss of miR-483 significantly increases multiple enzymes, including gamma-glutamyltransferase (GGT1), involved responses in adaptive oxidative stress potentially leading to mitochondrial dysfunction. In conclusion, our data indicated that miR-483 is important for protecting β-cell identity, and miR-483 deficiency induces β-cell dedifferentiation and oxidation stress.

3 PVN SK Channel Blockade Alters Sympathetic Nerve Bursting Pattern in Angiotensin II-Infused Rats

Author: Jenna Disser

Sympathetic nerve activity (SNA) demonstrates rhythmic activity that arises from integration of signals from lung inflation afferents, baroreceptor afferents, and respiratory neurons in the brainstem that influence presympathetic neurons in the rostral ventrolateral medulla (RVLM). The paraventricular nucleus (PVN) is a prominent regulatory center for SNA and PVN neurons have axon projections to the RVLM. Blockade of small conductance calcium-activated potassium (SK) channels in the PVN significantly increases splanchnic and renal SNA. The aim of this study was to determine the influence of chronic AngII infusion on SNA firing patterns at rest and following PVN SK channel blockade with apamin.

Experiments were performed in ventilated, male Sprague-Dawley control (Ctrl; n=5) rats, or rats infused with AngII (150 ng·kg−1·min−1) for 2 weeks (n=4). Power spectral density was calculated on 5-minute segments of SNA during baseline, and during the maximum response to apamin. Splanchnic and renal SNA spectral power in the 0-2Hz (low) frequency band was similar between Ctrl and AngII rats at baseline. PVN microinjection of apamin significantly ($p<0.05$) increased spectral power in the 0-2Hz band similarly in both groups.

In contrast, baseline spectral power in the 5-7Hz (cardiac) frequency band was significantly higher in AngII rats compared to control for both splanchnic (Ctrl 10.4±2.3 vs. AngII 26.8±2.8%; $p<0.05$) and renal (Ctrl 19.9±3.8 vs. AngII 35.3±1.5%; $p<0.05$) SNA. Interestingly, PVN microinjection of apamin significantly ($p<0.05$) attenuated spectral power in the 5-7Hz band in the AngII group alone for splanchnic (Ctrl 9.3±2.8 vs. AngII 7.7±0.8%) and renal (Ctrl 12.3±4.7 vs. AngII 11.1±1.9%) SNA. In conclusion, baseline cardiac-related spectral power was greater in AngII rats compared to Ctrl likely reflecting increased input from baroreceptor afferents. PVN SK channel blockade shifts the SNA burst pattern in both Ctrl and AngII rats towards lower frequency bursts known to have a greater influence on vascular tone.

4 Evaluating Genotoxicity of Mine Tailings ("Stamp Sands") on Two Game Fish in a Spawning Reef in Lake Superior (Michigan)

Author: John McCall

Quantifying changes in DNA chemistry presents a novel biomarker for monitoring wildlife responses to anthropogenic stressors under a genotoxicological framework.

Using a conserved epigenetic marker in vertebrates, we sequence the extent of methylation of genome-wide cytosines from two native fish species recruited from a spawning reef impacted by mining wastes. Our aim is to investigate the relationships between mine tailing exposure with changes in DNA methylation and subsequent gene expression that are representative of adverse developmental or toxicological stress in exposed fish.

Whole genome DNA extractions following reduced representation bisulfite sequencing methods have been completed from eggs of lake trout (Salvelinus namaycush) and whitefish (Coregonus clupeaformis) spawned at Buffalo Reef, Lake Superior in addition to samples collected from population outgroups. These genomes are being screened for changes in DNA methylation patterns in the Buffalo Reef spawning females relative to the outgroup samples. We predict a higher degree of DNA methylation among eggs spawned on the reef compared to the outgroups.

This research is contrasting DNA methylation patterns among lake trout and whitefish eggs reared across a gradient of mine tailing exposures under controlled experimental conditions. Remediation efforts at Buffalo Reef require an understanding of the relationship between mine tailing coverage of the reef and acute or chronic toxicity effects. This epigenetics approach will demonstrate the subtle chronic toxicity effects of mine tailings, and also demonstrate the applicability of epigenetics toward investigating species' responses to disturbances in a changing global ecosystem.

5 Quantifying The Energetic Contribution of Zebra Mussel Veligers to the Saginaw Bay Food Web

Author: Mitch Kehne

Invasive zebra mussels have caused major shifts to Great Lakes nutrient cycling, energy flow, and population dynamics since their introduction in the 1980s. Current research has focused attention on the impacts and ecological role of adult mussels, which can densely cover entire lake-bottoms and a variety of manmade substrates.

This project will provide necessary data on the lesser-studied veliger life-stage by assessing its energetic contribution to the food web of Lake Huron's Saginaw Bay. Analysis of fatty acid composition and energy densities will quantify their nutritional quality as a food source, and radio-labelled feeding experiments of known predator zooplankton species and heterotrophic bacteria will assess fate of veliger carbon. It is assumed that zebra mussel veligers possess low nutritional value and are not highly utilized as prey by native species in this system.

6 Chemical Force Microscopy: A tool for Nanoscale Characterization of Biomolecules

Author: Vaishali Sharma

Novel biologics, like virus-like particles and exosomes, have an increasing demand as diagnostics and/or therapeutics for currently untreatable diseases. However, limitations in characterization techniques have hindered further understanding of their biophysical and chemical properties.

To address this issue, we propose using chemical force microscopy (CFM), a technique that chemically maps a biomolecule at a single-particle, nanoscale level to detect and quantify the intermolecular interactions between different chemistries and the biomolecules. Overall, biophysical characterization with CFM will aid in developing unique biomolecules that will bring state of the art therapies for severe human diseases to market faster.

7 Deep-learning-based Image Segmentation for Image-based Computational Hemodynamic Analysis of Abdominal Aortic Aneurysms: A Comparison Study

Author: Zonghan Lyu

Computational hemodynamics is increasingly being used to quantify hemodynamic characteristics in and around abdominal aortic aneurysms (AAA) in a patient-specific fashion. However, the time-consuming manual annotation is hindering the clinical translation of computational hemodynamic analysis.

Thus, we investigate the feasibility of using deep-learning-based image segmentation methods to reduce the time required for manual segmentation. Two of the latest deep-learning-based image segmentation methods, ARU-Net and CACU-Net, were used to test the feasibility of automated computer model creation for computational hemodynamic analysis. Morphological features and hemodynamic metrics of 30 CTA scans were compared between predictions and manual models.
Results: The DICE score for both networks was 0.916, and the correlation value was above 0.95, indicating their ability to generate models comparable to human segmentation. The Bland-Altman analysis shows a good agreement between deep learning and manual segmentation results. Compared with manual (computational hemodynamics) model recreation, the time for automated computer model generation was significantly reduced (from ~2hr to ~10min).

Conclusions: Automated image segmentation can significantly reduce time expenses on the recreation of patient-specific AAA models. Moreover, our study showed that both CACU-Net and ARU-Net could accomplish AAA segmentation, and CACU-Net outperformed ARU-Net in terms of accuracy and timesaving.

1.2 Chemistry and Chemical Engineering

Chemical Engineering

1 Determination of Probiotic Electrophysiology Utilizing Dielectrophoretic Microdevices

Author: Iman Najafipour

Functional gastrointestinal disorders (FGIDs) affect 40% of people worldwide and are increasingly difficult to treat. The usage of probiotics, a microorganism with numerous health benefits found in natural food such as cultured dairy products, have yielded results with varying success for the treatment of gastrointestinal disorders. The most common probiotics belong to the genera Lactobacillus, Bifidobacterium, and Streptococcus which are known as lactic acid bacteria (LAB). Several evidence indicates success of probiotics for treatment and prevention of infections and chronic inflammatory disorders of the gastrointestinal tract. While the efficacy of probiotics in certain cases has been proven, results can vary between individuals, that is why further research in this area is still required. FGIDs require constant management, yet tools are not available for patients to monitor their gastrointestinal (GI) microbiome.

This research aims to develop a point-of-care diagnostic tool to monitor GI microbiomes in real time. Microfluidic platforms can enable rapid electrokinetic analysis of cells utilizing a small sample volume within polydimethylsiloxane (PDMS) microchannels interfaced with microfabricated electrodes. Dielectrophoresis (DEP), a highly cell selective electrokinetic tool, uses a non-uniform electric field to induce motion based on the cell's electrophysiological properties. The dynamic dielectric properties of cells depend on their size, morphology, membrane type, and cytoplasm. Therefore, based upon patterns of results from other bacterial systems, different lactic acid bacteria are postulated to exhibit different DEP properties.

In this work, DEP will be utilized to determine the dielectrophoretic spectra as a function of frequency of three LAB. The crossover frequency of the three strains will be determined in a custom-designed microfluidic device to determine if their DEP signature is sufficiently unique to achieve identification from an unknown sample. This work is the first exploratory step in designing a point of care device for individuals with FGIDs to manage their condition.

2 Low-cost, Stable, and Selective Synthetic biosensors for Lactate Detection

Author: Grace Dykstra

Normal lactate levels are within 1-2 mM but when these levels are increased even moderately from 2-4 mM this can be a sign of lactic acidosis and is attributed to many different causes such as sepsis and septic shock, cardiac arrest, lung disease and respiratory failure, and trauma within the body. Quick detection of lactate levels can help medical professionals diagnose and treat patients. Testing lactate levels can be performed using Molecularly Imprinted Polymer-based biosensors with the help of nano-deposits of Prussian Blue.

These biosensors use a molecularly imprinted cavity as their recognition element instead of the naturally occurring antibodies and enzymes commonly used today, with major advantages of low-cost, inherent selectivity, and stability. The Prussian blue nanoparticles allow for a biosensor that does not require an external recognition system; in turn the samples can be analyzed more quickly without external reactants for a simple one-step detection process.

3 Evaluation of Entropy Generation Minimization as a Process Design, Optimization, and Analysis Tool

Author: Zachary Olson

This work applies discounted cash flow analysis to simulated chemical/energy systems designed and optimized with entropy generation minimization in mind. By comparing the financial valuation of these systems to those designed and optimized using traditional techno-economic models, this work seeks to advance the understanding of the connection between entropy generation and economic performance.

1.3 Civil and Environmental Engineering

1. Dynamic Bioaccumulation Model for a mining impacted Aquatic Ecosystem

Author: Michelle Bollini

The Keweenaw area has been influenced by copper mining activities that occurred close to 100 years ago. Mining brought many people to the area and improved the local economy, but it also caused pollution with industrial chemicals such as, polychlorinated biphenyl compounds (PCBs). The properties of PCB compounds cause them to undergo long-range transport, resistance to metabolic transformations, bioaccumulate in ecosystems, and have negative impacts on human and environmental health.

The PCB contaminant burden magnifies with an increase in trophic level through mechanisms of bioconcentration and biomagnification. This project is focused on Torch Lake, Houghton as it is designated as an Area of Concern. The concentration of PCBs in the fish are above the allowable limit, which causes the implementation of strict fish consumption advisories. This has a major impact on the Keweenaw Bay Indian Community which formerly used the lake for subsistence fishing.

A kinetic bioaccumulation model was developed as a predictive tool to estimate PCB concentrations in the food web. Therefore, it can determine the recovery of the ecosystem succeeding remedial actions aimed to remove local sources. The mechanistic model is helpful when actual testing is not feasible and to determine responses to ecosystem perturbations.

2. Improve Winter maintenance decision support with an Artificial-Intelligence (AI)-Enhanced framework

Author: Hossein Tavakoli Dastjerdi

Attributed to the advances in Artificial Intelligence (AI) in recent years, new sources of data and data techniques have become available to be considered for developing road maintenance tools with improved accuracy, autonomy, and intelligence. In this study, a web-based AI-enhanced app is introduced to boost the autonomous decision-making quality and precision of winter road operations.

For this purpose, three innovations were made. First, the Convolutional Neural Network (CNN), one of the most remarkable machine-learning algorithms in recent years for deep learning image classification, has been successfully employed to identify the snow coverage on the road surface. Second, an AI decision-making algorithm was proposed and implemented to support the road engineers and operators for real-time winter maintenance operations. Third, a Smart Maintenance Decision Support System (SmartMDSS) was developed as an AI-empowered web-based app. On the back end, SmartMDSS extracts and analyzes data and makes winter road maintenance decisions. On the front end, SmartMDSS provides a user-friendly graphical interface showing all the valuable data and winter operations for specific points on the road and sends necessary warnings and notifications.

The advantages of SmartMDSS were demonstrated in the pilot study: (1) the tool becomes more intelligent as more data is received, (2) SmartMDSS can significantly reduce administrators' need to install instrumentation devices on the roads, and (3) the tool can be easily adjusted for local road agencies for instant budget savings in road maintenance.

1.4 Cognitive and Learning Sciences

1. Types of Questions Teachers Ask to Engage Students in Making Sense of a Student Contribution

Author: Nishant Binte Alam

In the student center classroom, where teachers constantly make decisions based on what is happening surrounding them, what they are noticing, and how they are interpreting student contributions, a teacher's interpretation and response to student mathematical contributions plays an important role to shape and direct students' thinking.

In particular, failing to ask productive questions that help students to engage in a sense-making discussion could deteriorate cognitive opportunities. This research is planning to study what types of questions teachers indicate they would ask to engage students in making sense of a high-leverage student mathematical contribution, what Leatham et al. (2015) refer to as a MOST (Mathematically Significant Pedagogical Opportunities to Build on Student Thinking) and their reasoning about why particular questions are or are not productive. In this study, a scenario-based survey questionnaire will be sent via email to 100 middle and high school teachers. In the given scenario, a MOST has surfaced, and teachers will be asked three questions about how they would respond in the scenario.

This research could lead us to determine if teachers are selecting the questions which are likely to be productive in supporting students' mathematical thinking and why they select the questions that they do. Knowing this will inform future work with teachers to productively use student thinking in their teaching.

1.5 Computer Science and Applied Computing

Computer Science

1. Distance Judgment In VR

Author: Soheil Sepahyar

The goal of this study is to investigate the impact of modern Head-Mounted Displays (HMDs) such as the Meta Quest Pro on distance perception in Virtual Reality (VR). We also aim to explore whether using the see-through mode on these devices can improve distance estimation accuracy. Additionally, we will examine the potential correlation between participants' accuracy and speed in distance judgments. Previous research has shown that people tend to underestimate distances in VR compared to the real world, which can negatively affect VR applications. To measure distance judgments, direct blind walking is a popular method where participants view a target and then walk towards it while blindfolded.

Researchers typically require participants to practice blind walking beforehand, but few studies provide details about this "pre-experiment blind walking" (PEBW) procedure. Our study will vary the amount of PEBW and assess its impact on subsequent distance judgments in VR. Our results will highlight the importance of clear reporting of PEBW procedures and suggest that a consistent procedure may be necessary for reliable comparisons between direct blind walking studies.

2. WebTA: A Machine Learning-Based Code Critique

Author: Pradnya Pendse

Coding has become an essential skill in today's world, and it is increasingly becoming relevant in every field, with many people learning to code as a hobby or to pursue a career in technology. However, novices often struggle with identifying and correcting syntactical errors and exceptions in their code. This can lead to frustration and a lack of progress in their learning journey. Along with writing logically and functionally correct code, coding standards are equally important and essential for writing high-quality code that is easy to understand, maintain, and scale. The project aims to solve the problem of new coders struggling with syntax errors and a lack of knowledge about coding standards and best practices.

Our project is developing a code critiquer application using machine learning algorithms to analyze code and identify antipatterns, which comprise syntax and stylistic errors as well as exceptions. It will also use data mining techniques to extract relevant information from large datasets of existing code to identify common patterns and best practices that can be used to improve the quality of the code. The system will be trained using a large dataset of code samples. Application based on Machine learning has advantages such as adaptability, automation, scalability, and unbiased making it a more flexible and dynamic solution as compared to any rule-based traditional application. Code critiquer is designed to be a useful tool for beginner programmers to improve their coding skills and avoid common errors. Additionally, it is web-based architecture provides users with the convenience of accessing the application from anywhere in the world without requiring them to install any software, resulting in easy accessibility and increased usability.

1.6 Applied Computing (Mechatronics and Health Informatics)

1. Gabor Filter-Embedded U-Net with Transformer-based Encoding for Biomedical Image Segmentation

Author: Abel Reyes

Medical image segmentation involves a process of categorization of target regions that are typically varied in terms of shape, orientation, and scales. This requires highly accurate algorithms as marginal segmentation errors in medical images may lead to inaccurate diagnosis in subsequent procedures. The U-Net framework has become one of the dominant deep neural network architectures for medical image segmentation.

Due to complex and irregular shape of objects involved in medical images, robust feature representations that correspond to various spatial transformations are key to achieve successful results. Although U-Net-based deep architectures can perform feature extraction and localization, the design of specialized architectures or layer modifications is often an intricate task.

In this paper, we propose an effective solution to this problem by introducing Gabor filter banks into the U-Net encoder, which has not yet been well explored in existing U-Net-based segmentation frameworks. In addition, global self-attention mechanisms and Transformer layers are also incorporated into the U-Net framework to capture global contexts. Through extensive testing on two benchmark datasets, we show that the Gabor filter-embedded U-Net with Transformer encoders can enhance the robustness of deep-learned features, and thus achieve a more competitive performance.

1.7 Forest Science

1. **"Restoration is Repairing Relationships" Manoomin (wild rice, zizania palustris) restoration in Keweenaw Bay Indian Community Homelands**

   Author: Cassandra Reed-VanDam

This research is focused on determining effective restoration efforts for wild rice (zizania palustris) within Keweenaw Bay Indian Community (KBIC) homelands using both ecological and cultural metrics. Wild rice, or manoomin in the Ojibwe language, is a culturally and ecologically significant plant relative for the KBIC, an Ojibwe nation located on the L'Anse Indian Reservation as established by the Treaty of 1854. Historically and currently, manoomin is a dietary staple present at many seasonal feasts and celebrations as well as a source of spiritual connection and teachings. Manoomin is an annual, emergent plant present in shallow, slow-flowing cool waters with occasional hydrological disruptions, often growing in soft muck, with large roots holding loose sediment and preventing erosion. The seed is a nutritious food source for many species, including fall migrating waterfowl, and the grass acts as a nursery and brooding habitat for many fish, ducks, and geese.

Historically, manoomin was present across much of the northern Great Lakes area, however their lake presence has declined since the early 1900s. Much of this loss is attributed to human development, specifically hydrologic changes due to damming, sulfate pollution from mining, introduction of invasive species, and rising winter temperatures due to climate change. While a culturally and ecologically important species, there is limited data about the effectiveness of restoration efforts in Michigan. Specifically, this research will address three objectives: 1) analyze existing data inventories of historical restoration efforts within KBIC homelands for a cohesive assessment, 2) define what successful restoration is for the KBIC in order to determine cultural and ecological metrics of success through semi-structured interviews with tribal rice harvesters and participant observations at community events, and 3) develop a KBIC specific guidance document with site-specific monitoring methods and good manoomin restoration practices.

2. Genetic Assessment of Isle Royale Wolves

Author: Samuel Hervey

Isolated populations of wildlife will have reduced genetic diversity which can impact evolutionary potential and result in the expression of deleterious alleles that reduce fitness and impact population viability. This was well documented over the last two decades for the gray wolves (Canis lupus) of Isle Royale. In 2017, only two wolves remained on the island that were unlikely to produce viable offspring due in part to a high level of inbreeding. To restore ecosystem dynamics to Isle Royale, 19 wolves were translocated in 2018 and 2019 from Grand Portage, MN (n=4), western Upper Peninsula, MI (n=4), Jostle Lake, ON (n=3), and Michipicoten, ON (n=8). As the founding population becomes established, it is important to monitor inbreeding to determine if and when further management action would be warranted.

To assess the founding population on Isle Royale we identified relationships among founders and estimated inbreeding coefficients using multiple molecular methods. We found wolves translocated from Michipicoten, ON were a family group consisting of a mother, a father and their six offspring. Of the wolves genotyped so far, two breeding pairs have been identified. The West end breeding pair consist of a female from Grand Portage, MN and a male from Michipicoten, ON, while the East end pair are full siblings translocated together from Michipicoten, ON. Future research will involve using noninvasive molecular methods to sample the remaining ungenotyped offspring to reconstruct the full pedigree on Isle Royale.

3. Estimating Trace Gas Flux Dynamics in Boreal Wetlands

Author: Eleanor Serocki

Peatlands, a type of wetland defined by deep carbon rich soils, are one of the most significant stores of carbon on the planet. However, given shifting hydrology with climate change, they are at risk of becoming one of the most significant non-anthropogenic sources of carbon. Because of the importance and volume of arctic and boreal peatland carbon stocks it is imperative that reliable models are available to estimate the rate of carbon loss into the atmosphere from these vulnerable ecosystems.

The spatially explicit models for trace gases (CO2 and CH4) are highly variable in landscapes dominated by peat complexes, and therefore fail to allow managers and policymakers to account for radically changing atmospheric carbon inputs. Using bottom-up remote sensing methods to estimate CH4 and CO2 fluxes in these key systems will inform Earth system modelling efforts necessary for understanding the effects of trace gas emissions on climate change scenarios.

We propose to use over 15 years of continuous long-term data collected from an Alaskan rich fen in order to 1.) investigate the mathematical relationship between water table depth and gas flux 2.) integrate vegetative cover as a potential control of gas flux within this context 3.) utilize space-based sensors to map water table and, therefore, produce a spatially explicit map of gas flux for our study systems.

4. Comparative analysis of the Quercus rubra and Q. ellipsoidalis genome structure

Author: Swapan Chakrabarty

Oaks (Quercus spp.) are the most abundant tree genera in the Northern Hemisphere, and they are widely distributed in the Americas, Asia, Europe, and North Africa. The rapid change in climatic and edaphic factors pose severe threats to the growth and survival of oak populations. The geographical distribution of the northern pin oak (Quercus ellipsoidalis) is much smaller than Q. rubra, but Q. ellipsoidalis is adapted to sandy, well-drained soils. This makes it an ecologically important species and a potential model for understanding adaptation to an environment.

The adaptation and stability of oaks in their present locations have significantly been affected by environmental changes, which can cause subsequent changes in the ecosystem. The Q. ellipsoidalis samples were collected from two hybrid zones where populations of pure species meet; these samples were used for whole genome sequencing. The BUSCO genome completeness is 98.0% with N50 of 61697690 bp.

In this study, we compared the genome structure of Q. ellipsoidalis with Q. rubra. The genome of Q. ellipsoidalis provides strong fundamentals of understanding the adaptation of oaks in the local environment. Our study not only introduces new genomics resources for Q. ellipsoidalis research but also exemplifies how structural variation drives fundamental functional discoveries in oak adaptation.

1.8 Geology and Mining Engineering and Science

Remote Sensing using Machine Learning for Off-Road Mobility

Author: Jordan Ewing

Terrain strength properties are critical when trying to achieve accurate mobility performance predictions for reliable operational planning using the NATO Next Generation-Reference Mobility Model (NG-NRMM). In situ measurements are the current approach to gathering this information. This data can be difficult to obtain from unknown territories and combat zones and place soldiers in harm's way. To avoid these limitations and risky scenarios, one needs to gather these soil properties remotely for generating Go / No-Go maps. (OPSEC # 7137).

1.9 Mathematics

Integrating External Controls by Regression Calibration for Genome-Wide Association Study

Author: IIrong Zhu

The genome-wide association study (GWAS) has successfully revealed many diseases associated variants. For a case–control study, the adequate power of association test can be achieved with a large sample size, although genotyping large control samples is expensive. A cost-effective strategy is proposed by integrating external control samples with publicly available genotyped data. However, the naïve integration of external controls may inflate the type I error rates if ignoring the systematic differences (batch effect) between studies, such as the differences in sequencing platforms, genotype calling procedures, population stratification, and so forth.

To account for batch effect, we propose to integrate External Controls into Association Test by Regression Calibration (iECAT-RC) in case-control association studies. Simulation studies showed that iECAT-RC not only can control type I error rates but also can boost statistical power in all models. We also applied iECAT-RC to the UK Biobank for the hypertension disease by considering genotype calling as the batch effect. The real data result shows that iECAT-RC can detect additional hypertension associated locus.

1.10 Mechanical Engineering

1. A Combined Active and Passive Micro-nucleation Enhancement Approach for High Heat-flux Flow-boiling Operations - Enabling Applications such as Next Generation Heat Sink for Electronic Chip Cooling System

Author: Divya Pandya

This presentation will describe the status of effective approaches for new heat-sink designs that address next-generation electronic cooling needs – specifically at chip or CPU levels. A unique and cost-effective flow-boiling approach is developed and demonstrated at the laboratory level – for a single channel "part" of a typically multi-channel heat-sink.

The presentation will describe enabling high heat-flux (70 – 200 W/cm2) flow-boiling based heat-sinks that use a more benign and electronically compatible fluid (environment friendly – GWP 300 - 400 (100 yr ITH) – liquid from 3M, Inc Novec 7000/7100) with boiling-surface temperatures near 40 - 60 ℃ and heat-sink pressures in 0.9 – 1.5 bars range. Proof of concept (PoC) experiments' successful demonstration of the fact that the proposed Active/Passive approach – of using micro-structured boiling surfaces in conjunction with resonant "in-plane" vibrations and oscillatory boiling-surface shear stresses for controlled but explosive growth in micro-nucleation rates – is promising. A controlled but explosive growth in micro-scale nucleation rates during flow-boiling of Novec HFE 7000/7100 is enabled by the uses of inexpensive meshed-copper for micro-structuring of the boiling surface and a pair of Piezoelectric-transducers for active imposition of suitable acoustic vibrations.

Since micro-structuring of boiling-surface is known to significantly enhance flow-boiling performance, the reported experiments employ a specific micro-mesh and diffusion-bonding based inexpensive approach to micro-structuring of the boiling-surface (leading to 40 – 60 % improvements in heat-flux – all else being the same – over plane unstructured copper-surface). At desired high heat-fluxes, these operations yield unacceptable performances, such as large pressure drops and instabilities due to causes within the heat sink, resulting in Critical Heat Flux (CHF) instability or outside of it, at the system-level, in any of its components. Large values of total mass-flux and very large vapor volume fluxes required for such high heat-flux values also lead to large pumping powers and unacceptable performances (flow instabilities, etc.).

For achieving low pressure-drops and a flow-control based stable operations that avoid system-level instabilities at even higher CHF values than what has been achieved in the Proof of Concept (PoC) experiments, the similar new experimental setup has been built. The meshes are ideal for transmitting longitudinal standing waves in a way that suitable amplitudes and frequencies of shear stresses can be induced in the micro-layers of the nucleating bubbles on the top-most mesh exposed to the working fluid. Therefore, micro-structuring approach is made much more efficient – with the associated reported patent targeting electronic cooling applications – by resonant acoustic energization through electronically controlled Piezoelectric-transducers.

2. Scheduling Multiple Tethered Underwater Robots for Entanglement Free Navigation

Author: Abhishek Patil

This work provides an operational strategy for the underwater multi-agent system of tethered robots, which are utilized in many real-world applications, such as surveillance, inspection, maintenance, exploration, and monitoring.

Specifically, this research focuses on developing an algorithm that prevents 1) the collision of the robots and 2) the entanglement of the tethers by determining the appropriate departure/arrival time at every node on the route for each robot. Based on the preliminary work on multi-robot system task allocation and path planning, we assume that the robots are given the routes for their missions. The proposed approach repetitively simulates the movement of the robots along their respective routes.

We have confirmed that the proposed algorithm can detect and prevent cable entanglements and collisions of the robots while moving along their convoluted paths, irrespective of the degree of complexity. The algorithm was repeatedly tested in a simulation with varying problem sizes to verify its effectiveness. The computational results show that the algorithm can produce reliable solutions to apply in real-time operations within a reasonable time.

3. Phase field regularized interface fracture modeling in fiber reinforced polymer composites

Author: Akash Kumar

Damage and failure in fiber reinforced polymer composites (FRPCs) are generally caused due to matrix cracking, fiber breakage, fiber-matrix debonding and delamination. Experimental investigation suggests that the delamination or interlaminar fracture is one of the most commonly observed failure mode in these materials. This happens due to the high interlaminar stresses in conjunction with the very low through thickness strength. In this work we attempt to characterize the interlaminar fracture behavior in carbon fiber reinforced composites (CFRP) using the phase field fracture model. In the proposed formulation, the phase field smears the sharp interfaces as regularized cohesive zones and also describes the bulk crack surface density allowing interaction between bulk crack and interface damage. In this way, the displacement jump created by the sharp interface is approximated as a smooth transition based on a first order Taylor series expansion of the assumed smoothed regularized displacement field.

We developed an approach to model the constitutive behavior of the FRP composite as a homogenized material consisting of an elastic matrix and axially deformable fibers characterized by the fiber volume fractions and orientations. The proposed model was implemented in ABAQUS/Standard by writing a user-element subroutine (UEL) to understand the fracture behavior of composite laminates in various loading conditions. Simulation was performed on double cantilever beam (DCB) with 0o fiber orientation to study the effect of regularization length for the smeared interface, and the interface traction separation properties (fracture strength and energy) on the global response. Furthermore, three-point bend specimens with different combination of laminas have been simulated, such as 90-90, 90-45 and 90-0.
In the case of 90o-90o laminates, the crack was observed to grow straight through the laminate and no delamination was noticed, however for 90o-45o and 90o-0o laminates, delamination was identified as the major cause of failure. In future we plan to validate our model predictions with experimental data for composites where fracture is dominated by interfacial failure and to extend this model for 3D composite fracture. The proposed model for interface fracture in FRPCs is easier to implement in a phase-field fracture framework and effective compared to the conventional cohesive zone-based approaches.

4. Snow Sensing for Photovoltaics single axis trackers

Author: Ayush Chutani

With the rapid deployment of photovoltaic (PV) systems around the world, PV is expanding in northern climate regions where snowfall is a major challenge for solar PV farms. Single axis trackers (SATs) increase the generation of solar plants at a competitive price and using bifacial panels is most effective in snow clad white ground due to high albedo. The objective of this project is to design and validate a snow measurement system that can measure snow on the top of moving panels by using laser-based sensors and digital image capture and to develop advanced tracker controls for improved snow shedding and higher efficiency in winters.

The study is complemented by power generation measurement at panel and string levels as well as plane of array solar irradiation; meteorological data at the location is recorded for the correct weather assessment and ultrasonic snow depth measurement at ground level provides a comparison for snow measurements. The target panels are observed by various cameras to provide a holistic image of snowfall and shedding events. Considering the need for correct measurement of snow on the surface of PV panels, a snow measurement system enables the development of an empirical classification that can help in correlation of the angles needed to shed the snow.

Snow shedding is an important factor in northern climates as it can increase the period for which the PV panels are generating power. This paper focuses on the novel snow measurement system design and prototype that measures snow on the top of moving solar PV panels.

5. Electrical Stimulation for Maturation of Heart Muscle Cells

Author: Roya Bagheri

Heart diseases are the main reason for mortality worldwide. In vitro heart, tissue models have heart regeneration, disease modeling, and drug testing applications. The immaturity of cardiomyocytes is one of the greatest drawbacks of the in vitro myocardium models. Electrical Stimulation is a promising method of promoting cardiomyogenic expression in vivo and in vitro. The stimulation setups used previously for stimulating cardiomyocytes mainly apply electric fields parallel to the substrate, which are not uniformly sensed by cells, i.e.

Here, we customized an electrical cell stimulation and recording apparatus (ESCARA) to apply uniform through-thickness and myocardium-relevant electrical stimulation to individual heart tissue models to help the development of cardiomyocytes. Furthermore, we investigated the effect of substrates of different thicknesses and conductivity on the electrical field and, consequently, on cardiomyocyte maturation. The electrical stimulation setup was 3D printed using a design similar to a common 24-well cell culture plate. The cardiomyocytes were isolated from 1-3-day-old neonatal rat hearts and cultured on different substrates for ten days. Substrates included Silicon (Si), Polydimethylsiloxane (PDMS), Polyethylene Terephthalate (PET), Polyvinyl Alcohol (PVA), and PVA-MXene composite to examine the effect of conductivity and thickness of substrates in the setup. Square pulses with a duration of 1 ms, an amplitude of 5 V, and a frequency of 1 Hz were continuously applied to the cells from days 5 to 8 of the culture.
The performance of cardiomyocytes was studied using immunofluorescence cardiomyocyte labeling (alpha-actinin). The expression of cardiomyocyte and maturation-relevant genes ACTC1 (actin alpha cardiac muscle), Myh6 (myosin heavy chain), TNNT2 (cardiac troponin T part of muscle contraction), and Gja1 (gap junction) was characterized by qPCR on day 8. The cells expressed mature cardiomyocyte markers of alpha-actinin.

Quantification of the expression of cardiac genes shows that electrical stimulation enhances the maturation of cardiomyocytes for thin samples (PET, PVA, and PVAMXene composite), which do not disturb the electric field. Hence, cells are entirely influenced by the electric field for conductive and non-conductive thin samples. Thicker and semiconducting samples (Si and PDMS) produce inconsistent data, i.e., the expression of some genes showed a significant difference, whereas others did not.

In conclusion, our customized electrical stimulation setup improved the expression of cardiac-specific genes. The setup can mimic in vivo cues for in vitro cell and tissue models to make them more suitable for cardiac regeneration and disease/drug testing applications.

6. Nonlinear Model Predictive Control of a Wave Energy Converter

Author: Tania Demonte Gonza

Wave energy is an attractive source of renewable energy due to the predictability of waves. However, efficient optimization of wave energy devices is crucial for transitioning from government-funded research to the competitive energy market. This study demonstrates the effectiveness of a nonlinear Model Predictive Controller (MPC) in optimizing the energy extraction of a heaving point absorber wave energy converter (WEC).

The WEC model accounts for nonlinear dynamic and static Froude-Krylov forces. The nonlinear MPC is evaluated under irregular waves over the power production region, with displacement and control force constraints to ensure safe operation while maximizing energy absorption. The nonlinear MPC approach is compared with a linear MPC strategy that approximates the Froude-Krylov forces linearly. The results reveal that the nonlinear MPC outperforms the linear MPC in terms of energy absorption.

7. Predicting the electronic structure of large-scale bulk metallic systems using machine learning

Author: Shashank Pathrudkar

We introduce a novel machine learning framework to predict the electron density of bulk metals and alloys at larger systems, which are inaccessible to Kohn-Sham (KS) density functional theory (DFT). Although KS-DFT is widely employed in materials research, its computational demands restrict it to smaller systems.

To overcome this computational bottleneck, we developed a machine learning-based approach that maps the atomic environment to the electron density using a novel representation for atomic environment that is frame-invariant and does not require any handcrafting or basis selection. Our method utilizes a ResNet-based neural network trained on DFT simulation data, with a transfer learning approach that involves initial training on DFT simulations of small simulation cells and further tuning using a very small amount of data from larger simulation cells.

To demonstrate the effectiveness of our model and transfer learning approach, we trained our model on simulation trajectories of a 32-atom aluminum system at various temperatures and implemented transfer learning using a single small length simulation of a 108-atom system to predict electron density for large-scale aluminum systems. We validate this model by predicting the electronic densities of the 500 and 1372 atom Al system and comparing it with the reference DFT results. The transfer learning approach significantly reduces the training data generation cost, given the $O(N^3) $ scaling of KS-DFT. The proposed model accurately predicts electronic structures for large systems while being several orders of magnitude faster than DFT and scales linearly with the number of atoms. We anticipate that this model can be used for any bulk metals and alloys and will be particularly effective for prediction of electronic structures at various alloy compositions.

1.11 Physics

1. Light Absorbing Aerosol – Cloud Interactions (LAACI)

Author: Shreya Joshi

Atmospheric light-absorbing aerosols, such as particles containing black carbon, significantly impact Earth's climate. These particles interact with the solar radiation scattering and absorbing light and they interact with clouds changing the cloud properties as well as being changed by in-cloud processes. Morphological changes of black carbon and per-particle internal mixing with other materials, such as organic coatings, affect the particle's scattering and absorption properties.

These processes have been the subject of previous studies; however, interactions of black carbon-containing particles with clouds have received less attention, and important questions remain open. Our LAACI project was designed to investigate these light absorbing aerosol – cloud interactions in the Michigan Tech cloud chamber. Initial experiments have been carried out to: (a) classify black particles using an aerodynamic aerosol classifier in tandem with a differential mobility analyzer, to remove multiply charged particles, (b) characterize the dry deposition rate of aerodynamically size selected black carbon particles in the chamber, (c) optimize a pumped counterflow virtual impactor to reject interstitial particles and collect residual particles from the evaporation of water droplets, and (d) characterize the optical and chemical properties of a surrogate for biomass burning organic material to be used as coating on black carbon particles.

Cloud experiments are planned to: (a) investigate changes in the morphology of the black carbon particles aggregates upon cloud activation and evaporation, (b) study changes in optical and cloud condensation nuclei properties of interstitial and residual particles, (c) explore the effects of coating material on black carbon particles and how these coatings affect aerosol-cloud interactions and the resulting aerosol and clouds properties. An overview of the project and the preliminary findings will be presented.

2. Optical Properties of Atmospherically Aged Tar Balls from the Free Troposphere

Author: Susan Mathai

Tar balls are particles emitted from biomass combustion which are light absorbing, amorphous, and highly viscous in nature. These spherical particles are transported into the troposphere and potentially can have a significant impact on the Earth's radiative balance. However, their climatic impacts are highly uncertain due to poorly constrained optical properties. In this study, we collected aerosol samples from the ACTRIS/GAW global station of Mt. Cimone, Italy at an altitude of 2165 m above sea level during summer of 2017. In several of the samples collected at the site, we found an abundance of tar balls. These samples are interesting because tar balls collected from the free troposphere underwent atmospheric processing, such as surface oxidation and polymerization, before reaching the collection site.

We determined the refractive index of single tar balls using electron energy loss spectroscopy for a broad wavelength range, from 200 to 1200 nm. From transmission electron microscopy (TEM) coupled with EDX we found particles with different mixing states such as tar balls mixed with soot, coated soot, externally mixed tar balls, tar balls mixed with potassium and sulfur and low viscosity secondary organic aerosols. Hence, we classified the tar balls into two groups, as internally and externally mixed, to study potential variations of the refractive indices with the mixing state.

We found that the average refractive index of internally mixed tar balls is 1.40 ± 0.05 and that of externally mixed tar balls is 1.36 ± 0.07. Furthermore, we used scattering and absorption efficiencies retrieved from Mie simulations to calculate the potential tar balls radiative forcing. Finally, we compared the radiative forcing of tar balls calculated from the optical properties published in different previous studies to understand the effect of differences in the reported refractive indexes.

3. Optical Properties of 2d Materials Beyond Graphene

Author: Manpreet Bohra

Transition metal dichalcogenides (TMDs) of semiconductor band structures have recently emerged as a new family of two-dimensional (2D) materials.TMDs have gained a lot of interest because of the additional degree of freedom arising from the twist angle, which offers a new platform for studying twist angle-dependent interlayer excitons, and phonons in stacked systems.Our research focuses on the precise control of the interlayer twist angle with a clean and large interfacing area.Our work makes significant contribution in understanding the phonon interactions using Raman spectroscopy for twisted bilayer structures.

4. Constraining Frictional Charging on Coarse Mode Atmospheric Dust Particles

Author: Ian Norwood

Coarse mineral dust grains larger than 5 microns have been shown to make significant contributions to global climate processes, impact regions experiencing desertification, and cause urban air quality issues. However, the most commonly used Earth climate models consistently underestimate the presence of coarse dust in the atmosphere. Constraining the frictional charging effects on these particles in the atmosphere may play a major role in improving the predictive power of models, where coarse dust potentially contributes up to 58% of total lost mass.

To correct these discrepancies and better understand the frictional 'triboelectric' charging effects on charge transfer between particles, it is necessary to measure the electrical charging dependency on varying size distributions. To achieve this, a small-scale experimental apparatus will be constructed, based on prior single-particle charge lifetime measurements. The addition of a both new and previously explored experimental group-charging setups will be used in combination with single-charge data to measure the electrical field and polarity dependence on particle size and quantity.

This data will then be used to refine the assumptions in current aerosol models and inform the development of a new, dynamic 3D electric field model, which can help to model the transportation of atmospheric dust and their associated 3D electric fields with additional charge-based coagulation assumptions.

1.12 Physiology and Kinesiology

1. **Brain-Derived Small Extracellular Vesicles from Dahl Salt-Sensitive Rats with High Salt Diet Induce Inflammation and Oxidative Stress**
   Author: Xinqian Chen

It has been reported that small extracellular vesicles (sEVs ≤ 200 nm) are implicated in the pathogenesis of multiple diseases including hypertension. However, the role of brain-derived sEVs in the development of salt sensitive hypertension (SSHTN) remains unclear.

We hypothesized that brain-derived sEVs from high salt diet-treated rats can induce inflammation and oxidative stress in the central nervous system (CNS). To test this hypothesis, brain-derived sEVs of Dahl salt-sensitive rats with high salt (HS) diet (Dahl-HS-sEV) were used to treat primary brain neuronal cultures and microinjected into brain lateral ventricles, respectively, proinflammatory cytokines, chemokines, and oxidative stress markers were measured through real-time PCR or fluorescent probes. sEVs isolated from Sprague Dawley (SD) rats with normal salt (NS) diet (SD-NS-sEV) were used as a control.

Data showed that Dahl-HS-sEV increased mRNA levels of inflammatory cytokines including TNFα (2.3-fold) and IL1β (3.7-fold), and chemokines including CCL2 (2.4-fold), CCL5 (2.1-fold), and CCL12 (4.2-fold), with significant difference ($P<0.05$). In addition, Dahl-HS-sEV treatment increased mRNA levels of transcription regulator, NF-κB (1.4-fold), and neuronal activation marker, c-FOS (1.3-fold), as well as CYBA (1.7-fold), in primary neurons, compared to SD-NS-sEV-treated cells ($P<0.05$). Confocal images showed that Dahl-HS-sEV significantly increased mitochondrial ROS levels, with total fluorescence intensity increased 1.6-fold relative to SD-NS-sEV treatment ($P<0.01$). SD-NS rats receiving intracerebroventricular injection of Dahl-HS-sEV had increased ($P<0.05$) PVN mRNA levels of IL1β (4.3-fold), CCL5 (2.6-fold), IL-6 (3.4-fold) and NOS2 (5.2-fold), compared to rats receiving SD-NS-sEV (5.5 μg/rat, n=4), 6h after injection.

These results suggested that in SSHTN, brain-derived sEVs may induce central inflammation and oxidative stress, which in turn results in an elevation of arterial blood pressure.

2. Presentation Abstracts

2.1 Biology and Biomedical Engineering

Biological Sciences

1. STK11/LKB1 Inactivation Sensitizes Cancer Cells to PDE3A Modulators

Author: Catherine Rono

Liver Kinase B1 (LKB1) is known as a serine/threonine kinase (STK11) and plays diverse roles in organisms. The functions of LKB1 mainly depend on phosphorylation and activation of various downstream kinases within the superfamily of AMP-activated protein kinases. Particularly, LKB1 functions as a pivotal tumor suppressor in humans and its loss contributes to tumorigenesis. In non-small cell lung cancer (NSCLC), LKB1 ranks as the third most commonly mutated gene. Metabolic regulation of LKB1 exhibits an essential role in this context, but most of the relevant mechanisms are undetermined. Here, we performed the transcriptomic profiling analysis and identified LKB1-dependent suppression of phosphodiesterases (PDE), which reveals a novel role of LKB1 in cyclic monophosphate metabolism.

Specifically, LKB1 suppresses PDE3A expression through activation of the downstream salt inducible kinase (SIK). Early evidence suggested that PDE3A modulators, such as anagrelide and estradiol, kill PDE3A-positive tumor cells via formation of PDE3A-SLFN12 complex. We uncovered that PDE3A modulators can selectively eliminate LKB1-deficient tumor cells, but not LKB1-intact cells. However, some of LKB1 deficient tumor cells, even with high PDE3A expression, were exceptionally resistant to PDE3A modulators. Resistance appears because SLFN12 is epigenetically silenced in those cells.

We found that expression of SLFN12 can be induced by either forced elevation of cAMP or epigenetic inhibitors, by which the resistance can be abolished. Overall, our findings not only reveal a new role of LKB1 in regulation of cAMP metabolism, but also suggest a novel targeted therapy for LKB1-deficient cancers.

2. MicroRNA-483 Deficiency in Pancreatic β-cells Stimulates Stress-Induced β-cell Dedifferentiation.

Author: Katy Matson

MicroRNAs (miRNA) are a group of small non-coding RNAs that negatively regulate target gene expression in response to metabolic changes in pancreatic islets. Dysregulation of miRNAs plays a crucial role in controlling the pathogenesis of diabetes. Our previous studies have identified higher expression of miR-483 in β-cells compared to α-cells. Mice with β-cell specific deletion of miR-483 (miR483-/-) exhibited high fat diet (HFD)-induced hyperglycemia and reduced glucose tolerance by the diminishing release of insulin. During the development of type 2 diabetes (T2D), β-cell dedifferentiation, or reversion, has been discovered to be a pathological mechanism for β-cell loss and dysfunction. Dedifferentiated β-cells transform to progenitor-like cells or transdifferentiate, or convert, to other endocrine cell types, like α-cells. However, the specific processes involved in these cell conversions are still under investigation. Notably, after HFD feeding the islets of miR483-/- mice showed elevated expression of aldehyde dehydrogenase family 1, subfamily A3 (Aldh1a3), a marker of β-cell dedifferentiation and a direct target of miR-483.
In this study, we induced diabetes with HFD and/or treatments of streptozotocin (STZ) and identified that a higher proportion of ALDH1A3-positive β-cells were colocalized with glucagon in miR483-/- mice compared to the control mice. Further confirmation of increased glucagon contents was shown in miR483-/- islets and miR483-deleted MIN6 cell line cells when treated with palmitate or STZ.

In addition, the loss of miR-483 significantly increases multiple enzymes, including gamma-glutamyltransferase (GGT1), involved responses in adaptive oxidative stress potentially leading to mitochondrial dysfunction. In conclusion, our data indicated that miR-483 is important for protecting β-cell identity, and miR-483 deficiency induces β-cell dedifferentiation and oxidation stress.

Biomedical Engineering

3. Impact of Atrial Hemodynamics on the Development of Device Related Thrombosis

Author: Brennan Vogl

Atrial fibrillation (AF) is the most common arrythmia in the world. Blood stasis in the left atrium (LA) — as a result of AF — is associated with thrombus development and often occurs in the left atrial appendage (LAA). Although anticoagulants are effective in mitigating strokes, their side effects make them unusable in many patients. A common alternative for reducing LAA related stroke, is to use a left atrial appendage occlusion (LAAO) device. Unfortunately, studies have also shown that about 3.8% of patients develop device related thrombosis (DRT) after LAAO. The factors leading to DRT are still unclear despite several clinical studies investigating potential predictors. The aim of this study is to evaluate the hemodynamic profiles of the LA in patients who have received an occlusion device, and to identify potential predictors for DRT.

Digital 3D patient-specific models were created from computed tomography scans. Finite element analysis (FEA) was used to deploy an occlusion device in each model. Computational fluid dynamic (CFD) simulations were performed on the models. Time averaged wall shear stress (TAWSS), oscillatory shear index (OSI), and endothelial cell activation potential (ECAP) were calculated for the top surface of the devices.

We observed lower TAWSS, higher OSI, and elevated ECAP on the top surface of device for the DRT patients. It has been reported that non-physiological levels of TAWSS are associated with an increased risk of thrombus formation. Understanding ECAP is of particular importance due to the endothelization that occurs after the deployment of an occlusion device. Flow abnormalities/disturbances and stasis have been reported for patients with AF. These disturbances can result in endothelial cell dysfunction which is associated with adverse cardiovascular outcomes like thrombogenesis.

In this study, we have demonstrated the feasibility of a combined FEA and CFD approach for the assessment of DRT in the LAA after LAAO.

4. **Computerized Differentiation of Growth Status for Abdominal Aortic Aneurysms**
   Author: Seyedmostafa Rezaeitaleshmalleh

Fast-growing abdominal aortic aneurysms (AAA) have a high rupture risk and poor outcomes if not promptly identified and treated. Our primary objective is to improve the differentiation of small AAAs' growth status (fast versus slow growing) through a combination of patient health information, computational hemodynamics, geometric analysis, and artificial intelligence. 3D computed tomography angiography (CTA) data available for 70 patients diagnosed with AAAs with known growth status were used to conduct geometric and hemodynamic analyses. Differences among ten metrics (out of ninety metrics) were statistically significant discriminators between fast and slow-growing groups. Using a support vector machine (SVM) classifier, the area under receiving operating curve (AUROC) and total accuracy of our best predictive model for differentiation of AAAs' growth status were 0.86 and 77.50%, respectively.

In summary, the proposed analytics has the potential to differentiate fast from slow-growing AAAs, helping guide resource allocation for the management of patients with AAAs.

5. **Deep-learning-based Image Segmentation for Image-based Computational Hemodynamic Analysis of Abdominal Aortic Aneurysms: A Comparison Study**
   Author: Zonghan Lyu

Computational hemodynamics is increasingly being used to quantify hemodynamic characteristics in and around abdominal aortic aneurysms (AAA) in a patient-specific fashion. However, the time-consuming manual annotation is hindering the clinical translation of computational hemodynamic analysis.

Thus, we investigate the feasibility of using deep-learning-based image segmentation methods to reduce the time required for manual segmentation. Two of the latest deep-learning-based image segmentation methods, ARU-Net and CACU-Net, were used to test the feasibility of automated computer model creation for computational hemodynamic analysis. Morphological features and hemodynamic metrics of 30 CTA scans were compared between predictions and manual models.
Results: The DICE score for both networks was 0.916, and the correlation value was above 0.95, indicating their ability to generate models comparable to human segmentation. The Bland-Altman analysis shows a good agreement between deep learning and manual segmentation results. Compared with manual (computational hemodynamics) model recreation, the time for automated computer model generation was significantly reduced (from ~2hr to ~10min).

Conclusions: Automated image segmentation can significantly reduce time expenses on the recreation of patient-specific AAA models. Moreover, our study showed that both CACU-Net and ARU-Net could accomplish AAA segmentation, and CACU-Net outperformed ARU-Net in terms of accuracy and timesaving.

2.2 Chemistry and Chemical Engineering

Chemistry

1 Oligonucleotide Synthesis under mild Deprotection Conditions

Author: Komal Chillar

Over a hundred non-canonical nucleotides have been found in DNA and RNA. Many of them are sensitive toward nucleophiles. Because known oligonucleotide synthesis technologies require nucleophilic conditions for deprotection, currently there is no suitable technology for their synthesis. The recently disclosed method regarding the use of 1,3-dithian-2-yl-methyl (Dim) for phosphate protection and 1,3-dithian-2-yl-methoxycarbonyl (Dmoc) for amino protection can solve the problem. With Dim-Dmoc protection, oligodeoxynucleotide (ODN) deprotection can be achieved with NaIO4 followed by aniline. Some sensitive groups have been determined to be stable under these conditions. Besides serving as a base, aniline also serves as a nucleophilic scavenger, which prevents deprotection side products from reacting with ODN. For this reason, excess aniline is needed.

We report the use of alkyl Dim (aDim) and alkyl Dmoc (aDmoc) for ODN synthesis. With a Dim-aDmoc protection, deprotection is achieved with NaIO 4 followed by K 2 CO 3. No nucleophilic scavenger such as aniline is needed. Over 10 ODNs including one containing the highly sensitive N4 -acetyl cytidine were synthesized. Work on extending the method for sensitive RNA synthesis is in progress.

2 Click Chemistry approach provides GLUT5-Targeting Glycoconjugates as potential more specific PET Imaging Probes

Author: Adelina Oronova

For decades, fluorodeoxyglucose (18F-FDG) has been the “gold standard” tracer for Positron Emission Tomography (PET) imaging of cancer as it reports a regional disease-linked increase in glucose demand. Nevertheless, false positive results are common, as increased glucose metabolism is also observed if infectious/inflammatory conditions are present. It leads to the accumulation of 18F-FDG in these regions through the ubiquitously present in all tissues facilitative sugar transporters (GLUTs). Diagnosis and staging of some cancers are also difficult due to the false-negative results since not all cancers rely on glucose for development and progression.

Hence, targeting pathways specific to cancer is desired for developing novel PET imaging agents to be diagnostically beneficial. Since many cancers significantly rely on fructose upon development, growth, and progression, fructose-transporting GLUTs are seen as diagnostic targets. Among these GLUTs, fructose specific GLUT5 transporter is a unique target for the development of PET imaging agents.

We report a fluoride-functionalized probe that specifically targets GLUT5 in the presence of sugar nutrients. The use of a late-stage functionalization strategy enabled by the click chemistry approach in the synthesis of the probe supports the extension of the current synthetic methodology to obtaining 18F-analogs for future GLUT5-specific in vivo cancer imaging probes. To access ManCou-F1, the glycoconjugate of coumarin and fructose-targeting sugar mimic (2,5-anhydro-D-mannitol, 2,5-AM) was used as a starting material for the late-stage click chemistry functionalization. The uptake of the new ManCou-F1 probe was investigated using a GLUT5-positive breast adenocarcinoma MCF7 cell line (early stage of cancer). Through multiple inhibition studies, it was established that the ManCou-F1 probe enables specific direct analysis of GLUT5 activity in cells in complete nutrient media. Data on the probe’s cancer selectivity, GLUT5 specificity, cytotoxicity, and uptake efficiency will be presented.

To conclude, a non-radiolabeled fluoride 2,5-AM–coumarin-based probe (ManCou-F1) compatible with late-stage functionalization has the potential to serve as a PET imaging agent for fructose-dependent diseases.

3 Effects of Epitranscriptomic RNA Modifications on the Catalytic Activity of SARS-CoV-2 Replication Complex

Author: Alexander Apostle

SARS-CoV-2 causes different symptoms and different degrees of harmfulness to different individuals. Potential reasons include an individual's viral dose exposure, the affinity of an individual's ACE2 to the spike protein of the virus, and the ability of the induced immune system to neutralize the virus. Beyond these, an individual's epitranscriptomic system could be among the causes as well. The viral RNA genome, once inside the host cell, can be subject to modifications by the host's epitranscriptomic machinery. Because the expression of the machinery varies in different individuals, it is reasonable to believe that RNA modifications of SARS-CoV-2 RNA are different as well and can positively or negatively affect downstream events that involve the RNA, such as, replication of the viral genome.
In this context, we synthesized several RNA templates containing modifications including pseudouridine (Ψ), 5-methylcytosine (m5C), N6-methyladenosine (m6A), N1-methyladenosine (m1A) and N3-methylcytosine (m3C) and studied their effects on the catalytic activity of SARS-CoV-2 replication complex (SC2RC), which included RNA dependent RNA polymerase (RdRp).

We found that Ψ, m5C, m6A and m3C had little effects on the activity, while m1A severely inhibited the enzyme. Both m1A and m3C disrupt canonical base pairing. That m1A inhibits SC2RC may imply that the modification can be difficult to identify even though it may exist and play a critical role. Putting aside other mechanisms by which the modifications cause individualized symptoms, the results indicated that individuals with a higher chance of m1A modification may stop viral replication and have less severe symptoms.

Chemical Engineering

4 Environmental and Economic Analyses of Recycling Waste plastic bottles via Dissolution Recycling Technology

Author: Utkarsh Chaudhari

Globally, more than 1000 organizations and 175 nations are facing the plastic waste problem and have realized the need to transition from “linear-to-circular” economy of plastics. While the current mechanical recycling technologies for plastics are struggling to increase the U.S. plastic recycling rates beyond 9%, chemical recycling technologies become important complementary technologies to the predominant mechanical recycling that are needed to realize the circular economy in plastics supply chains. Dissolution is one such chemical recycling technology that can recycle waste plastic back into high-quality virgin grade plastic.
However, the environmental and economic impacts of chemical recycling of waste polyethylene terephthalate (PET) via dissolution technology using a green solvent are unknown. Our study evaluated environmental metrics such as greenhouse gas (GHG) emissions and cumulative energy demand, and economic metrics such as net present value (NPV), minimum selling price, payback period, return on investment, and discounted internal rate of return for three dissolution processes with polymer recovery via anti-solvent, evaporation, and cooling precipitation techniques.

The dissolution process with evaporation technique was the most economically favorable, whereas that with cooling technique was the most environmentally favorable. The anti-solvent approach had low economic performance and the highest environmental impacts. The NPV for all of these technologies ranged from $2.67 MM to $10.93 MM for a capacity of 8,400 MT/year and was found to be the highest for dissolution with evaporation approach and the least for anti-solvent approach. The cradle-to-gate GHG emissions and energy demand for PET dissolution processes ranged from 1.33-3.77 kg CO2-eq/kg of chemically recycled (CR) PET and 18.9-56.1 MJ/kg of CR-PET, respectively. These economic and environmental metrics will be helpful in evaluating the sustainability of circular PET supply chains in the U.S.

5 Switchgrass Fermentability Study on Marginal Lands by Simulating Drought-Like Water-Stress.

Author: Sarvada Chipkar

‘Marginal land’ is a term used for cropping sites that have been abandoned due to various reasons including poor soil quality, low soil water content, challenging topography, or potential for nutrient deficiency due to overuse. As climate change affects weather patterns around the globe, second-generation bioenergy crops may be more affected when grown on marginal lands. The aim of this study was to understand the effect of soil water and temperature stress during switchgrass growth on marginal lands, and subsequently on the microbial ability to produce bioethanol from these crops.

To test this, an experiment was designed on five marginal lands sites with switchgrass exposed to reduced precipitation under rainout shelters (rainout samples) and normal precipitation without the shelters (ambient samples) from 2013-2021. The field sites were located across a latitudinal gradient in Michigan and Wisconsin (USA) with different climatic and edaphic conditions.

The efficiency of the rainout shelters to simulate similar water stress due to a drought in switchgrass was analyzed by relating the fermentation profiles to ethanol production, biomass yield, soil moisture content, soil and air temperatures, and switchgrass composition. During the first year (2018), the rainout shelters reduced the rainfall by 60%, causing a prominent difference in switchgrass fermentability harvested at the Wisconsin Central - Hancock field site compared to the ambient samples. The rainout shelters at other field sites failed to induce any major stress on biomass yield or fermentation performance for rainout samples compared to ambient in 2018. In the subsequent years (2019-2021), improvements were made to the shelter to exclude total rainfall, resulting in reduction in the biomass yield for rainout samples at most field sites compared to the paired ambient samples.

6 Reductive Bioleaching of Manganese Ores

Author: Neha Sharma

The increasing demand of manganese in industries and various hindrances in its production from low grade ores by conventional methods has made it imperative for researchers around the world to develop a method of manganese extraction from low grade ores that is both environment friendly and economical. Bioleaching has shown significant potential in manganese extraction and efficiencies of extraction have been found to be 70-98% with the help of various bacteria and fungi.

This study focuses on extraction of manganese with the help of microorganisms that were collected from their natural anaerobic environment where manganese reducing activity was evident. The extraction of manganese from manganese ore has been studied over a year in an anaerobic environment at room temperature and a pH around 5, without the addition of any mineral acids. We were able to extract more than 30% of high-grade manganese from ores with very low economic impact.

7 Evaluation of Entropy Generation Minimization as a Process Design, Optimization, and Analysis Tool

Author: Zachary Olson

This work applies discounted cash flow analysis to simulated chemical/energy systems designed and optimized with entropy generation minimization in mind. By comparing the financial valuation of these systems to those designed and optimized using traditional techno-economic models, this work seeks to advance the understanding of the connection between entropy generation and economic performance.

2.3 Civil and Environmental Engineering

1. Joint Probability Analysis of Extreme Precipitation and Water Level for Chicago, Illinois.

Author: Anna Li Holey

A compound flooding event occurs when there is a combination of two or more extreme factors that happen simultaneously and cause flooding. In the Great Lakes Region, it is common for a compound flooding event to occur with a high lake water level and heavy rainfall. With the potential of increasing water levels and an increase in precipitation under climate change, the Great Lakes' coastal regions could be at risk for more frequent and severe flooding. The City of Chicago which is located on Lake Michigan has a high population and dense infrastructure and is very vulnerable to a compound flooding event, even with the implementation of its water control structures.

For this case study, annual maximum precipitation and corresponding lake water level data were analyzed to examine the bivariate return period of a compound flood event using a copula function. The results show that under climate change if the water level were to rise by 0.2, 0.45, or 0.8 m, compound flooding events due to heavy precipitation and high-water level will be more likely in the future. By documenting the joint risk of potential compound flooding in this area, preventative measures and planning can be implemented.

2. Improve Winter maintenance decision support with an Artificial-Intelligence (AI)-Enhanced framework

Author: Hossein Tavakoli Dastjerdi

Attributed to the advances in Artificial Intelligence (AI) in recent years, new sources of data and data techniques have become available to be considered for developing road maintenance tools with improved accuracy, autonomy, and intelligence. In this study, a web-based AI-enhanced app is introduced to boost the autonomous decision-making quality and precision of winter road operations.

For this purpose, three innovations were made. First, the Convolutional Neural Network (CNN), one of the most remarkable machine-learning algorithms in recent years for deep learning image classification, has been successfully employed to identify the snow coverage on the road surface. Second, an AI decision-making algorithm was proposed and implemented to support the road engineers and operators for real-time winter maintenance operations. Third, a Smart Maintenance Decision Support System (SmartMDSS) was developed as an AI-empowered web-based app. On the back end, SmartMDSS extracts and analyzes data and makes winter road maintenance decisions. On the front end, SmartMDSS provides a user-friendly graphical interface showing all the valuable data and winter operations for specific points on the road and sends necessary warnings and notifications.

The advantages of SmartMDSS were demonstrated in the pilot study: (1) the tool becomes more intelligent as more data is received, (2) SmartMDSS can significantly reduce administrators' need to install instrumentation devices on the roads, and (3) the tool can be easily adjusted for local road agencies for instant budget savings in road maintenance.

3. Photochemical Fate of Free Amino Acids in Sunlit Surface Waters

Author: Benjamin Barrios

Dissolved free and combined amino acids are key sources of macronutrients such as carbon, nitrogen, and even sulfur in freshwater systems. Biological uptake of amino acids provides building blocks for protein synthesis and energy for microbial growth. In wastewater, dissolved combined amino acids account for up to 20% of bacterial nitrogen demand. While dissolved free amino acids only comprise a small fraction of total amino acids, they are considered rare and expensive due to high free energies of formation. In sunlit waters, abiotic transformation such as photochemical oxidation plays an important role for the fate of amino acids and is increasingly recognized for its role in biogeochemical cycling of key macronutrients. The photochemical degradation of free amino acids may occur via direct photolysis; however, indirect photolysis, in which the presence of dissolved organic matter sensitizes degradation through photochemically-produced reactive intermediates, such as triplet-state dissolved organic matter, singlet oxygen, hydroxyl radicals, and hydrogen peroxide, is often considered the dominant pathway. Considering the rapid and selective biotic uptake of amino acids in aquatic environments, understanding the photochemical degradation of amino acids in surface waters is a critical component of macronutrient cycling on a global scale.

We couple experiments and theoretical calculations to understand and predict the photochemical fate of three amino acids (i.e., histidine, tyrosine, and methionine) in the presence of three surrogate dissolved organic matter (i.e., 1,4-naphthoquinone, 2-naphthaldehyde, and umbelliferone) using a laboratory-scale solar simulator at 3 different solution temperatures. We use both density functional theory quantum mechanical calculations for the excited state reactions and bench-scale laboratory experiments for the quantification of fate of three free amino acids. The study findings highlight a roadmap of environmental research using an integrated approach of advanced experimental and theoretical techniques to discover unknown mechanisms that have not been elucidated by conventional approaches.

2.4 Cognitive and Learning Sciences

1. Relationship between Program Usability Characteristics and Intention to Use: Preliminary Data Implementing a Sport Injury Prevention Program

Author: Anne Inger Mortvedt

Adherence to exercise programs is low across multiple populations. For example, within the target population for ACL injuries, only ~4-20 % of sports teams have implemented evidence-based injury prevention programs. This study explored the relationship between usability characteristics and implementation likelihood for a newly developed ACL injury prevention program.

Twenty-two female handball players, aged 14 to 16, participated in the intervention study. Data on usability characteristics was collected through a modified usability scale similar to the System Usability Scale. Subcomponents of the usability scale included learnability, perceived effectiveness, ease of use, enjoyability and efficiency. Analyses on the total usability scale score revealed a significant difference between pre and post intervention responses, indicating that overall usability decreased over time ($p < 0.005$). Enjoyability was the subcomponent that primarily drove this change.

Total scale scores were significantly correlated with intention to use/implementation likelihood (Spearman's rho .54, $p = .009$). Perceived effectiveness and enjoyability were significantly correlated with intention to use the program (rho 0.50, $p = 0.02$ and rho 0.50, $p= 0.02$, respectively), indicating that program adherence is affected by whether they believe the program will work (e.g., reduce injuries) and whether they enjoy performing the program. We did not find any significant relationships between the three other subcomponents (e.g., learnability, ease of use and efficiency) and intention to use.

This preliminary data suggests that program designers may want to make sure participants understand why it is important to perform the program, in addition to developing an exercise program that they seem to enjoy performing. Future studies should capture more data on the usability scale/subscales to ensure the factor structure is consistent and items display appropriate psychometric properties.

2. **Pilot test of critical flicker fusion in combination with functional near infrared spectroscopy (fNIRS) in order to accurately measure cognitive workload during a visuospatial vigilance task.**
   Author: Lauren Sprague

3. **Exploring the difference in Movement Corrections following Visual and Physical perturbations.**
   Author: Isaac Flint

Making online movement corrections is vital to a person's ability to navigate the environments they live in. Failures often result in injury, such as tripping, car collisions, or bumping into hazardous surfaces. This experiment explores the behavioral (movement characteristics) and cortical (EEG) responses following two types of perturbations to arm-reaching movements, with a sample of young adult Michigan Tech students. Visual perturbations were administered by changing the visual location of a curser compared to a participant's hand position during random experimental trials. Physical (mechanical) perturbations were administered via a robotic arm that unexpectedly moved participants' arms during other random experimental trials. These experimental trials were further divided into two sizes of perturbations.

One size that placed the cursor outside of a set of obstacles, and one where the perturbation put the cursor on a collision course if the participant did not make a movement correction. Our results show that the type and size of perturbation had an impact on not only the behavioral characteristics of the movement corrections, but also the EEG event-related potentials that followed the perturbation. Differences were also observed for trials with collisions and trials without collisions. These results are a step toward understanding the neuro-cognitive correlates of online movement corrections. This knowledge will inform future work assessing how age and cognitive declines in an aging population may affect their ability to make successful movement corrections.

2.5 Forest Science

1. Indigenous community-directed research: An Ojibwa Forest Ecosystem Characterization

Author: Thi Mai Anh

Indigenous knowledge is crucial to ecosystem resilience, well-being, and livelihoods. Due to the long history of injustice in research engaged with Indigenous peoples, collaboration and partnerships still often face mistrust. Research driven by guidance from Indigenous communities is crucial, as is respecting Indigenous ways of knowing, sharing authority, and aligning with their priorities. This study aims to develop research to address the resilience of livelihoods in a forest-dominated ecosystem following guidance with/by/as the Keweenaw Bay Indian Community (KBIC). Using ethnographic methods and group discussions, we designed research goals and approaches that align with community priorities, reflect community values, and respect Ojibwa autonomy. Forest systems are a top priority for KBIC government units. The KBIC Forestry Department articulated the need for information on forest dependencies, climate change observations, and impacts on KBIC livelihoods and forest ecosystems. Exploring KBIC's resilience regarding the importance of practicing treaty rights is especially needed. Following the KBIC Seasons of Research Guide, we have co-developed a research project, Bridging Indigenous and Western science for resilience, livelihood, and stewardship planning: An Ojibwa Forest Ecosystem Characterization. This study aims to (1) characterize an Ojibwa forest ecosystem; (2) determine the primary socio-ecological factors influencing KBIC livelihoods; (3) assess socio-ecological resilience within the Ojibwa forest ecosystem. KBIC Natural Resources Department and Forestry Department will jointly design the research survey, which will be conducted as the 2024 KBIC's Annual Inland Harvest Survey. Study results will be used as evidence for KBIC harvest regulation updates, for protecting natural resources inland, the Tribal hunting, trapping, and gathering rights retained by the 1842 Treaty. Preliminary results indicate that equitable University-Indigenous community partnerships can support long-term collaborations and benefit both Indigenous communities and academic research goals. Research partnerships are a shared responsibility to restore reciprocal relationships, revitalize our future, and support livelihoods and well-being.

2. Invertibrate DNA (iDNA) from Silphid Beetles as a Novel Tool to Sample Mammals

Author: Katherine Higdon

Invertebrate DNA (iDNA) is an established method for mammalian biodiversity through the sampling of invertebrate diets. We used a novel method of iDNA sampling using the family of Silphidae, composed of burying beetles (Nicrophorinae) and carrion beetles (Silphinae), which have not yet been proven as iDNA sources for mammalian diets.

Applying methods from our preliminary study (2019), two field seasons were conducted in 2021 and 2022 to apply Silphid iDNA techniques to an experimental forest with various harvest treatments in order to determine both if Silphids display preferences in treatment type and if their diets were influenced by the treatment they selected. Between the two field seasons, nearly 1500 individuals were collected. Selection preference was determined using Non-Metric Multidimensional Scaling ordination to compare community compositions between silviculture treatment types.

The results indicate strong differences in silviculture treatment use between the two-family groups within the Silphids. Methods to obtain diets follow the workflow of a DNA extraction, PCR amplification, purification steps, and sequencing on an Illumina platform. Mammals including shrews and a star-nosed mole have been sequenced from carrion beetles, and these are species not easily sampled for in traditional mammal trapping due to their secretive nature or trap sensitivity. Additional results from the iDNA analyses are forthcoming.

3. Tree genetic improvement methods: current trends and future

Author: Swapan Chakrabarty

Genetic improvement of trees is essential for increasing the adaptability of trees to changing environments and biotic and abiotic stresses and for increasing the productivity and quality of forest products. For efficient tree improvement, selecting a suitable breeding method is essential.

We've reviewed existing literature and conducted a meta-analysis using more than 1500 scholarly publications published during 1990-2021. We categorized all the articles into three broad three improvement methods, including conventional or classical breeding, genomics selection or marker-assisted selection, and genetic engineering or genetic modification.

The results of our meta-analysis indicated that higher adaptability, productivity, and quality are the main objectives of tree improvement. Growth, quality, and biotic and abiotic stress tolerance-related traits are considered the most important traits. In previous studies, conventional breeding methods were used to improve these traits, but with the advent and development of state-of-the-art genetics, genomics, bioinformatics, and artificial intelligence tools, tree improvement has become more precise and rapid than previous. Genomic selection and genetic modification of trees are getting more popular. These results provide future directions for selecting more efficient tree improvement techniques.

2.6 Geology and Mining Engineering and Science

Impacts of 'La Canícula' ("Dog Days of Summer") on agriculture and decision-making in Salvadoran rural communities

Author: Paola Rivera Gonzalez

The Central American Dry Corridor (CADC), a tropical dry forest region, is characterized by distinct rainy and dry seasons that influence the local agricultural calendar and decision-making in rural communities. 'La canícula' is a period of decreased precipitation during the rainy season, which occurs along the corn crop season in El Salvador.

The 'canícula' is expected to change in intensity and duration in the next decades, which would impact small-scale farmers and their livelihoods. Climate variability and uncertainty has led to crop loss, water scarcity, and food insecurity in rural communities dependent on sustenance farming. Governmental and non-governmental projects were implemented in the communities in response to these impacts, encouraging agro-ecological and adaptation practices. Farmers' experiences with a changing climate led to reformed decision-making processes (eg. agricultural calendar, seed type usage, crop rotation) to optimize their harvest, supplementing the traditional practices they learned from past generations.
Decision-making processes in the communities are mostly independent from official government weather reports, due to limited data accessibility, hazard monitoring, and high uncertainties in the data, and most farmers rely on their own experiences and knowledge of land management.

Remote Sensing using Machine Learning for Off-Road Mobility

Author: Jordan Ewing

Terrain strength properties are critical when trying to achieve accurate mobility performance predictions for reliable operational planning using the NATO Next Generation-Reference Mobility Model (NG-NRMM). In situ measurements are the current approach to gathering this information. This data can be difficult to obtain from unknown territories and combat zones and place soldiers in harm's way. To avoid these limitations and risky scenarios, one needs to gather these soil properties remotely for generating Go / No-Go maps. (OPSEC # 7137).

2.7 Humanities

1. The Crystal Frontier: Facets of Pan-Indian Imagery in Japanese Anime and Manga

Author: Kendall Belopavlovich

The crystal frontier is a virtual, mediated space where Western imaginaries of cowboys, Indians, and a longing for open, unclaimed environments sprawl into endless pastures and planets. Using Gilles Deleuze's film theory and the notion of the crystal-image, this presentation outlines some of the major facets of North American Indigenous visual representation in American and Japanese popular media, highlighting the sometimes complimentary and sometimes contradictory nature of stereotypical images.

By calling attention to the flow of images across nation-state and tribal borders, this presentation also challenges the "transnational" in favor of the "transborder", which considers settler colonialism as an ongoing project.

2. 222 Days of Platform Lockdown: Circumvention Culture, Digital Activism, and Internet Censorship

Author: Genius Amaraizu

This work investigates internet censorship in Nigeria, describing experiences and citizens' led circumvention practices following the ban of Twitter by the Nigerian government. Based on a quantitative survey and qualitative interview of active Twitter users in Lagos and Abuja Nigeria, the research realizes and categorizes circumvention practices embraced within the period of effecting the ban into technology, self-censorship, and platform jumping.

This study further investigates how circumvention culture has become a form of digital activism and how the social media environment in democracies have experienced censorship within the last few decades. Citizenry experiences and the complexities of fight against platform lockdown and the role of digital activism prior to censorship is also analyzed. Internet censorship is new in Nigeria and has bred uncertainties among user practices and government censorship perseverance.

This study contributes to a broader understanding of how circumvention practices have become cultural practices and experiences that emerge as embodied internet war against censorship and the preemptive and predictive conditions of inefficiency of internet censorship policies in established democracies.

2.8 Material Science and Engineering

Effect of Cooling Rate on W-phase Formation in Al-Cu-Sc Alloys
Author: Austin DePottery

Aluminum-copper-scandium alloys show significant potential for high strength applications; however, the formation of the detrimental W phase (nominally Al8Cu4Sc) has prevented commercial adoption. There is not a strong consensus as to what conditions lead to the formation of W phase, but two key factors are the cooling rate during solidification and the homogenization heat treatment. In this work, the effect of cooling rate on the formation of W phase in Al-Cu-Sc alloys is investigated utilizing wedge molds that produce solidification rates from ~0.25-100 K/s. Samples are examined in both the as-cast state and following homogenization and aging treatments.

2.9 Mathematics

Bound-preserving discontinuous Galerkin methods with Patankar time discretization for chemical reacting flows
Author: Fangyao Zhu

I will talk about bound-preserving DG methods for chemical reactive flows. For this problem we must ensure the density and internal energy are kept positive, and the mass fraction of each species is between 0 and 1. We apply the bound-preserving technique to the DG methods. Though traditional positivity-preserving techniques can successfully yield positive density, internal energy, and mass fractions, it may not enforce the upper bound 1 of the mass fractions.

To solve this problem, we need to make sure the numerical fluxes in the equations of the mass fractions are consistent with that in the equation of the density; choose conservative time integrations such that the summation of the mass fractions is preserved. With the above two conditions, the positive mass fractions have summation 1, then they are all between 0 and 1. For time discretization, we apply the modified Runge-Kutta/multi-step Patankar methods.

Such methods can handle stiff sources with relatively large time steps, preserve the positivity of the target variables, and keep the summation of the mass fractions to be 1. To evolve in time, suitable slope limiters can be applied to enforce the positivity of the solutions. Numerical examples will be shown.

2.10 Mechanical Engineering

1. A Combined Active and Passive Micro-nucleation Enhancement Approach for High Heat-flux Flow-boiling Operations - Enabling Applications such as Next Generation Heat Sink for Electronic Chip Cooling System

Author: Divya Pandya

This presentation will describe the status of effective approaches for new heat-sink designs that address next-generation electronic cooling needs – specifically at chip or CPU levels. A unique and cost-effective flow-boiling approach is developed and demonstrated at the laboratory level – for a single channel "part" of a typically multi-channel heat-sink.

The presentation will describe enabling high heat-flux (70 – 200 W/cm2) flow-boiling based heat-sinks that use a more benign and electronically compatible fluid (environment friendly – GWP 300 - 400 (100 yr ITH) – liquid from 3M, Inc Novec 7000/7100) with boiling-surface temperatures near 40 - 60 °C and heat-sink pressures in 0.9 – 1.5 bars range. Proof of concept (PoC) experiments' successful demonstration of the fact that the proposed Active/Passive approach – of using micro-structured boiling surfaces in conjunction with resonant "in-plane" vibrations and oscillatory boiling-surface shear stresses for controlled but explosive growth in micro-nucleation rates – is promising. A controlled but explosive growth in micro-scale nucleation rates during flow-boiling of Novec HFE 7000/7100 is enabled by the uses of inexpensive meshed-copper for micro-structuring of the boiling surface and a pair of Piezoelectric-transducers for active imposition of suitable acoustic vibrations.

Since micro-structuring of boiling-surface is known to significantly enhance flow-boiling performance, the reported experiments employ a specific micro-mesh and diffusion-bonding based inexpensive approach to micro-structuring of the boiling-surface (leading to 40 – 60 % improvements in heat-flux – all else being the same – over plane unstructured copper-surface). At desired high heat-fluxes, these operations yield unacceptable performances, such as large pressure drops and instabilities due to causes within the heat sink, resulting in Critical Heat Flux (CHF) instability or outside of it, at the system-level, in any of its components. Large values of total mass-flux and very large vapor volume fluxes required for such high heat-flux values also lead to large pumping powers and unacceptable performances (flow instabilities, etc.).

For achieving low pressure-drops and a flow-control based stable operations that avoid system-level instabilities at even higher CHF values than what has been achieved in the Proof of Concept (PoC) experiments, the similar new experimental setup has been built. The meshes are ideal for transmitting longitudinal standing waves in a way that suitable amplitudes and frequencies of shear stresses can be induced in the micro-layers of the nucleating bubbles on the top-most mesh exposed to the working fluid. Therefore, micro-structuring approach is made much more efficient – with the associated reported patent targeting electronic cooling applications – by resonant acoustic energization through electronically controlled Piezoelectric-transducers.

2 Scheduling Multiple Tethered Underwater Robots for Entanglement Free Navigation

Author: Abhishek Patil

This work provides an operational strategy for the underwater multi-agent system of tethered robots, which are utilized in many real-world applications, such as surveillance, inspection, maintenance, exploration, and monitoring.

Specifically, this research focuses on developing an algorithm that prevents 1) the collision of the robots and 2) the entanglement of the tethers by determining the appropriate departure/arrival time at every node on the route for each robot. Based on the preliminary work on multi-robot system task allocation and path planning, we assume that the robots are given the routes for their missions. The proposed approach repetitively simulates the movement of the robots along their respective routes.

We have confirmed that the proposed algorithm can detect and prevent cable entanglements and collisions of the robots while moving along their convoluted paths, irrespective of the degree of complexity. The algorithm was repeatedly tested in a simulation with varying problem sizes to verify its effectiveness. The computational results show that the algorithm can produce reliable solutions to apply in real-time operations within a reasonable time.

3. Phase field regularized interface fracture modeling in fiber reinforced polymer composites

Author: Akash Kumar

Damage and failure in fiber reinforced polymer composites (FRPCs) are generally caused due to matrix cracking, fiber breakage, fiber-matrix debonding and delamination. Experimental investigation suggests that the delamination or interlaminar fracture is one of the most commonly observed failure mode in these materials. This happens due to the high interlaminar stresses in conjunction with the very low through thickness strength. In this work we attempt to characterize the interlaminar fracture behavior in carbon fiber reinforced composites (CFRP) using the phase field fracture model. In the proposed formulation, the phase field smears the sharp interfaces as regularized cohesive zones and also describes the bulk crack surface density allowing interaction between bulk crack and interface damage. In this way, the displacement jump created by the sharp interface is approximated as a smooth transition based on a first order Taylor series expansion of the assumed smoothed regularized displacement field.

We developed an approach to model the constitutive behavior of the FRP composite as a homogenized material consisting of an elastic matrix and axially deformable fibers characterized by the fiber volume fractions and orientations. The proposed model was implemented in ABAQUS/Standard by writing a user-element subroutine (UEL) to understand the fracture behavior of composite laminates in various loading conditions. Simulation was performed on double cantilever beam (DCB) with 0o fiber orientation to study the effect of regularization length for the smeared interface, and the interface traction separation properties (fracture strength and energy) on the global response. Furthermore, three-point bend specimens with different combination of laminas have been simulated, such as 90-90, 90-45 and 90-0.
In the case of 90o-90o laminates, the crack was observed to grow straight through the laminate and no delamination was noticed, however for 90o-45o and 90o-0o laminates, delamination was identified as the major cause of failure. In future we plan to validate our model predictions with experimental data for composites where fracture is dominated by interfacial failure and to extend this model for 3D composite fracture. The proposed model for interface fracture in FRPCs is easier to implement in a phase-field fracture framework and effective compared to the conventional cohesive zone-based approaches.

4. Snow Sensing for Photovoltaics single axis trackers

Author: Ayush Chutani

With the rapid deployment of photovoltaic (PV) systems around the world, PV is expanding in northern climate regions where snowfall is a major challenge for solar PV farms. Single axis trackers (SATs) increase the generation of solar plants at a competitive price and using bifacial panels is most effective in snow clad white ground due to high albedo. The objective of this project is to design and validate a snow measurement system that can measure snow on the top of moving panels by using laser-based sensors and digital image capture and to develop advanced tracker controls for improved snow shedding and higher efficiency in winters.

The study is complemented by power generation measurement at panel and string levels as well as plane of array solar irradiation; meteorological data at the location is recorded for the correct weather assessment and ultrasonic snow depth measurement at ground level provides a comparison for snow measurements. The target panels are observed by various cameras to provide a holistic image of snowfall and shedding events. Considering the need for correct measurement of snow on the surface of PV panels, a snow measurement system enables the development of an empirical classification that can help in correlation of the angles needed to shed the snow.

Snow shedding is an important factor in northern climates as it can increase the period for which the PV panels are generating power. This paper focuses on the novel snow measurement system design and prototype that measures snow on the top of moving solar PV panels.

5. Thermophoresis in Nanoparticles-based Phase Change Material for Thermal Energy Storage Applications

Author: Udit Sharma

Phase Change Materials (PCM) can be loaded with solid nanoparticles to enhance its thermal conductivity. When this system is subjected to a temperature gradient then the effect of thermal diffusion can come into play. This could result in the motion of particles on top of Brownian motion due to the applied temperature gradient and this process is known as thermophoresis. The analysis of thermophoresis can provide the potential for the particle migration. The analysis is performed using the temperature dependent properties like density, viscosity, and thermal conductivity.

To understand the relative impact of thermal diffusion to Brownian diffusion (concentration driven diffusion) a non-dimensional term Thermal diffusion factor is introduced. The potential for the migration is analyzed for the impact of the size of nanoparticles (2 nm diameter to 20 nm diameter), type of nanoparticles (copper, alumina, Titania, silver, and gold), volume fraction of particles (upto 5 % loading), type of PCM (acetic acid, acrylic acid, water, ethylene glycol, capric acid, paraffin wax and formic acid) and the operating temperature (melting point of the fluid to 360 K).

It is found that highly conductive, small particles are more prone to be uniformly distributed while for highly viscous fluid operating at lower temperature, there is potential for the particle migration.

6. Band Gap estimation of D-LEGO meta structures using FRF based sub structuring and Bloch Wave Theory

Author: Hrishikesh Gosavi

Periodic structures are found to exhibit band gaps which are frequency bandwidths where structural vibrations are absorbed. In this study, meta-structures are built by dynamically linking oscillators in a periodic pattern, which are referred to as Dynamically Linked Element Grade Oscillators or D-LEGOs. The location of the bandgaps is numerically determined for a one-dimensional D-LEGOs. The unit cell for the D-LEGO structure is considered to be made up of two longitudinal bar-elements of different properties. For such a structure, the frequency response functions (FRFs) of a single unit cell are used to estimate the bandgaps of a periodic-lattice structure by adapting Bloch wave theory. Alternatively, the FRF of the multi-unit cell is determined using FRF Based Substructuring (FBS) approach. The bandgaps resulting from these two approaches are compared and verified.

7. Design Of Continuously Variable Transmission (Cvt)

Author: Vasu Bhardwaj

The use of Continuous Variable Transmission (CVT) in All Terrain Vehicles (ATVs) allows for infinite gear ratios without compromising power loss, unlike manual transmissions. The engine is coupled with the CVT, which is further coupled to the constant ratio gearbox, providing the ability to adjust the speed and torque of the vehicle based on varying road and load conditions.

This study encompasses the design, manufacturing, and tuning of the CVT, with a focus on achieving better acceleration and efficient hill climbing while maintaining vehicle strength and reducing weight. Market research is conducted to determine the cost and feasibility of material selection, and calculations are performed to determine the desired ratios and belt selection for the vehicle.

Using SOLIDWORKS software, the primary and secondary clutch designs are created. Topology optimization analysis is carried out in CAE software to optimize the CAD design and reduce weight while maintaining the load flow path. This analysis provides the dimensions of the different components required for the assembly, and the final design is analyzed and validated to ensure proper functionality.

8. Electrical Stimulation for Maturation of Heart Muscle Cells

Author: Roya Bagheri

Heart diseases are the main reason for mortality worldwide. In vitro heart, tissue models have heart regeneration, disease modeling, and drug testing applications. The immaturity of cardiomyocytes is one of the greatest drawbacks of the in vitro myocardium models. Electrical Stimulation is a promising method of promoting cardiomyogenic expression in vivo and in vitro. The stimulation setups used previously for stimulating cardiomyocytes mainly apply electric fields parallel to the substrate, which are not uniformly sensed by cells, i.e.

Here, we customized an electrical cell stimulation and recording apparatus (ESCARA) to apply uniform through-thickness and myocardium-relevant electrical stimulation to individual heart tissue models to help the development of cardiomyocytes. Furthermore, we investigated the effect of substrates of different thicknesses and conductivity on the electrical field and, consequently, on cardiomyocyte maturation. The electrical stimulation setup was 3D printed using a design similar to a common 24-well cell culture plate. The cardiomyocytes were isolated from 1-3-day-old neonatal rat hearts and cultured on different substrates for ten days. Substrates included Silicon (Si), Polydimethylsiloxane (PDMS), Polyethylene Terephthalate (PET), Polyvinyl Alcohol (PVA), and PVA-MXene composite to examine the effect of conductivity and thickness of substrates in the setup. Square pulses with a duration of 1 ms, an amplitude of 5 V, and a frequency of 1 Hz were continuously applied to the cells from days 5 to 8 of the culture. The performance of cardiomyocytes was studied using immunofluorescence cardiomyocyte labeling (alpha-actinin). The expression of cardiomyocyte and maturation-relevant genes ACTC1 (actin alpha cardiac muscle), Myh6 (myosin heavy chain), TNNT2 (cardiac troponin T part of muscle contraction), and Gja1 (gap junction) was characterized by qPCR on day 8. The cells expressed mature cardiomyocyte markers of alpha-actinin.

Quantification of the expression of cardiac genes shows that electrical stimulation enhances the maturation of cardiomyocytes for thin samples (PET, PVA, and PVAMXene composite), which do not disturb the electric field. Hence, cells are entirely influenced by the electric field for conductive and non-conductive thin samples. Thicker and semiconducting samples (Si and PDMS) produce inconsistent data, i.e., the expression of some genes showed a significant difference, whereas others did not.

In conclusion, our customized electrical stimulation setup improved the expression of cardiac-specific genes. The setup can mimic in vivo cues for in vitro cell and tissue models to make them more suitable for cardiac regeneration and disease/drug testing applications.

9. Nonlinear Model Predictive Control of a Wave Energy Converter

Author: Tania Demonte Gonza

Wave energy is an attractive source of renewable energy due to the predictability of waves. However, efficient optimization of wave energy devices is crucial for transitioning from government-funded research to the competitive energy market. This study demonstrates the effectiveness of a nonlinear Model Predictive Controller (MPC) in optimizing the energy extraction of a heaving point absorber wave energy converter (WEC).

The WEC model accounts for nonlinear dynamic and static Froude-Krylov forces. The nonlinear MPC is evaluated under irregular waves over the power production region, with displacement and control force constraints to ensure safe operation while maximizing energy absorption. The nonlinear MPC approach is compared with a linear MPC strategy that approximates the Froude-Krylov forces linearly. The results reveal that the nonlinear MPC outperforms the linear MPC in terms of energy absorption.

10. Predicting the electronic structure of large-scale bulk metallic systems using machine learning

Author: Shashank Pathrudkar

We introduce a novel machine learning framework to predict the electron density of bulk metals and alloys at larger systems, which are inaccessible to Kohn-Sham (KS) density functional theory (DFT). Although KS-DFT is widely employed in materials research, its computational demands restrict it to smaller systems.

To overcome this computational bottleneck, we developed a machine learning-based approach that maps the atomic environment to the electron density using a novel representation for atomic environment that is frame-invariant and does not require any handcrafting or basis selection. Our method utilizes a ResNet-based neural network trained on DFT simulation data, with a transfer learning approach that involves initial training on DFT simulations of small simulation cells and further tuning using a very small amount of data from larger simulation cells.

To demonstrate the effectiveness of our model and transfer learning approach, we trained our model on simulation trajectories of a 32-atom aluminum system at various temperatures and implemented transfer learning using a single small length simulation of a 108-atom system to predict electron density for large-scale aluminum systems. We validate this model by predicting the electronic densities of the 500 and 1372 atom Al system and comparing it with the reference DFT results. The transfer learning approach significantly reduces the training data generation cost, given the $O(N^3) $ scaling of KS-DFT. The proposed model accurately predicts electronic structures for large systems while being several orders of magnitude faster than DFT and scales linearly with the number of atoms. We anticipate that this model can be used for any bulk metals and alloys and will be particularly effective for prediction of electronic structures at various alloy compositions.

2.11 Physics

1. Light Absorbing Aerosol – Cloud Interactions (LAACI)

Author: Shreya Joshi

Atmospheric light-absorbing aerosols, such as particles containing black carbon, significantly impact Earth's climate. These particles interact with the solar radiation scattering and absorbing light and they interact with clouds changing the cloud properties as well as being changed by in-cloud processes. Morphological changes of black carbon and per-particle internal mixing with other materials, such as organic coatings, affect the particle's scattering and absorption properties.

These processes have been the subject of previous studies; however, interactions of black carbon-containing particles with clouds have received less attention, and important questions remain open. Our LAACI project was designed to investigate these light absorbing aerosol – cloud interactions in the Michigan Tech cloud chamber. Initial experiments have been carried out to: (a) classify black particles using an aerodynamic aerosol classifier in tandem with a differential mobility analyzer, to remove multiply charged particles, (b) characterize the dry deposition rate of aerodynamically size selected black carbon particles in the chamber, (c) optimize a pumped counterflow virtual impactor to reject interstitial particles and collect residual particles from the evaporation of water droplets, and (d) characterize the optical and chemical properties of a surrogate for biomass burning organic material to be used as coating on black carbon particles.

Cloud experiments are planned to: (a) investigate changes in the morphology of the black carbon particles aggregates upon cloud activation and evaporation, (b) study changes in optical and cloud condensation nuclei properties of interstitial and residual particles, (c) explore the effects of coating material on black carbon particles and how these coatings affect aerosol-cloud interactions and the resulting aerosol and clouds properties. An overview of the project and the preliminary findings will be presented.

2. Organic and Elemental Carbon in the Urban Background in an Eastern Mediterranean City

Author: Zaid Bakri

The Mediterranean region is an important area for air pollution as it is the crossroads between three continents; therefore, the concentrations of atmospheric aerosol particles are influenced by emissions from Africa, Asia, and Europe. Here we concentrate on an eleven-month time series of the ambient concentration of organic carbon (OC) and elemental carbon (EC) between May 2018–March 2019 in Amman, Jordan. Such a dataset is unique in Jordan.

The results show that the OC and EC annual mean concentrations in PM2.5 samples were 5.9 ± 2.8 μg m–3 and 1.7 ± 1.1 μg m–3, respectively. It was found that the majority of OC and EC concentrations were within the fine particle fraction (PM2.5). During sand and dust storm (SDS) episodes OC and EC concentrations were higher than the annual means; the mean values during these periods were about 9.6 ± 3.5 μg m–3 and 2.5 ± 1.2 μg m–3 in the PM2.5 samples.
Based on this, the SDS episodes were identified to be responsible for an increased carbonaceous aerosol content as well as PM2.5 and PM10 content, which may have direct implications on human health. This study encourages us to perform more extensive measurements during a longer time period and to include an advanced chemical and physical characterization for urban aerosols in the urban atmosphere of Amman, which can be representative of other urban areas in the region.

2.12 Physiology and Kinesiology

1. Historical Performance Trends in Winter Ultra-Endurance Events

Author: Kyle Wehmanen

Winter ultra-endurance events provide some of the most difficult challenges in human performance. Competitors travel across snow-covered terrain via bike, foot, or ski. To date, there are no reports that document which mode of locomotion yields the fastest finish times. Our purpose was to compare race performance across these three locomotive modes (bike, foot, and ski) for four winter ultra-endurance events.

Finish times from the Tuscobia 80, Arrowhead 135, and Iditarod Trail Invitational 350- and 1000-mile events were extracted from 2000-2022 using publicly available data. Times of the top three participants in each category were used for analysis. The effect of locomotive mode and event year were analyzed using a two-way ANOVA. Differences in finish times and race speeds between locomotive modes was assessed using a post-hoc Tukey test.

For the Tuscobia 80, Arrowhead 135, and ITI 350, finish times for bike (9±1, 18±6, 97±48 hrs) were faster than those for foot (21±3, 41±9, 163±43 hrs) and ski (23±8, 39±12, 174±44 hrs) ($p<0.001$), however, finish times for foot and ski did not differ ($p>0.40$). Race speeds for the three shorter events were greater for bike compared to both foot and ski ($p < 0.001$) but foot and ski did not differ ($p>0.40$). For the ITI 1000, finish times for bike (433±90 hrs) were faster than those for foot (642±123 hrs) ($p<0.001$) and bike speed was greater than foot speed ($p<0.001$).

In the last two decades, bicycling has consistently yielded the fastest times and speeds in four winter ultra-endurance events. Results indicate that bicycling offers the superior mode of transport and suggest that it has a lower metabolic cost of transport compared to foot and ski. Finally, finish times for all four events have decreased over time independent of locomotive mode suggesting improvements in training and/or technology.

2. Exercise Augments small Conductance Ca2+ -Activated Potassium Channel (SK) function in the Paraventricular Nucleus (PVN) of Sprague Dawley rats to reduce Sympathetic Outflow

Author: Greg Miodonski

Elevated sympathetic outflow is a key feature of cardiovascular disease (CVD) that worsens disease progression. Our lab has shown that SK channels expressed in the PVN play a crucial role in regulating neuronal activity and sympathetic outflow, and that SK channels become dysfunctional in rats fed a high salt diet. Exercise has been shown to be an effective treatment for reducing sympathoexcitation in CVD including hypertension and heart failure, but the underlying mechanisms are not fully understood.

We hypothesized that aerobic exercise would upregulate SK channel function in the PVN to reduce sympathetic nerve activity (SNA). To test this, 5–6-week-old Sprague Dawley rats were divided into sedentary (SED) and exercise (EXT) two groups and fed a 0.4% NaCl normal salt diet. Following acclimation, EXT groups ran on a motorized treadmill 5 days/week for 8-10 weeks. Conscious blood pressure was measured weekly via tail plethysmography. After 8-10 weeks, animals were anesthetized and underwent in vivo surgery to record the renal sympathetic nerve activity (RSNA) and mean arterial pressure (MAP) following PVN microinjection of the SK channel blocker, apamin (0.25mM, 100nL).

The data showed that the RSNA response to PVN apamin was significantly enhanced in EXT rats compared with SED rats (320.8 ± 174.6 % baseline, n=9 vs 184.8 ± 143.1 % baseline, n=9; $p = 0.02$). The corresponding ABP response to apamin was not significantly different in EXT rats compared with SED rats (20.40 ± 9.98 mmHg, n=9 vs 25.27 ± 9.97 mmHg, n=8; $p = 0.1658$).

Our data indicates exercise enhances PVN SK channel function to reduce sympathetic outflow. This improvement of SK channel function may be one mechanism by which exercise reduces SNA in CVD including hypertension and heart failure.

3. **Brain-Derived Small Extracellular Vesicles from Dahl Salt-Sensitive Rats with High Salt Diet Induce Inflammation and Oxidative Stress**
Author: Xinqian Chen

It has been reported that small extracellular vesicles (sEVs ≤ 200 nm) are implicated in the pathogenesis of multiple diseases including hypertension. However, the role of brain-derived sEVs in the development of salt sensitive hypertension (SSHTN) remains unclear. We hypothesized that brain-derived sEVs from high salt diet-treated rats can induce inflammation and oxidative stress in the central nervous system (CNS). To test this hypothesis, brain-derived sEVs of Dahl salt-sensitive rats with high salt (HS) diet (Dahl-HS-sEV) were used to treat primary brain neuronal cultures and microinjected into brain lateral ventricles, respectively, proinflammatory cytokines, chemokines, and oxidative stress markers were measured through real-time PCR or fluorescent probes. sEVs isolated from Sprague Dawley (SD) rats with normal salt (NS) diet (SD-NS-sEV) were used as a control.

Data showed that Dahl-HS-sEV increased mRNA levels of inflammatory cytokines including TNFα (2.3-fold) and IL1β (3.7-fold), and chemokines including CCL2 (2.4-fold), CCL5 (2.1-fold), and CCL12 (4.2-fold), with significant difference ($P<0.05$). In addition, Dahl-HS-sEV treatment increased mRNA levels of transcription regulator, NF-κB (1.4-fold), and neuronal activation marker, c-FOS (1.3-fold), as well as CYBA (1.7-fold), in primary neurons, compared to SD-NS-sEV-treated cells ($P<0.05$). Confocal images showed that Dahl-HS-sEV significantly increased mitochondrial ROS levels, with total fluorescence intensity increased 1.6-fold relative to SD-NS-sEV treatment ($P<0.01$). SD-NS rats receiving intracerebroventricular injection of Dahl-HS-sEV had increased ($P<0.05$) PVN mRNA levels of IL1β (4.3-fold), CCL5 (2.6-fold), IL-6 (3.4-fold) and NOS2 (5.2-fold), compared to rats receiving SD-NS-sEV (5.5 μg/rat, n=4), 6h after injection.

These results suggested that in SSHTN, brain-derived sEVs may induce central inflammation and oxidative stress, which in turn results in an elevation of arterial blood pressure.

2.13 Social Sciences

1 Feeding Our Local Communities. The benefits of food assistance programs at local farmers markets

Author: Courtney Archambeau

For those that live in rural areas, finding food that is good and affordable can be difficult, especially for those that rely on assistance from the Supplemental Nutrition Assistance Program or SNAP. However, incentive programs have been put in place to assist those with SNAP benefits to purchase fresh fruit and vegetables from farmers markets throughout the United States. This study focuses on three population centers located in Houghton County in Michigan's western upper peninsula and focuses on how farmers markets can be made more inviting for those of lower socioeconomic status.

Studying local food systems is of interest because they have unique characteristics encompassing a multitude of aspects of social impact investing that can include farming practices that benefit the environment, economic stability for local residents and building capacity of local businesses. Data collection will take place via participant observations of the farmers markets and semi-structured interviews with key stakeholders, including but not limited to, social service agencies, farmers market coordinators and farmers to answer the following questions: how can we make farmers markets more inviting and their food more accessible to those of lower socioeconomic status?

By studying farmers markets, how can programs such as the Double Up Food Bucks (DUFB) program be incentivized so that local markets, whether farmers or grocers, accept it? What education would need to be in place and how would my research help others implement the program to make our local food systems more inclusive? How might the recently adopted DUFB and SNAP acceptance at the Calumet Market inform wider-scale adoption of these programs at markets across the Western U.P. region?

2 Energy Resilience in the Western UP Health System

Author: Eric Boyer-Cole

Energy security is an important issue in any hospital, but in the Western UP unique vulnerabilities make energy security a much more tangible problem. Natural disasters can cause power outages ranging from minutes to days, and it is important that the healthcare system in the western UP is prepared to handle not only routine disasters, but likely increasingly severe disasters as the effects of climate change make themselves known. Literature in this area has revealed a large hole in knowledge about this geographical area, robbing policymakers of useful information to inform both budgetary and agenda decisions. Using interviews from a multitude of administrators and stakeholders in the field, as well as quantitative data collected from multiple healthcare facilities in the area, we have attempted to construct a comprehensive image of the readiness of the UP-healthcare system in regard to responding to natural disasters. Hospital administrators have been fairly optimistic that the hospitals are ready for whatever disaster they might encounter. However, the opinion from a broader stakeholder perspective is more cautious. Our findings indicate an energy infrastructure lacking in redundancy and relying on increasingly cost-ineffective solutions that are dependent on surrounding transportation infrastructure to be reliable. Hospitals have expressed a lack of investment in more reliable or renewable options, partially due to the fact that many view energy costs as a small portion of their budget. The hope for these findings is that it will influence decision making at the hospital and state level to put more redundant and reliable systems in place to protect our health infrastructure in the event of a disaster, as disasters are becoming more and more common in the unreliable weather influenced by climate change.

3 | Acknowledgements

The Graduate Student Government would like to acknowledge the GSG Research Committee, the GSG Executive Board and the Graduate School for planning, organizing, supporting, and participating in the 2023 Graduate Research Colloquium.

The Graduate Student Government also would like to extend a special thanks to all the faculty who volunteered as judges for this year's Graduate Research Colloquium.