



Michigan Technological University

2024

Undergraduate Research &
Scholarship Symposium

Welcome to the 2024 Undergraduate Research & Scholarship Symposium!

This symposium highlights cutting-edge research conducted over the past year by some of our best and brightest undergraduate students at Michigan Tech.

Each student was mentored by a faculty member who took great care to guide them through the exhilaration, frustrations, painstaking work, and rewards of the research process. They have spent long hours in the lab, library, or out in the field collecting data, conducting interviews, reviewing primary and secondary sources, designing experiments, testing hypotheses, and analyzing their findings. The results of their work help us to build new models, encourage innovation, live in a better way, and deepen our understanding of the world around us. Through the process, they've built strong relationships and acquired skills that will help launch their future careers.

The projects showcased today represent a wide array of disciplines and highlight the diversity of research areas and avenues possible at Michigan Tech. Many of the students presenting their work today have been supported by university programs such as the Summer Undergraduate Research Fellowship (SURF) and the Undergraduate Research Internship Program (URIP). Our sincere thanks go out to everyone who has supported our students: faculty mentors, families, departments, colleges, and communities. In particular, thank you to the Copper Shores Community Health Foundation, the DeVlieg Foundation, and the Tech Forward: Sustainability and Resilience Initiative for funding URIP.

I know you will enjoy interacting with these exceptional students and learning about their research journeys, experiences, and outcomes. I encourage you to come with an open mind, to ask challenging questions, and to help these students on their path to create a brighter tomorrow.

Sincerely,

A handwritten signature in black ink, appearing to read 'M Seigel', written in a cursive style.

Marika Seigel
Dean, Pavlis Honors College

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101. A Self-auditing Protocol for Decentralized Cloud Storage via Trusted Hardware Components

Student Presenter: Josh Dafoe, Mathematics and Computer Science
Faculty Advisor: Bo Chen, Computer Science, Security and Privacy Lab

Introduction:

Ensuring integrity of the data outsourced to a decentralized cloud storage system is a critical but challenging problem. To provide this guarantee, current decentralized cloud storage systems rely on blockchain and smart contracts to establish a trusted entity which can audit the storage peers. This would result in a significant overhead as each smart contract is run on all the miners of the blockchain. By leveraging trusted hardware components equipped with the storage peer, this work has designed a unique self-auditing protocol which can ensure data integrity in the decentralized cloud without relying on the blockchain and smart contracts.

Materials and Methods:

In this research, we designed a self-auditing protocol for decentralized cloud storage, eliminating the expensive reliance on blockchain and smart contracts. Our approach is to use trusted hardware components within each storage node, namely the Trusted Execution Environment (TEE) and Flash Translation Layer (FTL).

We assume that each peer is equipped with a TEE, and an SSD that includes the FTL firmware layer. Both of these components are isolated from the untrusted operating system (OS), which sits between them.

Our protocol operates autonomously within each node, utilizing the TEE as a secure auditor. It conducts regular integrity checks on randomly selected data segments, validating the data integrity.

To detect threats such as data tampering, replay attacks, outsourcing attacks, and DOS attacks, our protocol involves the FTL encrypting data when audit data is requested by the TEE. It uses a symmetric key, which is shared between the TEE and FTL and is regenerated for each audit session through a Key Derivation Function (KDF).

We created a prototype using OpenNFM ported to a LPC-H3131 development board, and Intel SGX on a Lenovo laptop to test our protocol. This prototype validated the key phases of our approach, including file preparation, and auditing.

Results and Discussion:

There are a few very significant attributes of our design which give it very desirable properties in a decentralized cloud storage system. As far as we are aware, there is no cloud storage system currently providing all of the properties that we have achieved.

The first property is non-outsourcability. This is the property that the storage server cannot outsource the data to some external store, thus compromising speed and reliability. Using the FTL in our design allows us to validate that the audited data was stored in the local SSD associated with the modified FTL.

The second property is server-side computation. This is the property that all the overhead associated with auditing the data is outsourced to the server itself. Through using trusted hardware, we are able to ensure that the desired computation is performed with no client burden despite a compromised OS.

Additionally, this is all done with no coordination between nodes. This coordination severely limits the scalability of current decentralized cloud storage systems, and any current solutions to limiting coordination sacrifice decentralization for this scalability. Typically, all miners on the blockchain validate every performed audit, whereas in our solution, this is all done within a single peer.

102. Virus Purification Using Diverse Ion Exchange Chromatography and Heparin Affinity Chromatography

Student Presenter: Madison Baldwin, Chemical Engineering

Faculty Advisor: Dr. Caryn Heldt, Chemical Engineering Department, Heldt Bioseparations Laboratory

Introduction:

Effective virus purification plays an integral role in vaccine research and by extension, public health. Contaminating impurities produced in the virus growth stage can interfere with experiments in the lab and delay important findings to improve vaccine manufacturing. With 70% of vaccine production costs being attributed to the removal of impurities [1], it is clear that virus purification can be cost-intensive both in the pharmaceutical industry and in the research lab. In this study, ion exchange chromatography and heparin affinity chromatography will be used in conjunction to provide relatively inexpensive and quick virus purification for research use.

Materials and Methods:

Porcine parvovirus (PPV) will be used as vaccine model for our purification. Anion exchange chromatography (AEX) and cation exchange chromatography (CEX) will be evaluated in the purification of PPV exploring two different conditions: pH and salt concentration, due to the way that these conditions affect the binding of PPV and impurities by altering virus surface charge and binding strength. pH 3.5-4.5 and 100-300 mM and pH 6-8 and 100-300 mM of NaCl will be tested for AEX and CEX, respectively. AEX and CEX purification will be performed using a Mustang Q and Mustang S membrane, respectively. An MTT assay will be performed on the elutes to determine virus titer and Bradford assay will allow us to determine protein concentration. The IEX elutes from the favored conditions will then be further purified through heparin chromatography.

Results and Discussion:

This research is ongoing. In previous screening experiments we have tested the aforementioned conditions for AEX on PPV showing a 24.3% recovery of PPV and scarce protein removal in the elution step. The favored conditions in AEX for PPV elution were pH 6 and 400mM NaCl. In future experiments, it is expected that lower pH and high salt concentration will improve the recovery of PPV in CEX and it will increase the protein removal. Heparin chromatography will increase protein purity in combination with CEX. A successful purification method would provide at least 50% PPV recovery with at least three logs of contaminating protein and DNA removal.

103. Added Mass of a Spherical Buoy at Varying Heights

Student Presenter: Estyn LaMotte, General Mathematics, Applied Physics
Faculty Advisor: Hassan Masoud, Mathematics

Introduction:

The ocean is a body of water that is constantly moving: more precisely, oscillating. An oscillation is necessarily associated with a power, which in this case can be harnessed by a buoy. But such buoys to use the power of the ocean's waves require more understanding to be used efficiently. We consider here the added mass of such a buoy, a descriptor of how the buoy is affected by the ocean, at varying small depths within the surface of a fluid.

Materials and Methods:

Perturbation- an approximation method by inducting a power series on a reasonably small variable so that a finite number of solutions may be used to approximate a full solution.

Separation of Variables- a standard method of solving partial differential equations, in this case a Laplace equation.

Domain Perturbation- a method of perturbation which involves mapping a domain to something easier to work with in exchange for making the solution conditions harder.

Results and Discussion:

Although the research is yet incomplete, we believe that by this fall we will reach an approximation of the added mass of a spherical buoy and varying depths. Specifically we consider depths where the center cut of the sphere lies at or above half sea level, which is the most probable case for a real buoy. We do however note that there are odds that this approximation is less effective than we expect. This though would also be a significant result, as our approximation will be cubic, and this implies that a cubic polynomial cannot accurately model this added mass phenomenon. Otherwise, we pose an efficient method for accurately considering the motion of buoys with a closed approximation rather than a numerical approach.

104. Measuring Diffusion of Viruses in Aqueous Two-Phase Systems Utilizing Microfluidics

Student Presenter: Sydney Dankert, Chemical Engineering

Faculty Advisor: Dr. Caryn Heldt, Chemical Engineering

Introduction:

Aqueous two-phase systems (ATPS) is an advanced system of extraction for viruses that can operate continuously. This technology has the opportunity to replace existing batch chromatography systems and the higher costs associated. Current research is investigating the necessary parameters to scale up the ATPS separation technique from lab bench scale to industrial production. Recent advancements in ATPS using microfluidic platforms have allowed for a deeper look into the diffusion phenomenon affecting ATPS diffusion on the microscale which will led to industrial scale up.

Materials and Methods:

The microchannel used for the experiment is referred to as a Y-channel where two inlets meet to create a diffusion interface flowing through the device. One side of the Y has fluorescently tagged protein or virus meeting the other side of the Y with no fluoresces. The branches of the Y channel meet to create an image of fluorenes diffusion (concentration gradient) where the fluorescence color diffuses into the uncolored side of the system as residence time progresses down the channel showing the effect of diffusion on the ATPS.

Fluorescently-tagged model protein or virus was spiked into the polymer- or salt-rich phase of each ATPS and fed into one inlet of a Y-shaped microfluidic channel. Plain polymer- or salt-rich phase was fed into the other side, creating a concentration profile that could be captured by the camera of an inverted fluorescence microscope. Images were collected at increasing residence times down the channel. Concentration profiles were derived by a python code from these fluorescence images and subsequently compared with a theoretical diffusion model. The fit of the model was optimized by changing the diffusion coefficient.

Results and Discussion:

Current preliminary data has provided three different diffusion coefficients for unique viscosities of ATPS. Analysis on the concentration profiles determined the best method for future modeling of the diffusion of viruses in ATPS on the micro scale. This future modeling of the diffusion coefficient from the micro scale testing will support the applications methods on a larger scale. The scale up method will take the diffusion coefficient determined on the microscale, use it to determine the mass flux of the ATPS and build a model from the flux with key characteristics of required surface area and mixing of a large scale separation. It was determined that the next steps for investigation will use a glass microdevice to collect advanced data with new nanoparticles which provides an ideal comparison to biological systems.

105. Migration Signatures: Net Migration by Age for US Counties.

Student Presenter: Benjamin Wireman, Mathematics
Faculty Advisor: Richelle Winkler, USDA Economic Research Service

Introduction:

This research studies age-specific migration patterns for all US counties, each decade from 1960s-2010s. Most counties in the US have a “signature” pattern to their age-specific migration that is consistent over time. Our research analyzes these signatures and clusters them into types. Our research provides new quantitative methods for comparing migrations signatures which is important for future migration research as well as for anyone making plans based on migration such as policymakers.

Materials and Methods:

Our research analyzes an ongoing database of age based migration rates for each county for each decade. The data is generated using a residual method using census data and vital statistics records. Using this previously generated data, our research methods are purely data analysis.

We interpret the data set as a collection of vectors. Each county-decade forms a vector with the age specific migration rates as the components. From here the methodology is largely 3 steps: Descriptive interpretability, finding the signature types, and labeling the country-decades.

Descriptive interpretability:

Using a masked singular value decomposition to reduce the dimensions and a spherical projection to create a human interpretable visualization of the data’s distribution. Comparison and temporal change can also be plotted on this distribution.

Finding the signature types:

Using the cosine metric we apply a modified hierarchical clustering procedure. We use the inconsistency measure to cluster and reduce the data set down to large homogeneous clusters. The primary singular vector of each cluster become the signature types.

Labeling the county-decades:

Finally we use a modified cosine metric to label the percent of square variance of each county-decade that can be explained by each signature type. This is our measure of classification.

Results and Discussion:

In a sense our research is still ongoing. At this point we have concluded the classification of signature types, and we are working towards publishing our findings.

One main outcome of our research is the methodology that we developed. Our results reinforce previously qualitative research on county migration types, but provides a first method for computing quantitative analysis. The signature types we have identified reinforce known theories.

The numerical classification measure of each country-decade into each type, is our other main outcome. We hope to publish this result. It is useful because it provides a numerically interpretable scale from -1 to 1. This is useful for further research and for policy makers as it allows numerical analysis of what the county type is and how consistent the migration is over time.

106. Biopsychosocial predictors of return to sport and secondary ACL injury: a systematic review with meta-analysis

Student Presenter: Riley Stichter, Human Biology

Faculty Advisor: Dr. Erich Petushek, Department of Cognitive and Learning Science

Introduction:

Injury to the anterior cruciate ligament (ACL) is one of the most common traumatic injuries among athletes. While ACL reconstruction surgery is being increasingly performed, only around 65% of individuals successfully return to their preinjury level of sport or activity [1]. Studies have indicated that functional outcomes alone are not sufficient to evaluate one's ability to return to sports and that patient reported function and psychological factors should be assessed as well [2]. Our study explored the ability of psychosocial patient reported outcome measures (PROMs) to predict ability to return to sport and secondary injury compared to biological factors.

Materials and Methods:

A computerized search of the electronic databases PubMed / MEDLINE, CINAHL, EMBASE, and Web of Science was conducted. Only observational studies reporting baseline biopsychosocial patient-reported metrics as well as RTS, rates of graft re-rupture, and/or contralateral ACL injury with a prospective design were considered for inclusion in this investigation. Two reviewers independently screened articles and extracted relevant data from each included study. A meta-analysis package with R programming system was then used to combine this data and determine the predictive ability of both the specific psychosocial variable as well as the biological variables.

Results and Discussion:

Our results are ongoing. We screened 2896 articles to include 33 articles in our meta-analysis based on the inclusion criteria. Studies that used participants outside of the mean age [<15 (inclusive of 15), >36 (inclusive of 36)], solely revision ACLR data, multiligament knee injury (MCL, LCL, PLC, and/or PCL repaired or reconstructed), minimum follow-up <6 months, or non-original data were excluded. We anticipate that common biological risk factors, such as female sex, increased joint laxity, and biomechanical movement patterns will predict a decreased rate in return to sports and an increased rate in secondary injury. We also envision that specific psycho-social factors will have the same ability to predict an increase or decrease likelihood of return to sport and reinjury. It is possible that psycho-social factors will have more predictive ability than biological factors. This review will help determine which scales and constructs are most useful to predict poor patient outcomes. Increasing knowledge in this area is important, as there is a need for a more efficient yet comprehensive scale to be created that encompasses not only functional patient reported outcomes, but also psycho-social patient reported outcomes.



107. An Innovative Method for Sustainable Hydrogen Production

Student Presenter: Troy Metz, Mechanical Engineering
Faculty Advisor: Dr. Jeffrey Allen, Mechanical Engineering Department

Introduction:

As large economies, such as the United States, shift away from fossil fuels, other fuels are needed. Hydrogen is a promising clean energy source. However, most hydrogen produced today is from steam methane reforming, which produces carbon dioxide. Electrolysis does not directly produce carbon dioxide but is energy intensive and therefore expensive. Producing low-cost hydrogen with little to no carbon dioxide is the focus of this work. The proposed hydrogen production mechanism is an electrochemical process using inexpensive and abundant iron oxides as catalysts.

Materials and Methods:

The first method considered was a modification of the techniques developed by Karatza et al. (2020). Karatza et al. compressed high purity magnetite into pellets, premagnetitized the pellets, and applied electrical power and a magnetite field to the samples at various temperatures. The magnetite pellets reacted with water vapor at temperatures between 250 - 310C. The modified technique that was explored involved natural magnetite samples sourced from the Bristol Bay area in Alaska. Instead of compressing the samples into pellets and greatly reducing the surface area, the magnetite was treated as a packed bed. Lastly, the magnetite field and electric power were removed from the experiment.

Heat transfer models were developed for the magnetite, water vapor, and nitrogen gas to estimate the energy requirements and set-point temperatures needed for an experiment. The shrinking core model was applied to the magnetite grains. A mixing model was created for the nitrogen and water vapor. Investigations into the Gibbs free energy of the magnetite-water reaction revealed issues with the proposed experiment. FactSage 8.2 was used to model the reactions. The results indicated the proposed reaction would not occur. An alternative set of reactions were proposed in which magnetite was converted into wustite, which would in turn be converted into hematite. Further investigations indicated the reaction would not proceed to hematite.

The electrochemical reaction of magnetite and water was also considered. The voltage at various temperatures was calculated. The results show that the electrochemical reaction requires less voltage than traditional electrolysis. The electrochemical reaction is promising and deserves further review.

Results and Discussion:

Research is currently ongoing. One aspect being investigated is the feasibility of making the electrochemical reaction a cycle. This would eliminate the need for constantly replacing the “spent” iron after the reaction is complete. The ability to reuse the iron feedstock would leave open the potential for the addition of other elements to the iron samples that would further reduce the activation energy barrier. Iron is inexpensive on Earth, but on the Moon or Mars, any accumulated iron would be extremely valuable. A potential implication is if the iron-water electrochemical method of producing hydrogen is favorable, then this method may be used to produce hydrogen in space.

108. Expanded Development of Long White Pine Tree-ring Records to Support Brown to Blue Carbon Accounting for Lake Superior

Student Presenter: Rebecca Feber, Environmental Engineering

Faculty Advisor: Steven Voelker, College of Forest Resources and Environmental Science

Introduction:

The term “blue carbon” draws attention to the need to quantify the amount of carbon stored in coarse woody debris within coastal systems (Macreadie et al. 2019). In coastal systems, every carbon pool has different residence times and therefore releases carbon dioxide back into the atmosphere at different rates (Macreadie et al. 2021). There are currently no assessments of pool sizes or carbon residence time of coarse wood in Lake Superior. These assessments will determine Lake Superior’s contribution to carbon removal from the atmosphere.

Materials and Methods:

The data used for this research was collected in the form of tree cookie samples from Gemini lake in Hiawatha Township during the summer of 2023. Once the samples were collected, they were brought back to the lab and were sanded. The sanded samples were then measured using the Velmex TA Measurement System to measure all the rings on samples that had more than 75 rings. The samples were then cross dated through the COFECHA software to statistically cross date the samples and assign absolute calendar dates to each ring. Once the data was cross dated properly, select samples were chosen for stable isotope analyses to determine the accuracy of the cross dating.

Results and Discussion:

The research is ongoing; however, through the statistical cross dating of the samples, the trees were dated back to the year 1200. The samples were paired with trees from past projects to help create a complete chronology of the southern shore of lake superior. The hope is that this chronology will help to cross date future driftwood from lake superior to be able to create carbon residence time of the coarse wood and a carbon removal rate.



109. Evaluation of aqueous two-phase systems for the purification of influenza B virus

Student Presenter: Liza Korolkov, Chemical Engineering, minor in Bioprocess Engineering
Faculty Advisor: Dr. Caryn Heldt, Heldt Bioseparations Lab

Introduction:

With the increasing demand for viral vaccine manufacturing, optimization of downstream processing is becoming increasingly important. Traditionally, chromatography is used for purification, but it can be expensive and issues like low binding capacity arise. Aqueous two-phase systems (ATPS) are an alternative to traditional methods and are more economically friendly due to low material cost and their possibility for high product yield and purity. In addition, ATPS may be able to decrease the number of unit operations and can be easily integrated into a continuous process. In the Heldt Lab, we are currently focused on increasing virus purification yield when utilizing ATPS.

Materials and Methods:

ATPS are formed when two polymers or a polymer and a salt, along with water, are combined and form a two-phase system. For our purposes, we use a polymer/salt system consisting of 8 kDa polyethylene glycol (PEG), 30 w/w% sodium citrate (citrate), and Influenza B virus, which is a very labile enveloped virus. In stage 1, PEG, citrate, water, and IBV are mixed. The goal is for the virus to move into the PEG-phase and impurities to stay in the citrate-phase. The PEG is difficult to process while maintaining high recovery, so we need a second stage. Virus-laden PEG from the first stage is mixed with citrate at a different concentration to form the second stage. This time, the IBV partitions into the citrate.

How the virus partitions is affected by many factors including tie line length (TLL), tie line ratio (TLR), pH, PEG molecular weight, temperature, and hydrophobicity. The hemagglutination assay (HA) and reverse transcriptase qPCR were used to determine IBV recovery in the ATPS samples. PicoGreen and Bradford assays were used for the detection of impurities like host cell DNA and protein, respectively.

Results and Discussion:

Five different conditions were tested to optimize ATPS purification for IBV. The parameters investigated were TLL and TLR. High concentrations of PEG and citrate result in a high TLL, while low concentrations result in a low TLL. The partition coefficient, K , is the ratio of top-phase concentration to bottom-phase composition. TLR is similar and refers to the ratio of the top-phase volume to the bottom-phase volume. The first stage is performed at a high TLL, resulting in a high partition coefficient, so the virus partitions into the top (PEG). The second stage is performed at low TLL, decreasing the partition coefficient, so the virus partitions in the bottom (citrate) phase. The best condition yielded recoveries $>100\%$ based on HA and qPCR results. Such high values of recoveries stem from PEG and citrate interference in our analytical methods. The Bradford and PicoGreen assays determined 99% protein removal and 97% DNA impurity removal, respectively, in our best-condition ATPS samples. ATPS purification can lead to the purification of the IBV with an acceptable virus recovery and impurity removal. The process is simple and fast and easy to scale up or use in continuous mode.

110. Continuous Purification for Viral Gene Therapeutics Utilizing Aqueous Two-Phase Systems

Student Presenter: Abigail Ruthenberg, Chemical Engineering
Faculty Advisor: Caryn Heldt, Department of Chemical Engineering

Introduction:

Thirteen FDA approvals have been awarded and hundreds of clinical trials are ongoing for virus-based gene therapies. Viral vectors deliver therapeutic genetic material to treat and often cure illnesses like cancer, genetic diseases, and autoimmune diseases. These therapies often cost over \$1 million per dose due to high manufacturing costs. Viral vectors are currently produced in batch mode, but continuous processing can lower manufacturing costs by minimizing downtime, reducing plant footprint, and decreasing processing time. One continuous-processing method is purifying viral vectors through aqueous two-phase systems (ATPS), which partitions the viral product and impurities into two different liquid phases.

Materials and Methods:

This experiment demonstrated the versatility of ATPS purification for multiple viral products including adeno-associated virus (AAV), porcine parvovirus (PPV), herpes simplex virus (HSV), and lentivirus. During the first stage of ATPS, viral stock was mixed with sodium citrate salt (citrate), water, and polyethylene glycol (PEG) polymer and centrifuged to separate the two phases. The virus was salted out of the citrate-rich phase and partitioned into the PEG-rich phase. This serves to purify the virus since the impurities remain in the salt-rich phase. During the second stage of ATPS, the virus-laden PEG was mixed with fresh citrate salt and water at a different chemical condition. The virus then partitioned into the salt-rich phase, which has a lower viscosity and eases further processing. ATPS chemical conditions were optimized for each viral vector to maximize product recovery and impurity removal. Viral titer was measured using cell infectivity assays and droplet digital polymerase chain reaction (ddPCR). Protein and DNA impurity removal were measured using the Bradford and Picogreen assays. Ratios of fully packaged vectors to empty vector capsids were measured using biolayer interferometry (BLI).

Results and Discussion:

We have previously found that through purification using ATPS in batch mode, PPV has a 66% recovery with over 95% protein impurity removal and 91% host-cell DNA removal. We are now evaluating the applicability of this purification method to multiple viruses. We found that HSV has a 86% recovery with 96% protein impurity removal and 98% host-cell DNA removal through ATPS. Using ddPCR, we have found 80% recovery of AAV2 after ATPS with impurity removal results pending. We are currently optimizing analytical methods to quantify the recovery and impurity removal for lentivirus by ddPCR. We anticipate that these assays will be successfully optimized, and purification of these viral vectors through ATPS could lead to similarly high recoveries and impurity removals. ATPS may also have the ability to separate empty and full viral vector capsids, which could be determined through BLI. ATPS also results in 50% lower production costs when compared to traditional processes at large scales, as it relies on environmentally friendly raw materials instead of expensive proprietary materials. These results demonstrate ATPS as a cost-effective and versatile alternative that could be incorporated into a fully continuous purification process to reduce the cost of lifesaving viral gene therapies.

111. Immunofluorescent Labeling for Zinc and Platinum in Old Rats

Student Presenter: Lindy Oujiri, Biomedical Engineering
Faculty Advisor: Dr. Jeremy Goldman, Biomedical Engineering

Introduction:

The project compares Zinc and Platinum wire implants in 1 year old rats to evaluate differences in inflammation between young and old rats. Zinc is a known biocompatible and biodegradable metal, however it has a low tensile strength, preventing it from being a suitable stent material on its own [1]. It is often alloyed to increase mechanical properties, but alloying raises questions concerning its biocompatibility. Pro inflammatory markers as well as smooth muscle proliferation were evaluated and measured for each type of metal.

Materials and Methods:

For CD68 labeling, cross sections are fixed in 100% Ethanol, and washed with PBS three times, 5 minutes each. Slides are blocked with a 10% (v/v) goat serum, avidin, and biotin. The primary antibody is anti-CD68 with secondary biotinylated goat anti-rabbit IgG. The primary and secondary antibodies are diluted and incubate for one hour. A fluorescent molecule is added to the biotinylated secondary antibody, Streptavidin alexa fluor 488 conjugate, and incubated one hour. Cell nuclei are labeled using 4',6-diamidino-2-phenylindole (DAPI), by soaking it in diluted DAPI for two minutes. Slides are coverslipped and imaged immediately after. From here, thresholding finds numerical values for macrophage infiltration.

For a-SMA labeling, cross sections are fixed in 100% Methanol and washed 3 times in PBS. Goat serum is applied for 30 minutes. The primary antibody is anti-alpha smooth muscle actin, and the secondary is goat anti-rabbit IgG Alexa fluor 488. The primary and secondary antibodies are diluted and incubated for 1 hour each. DAPI is then applied for two minutes. The specimens are mounted and imaged. Thresholding is based on the signal emitted from the fluorescent antibody. This allows for numerical data collection regarding smooth muscle cells present in the neointimal tissue.

Results and Discussion:

The qualitative results supported large differences between the two age groups, and I am currently working on compiling and performing statistical tests to display the results quantitatively. A paper will eventually be published surrounding these findings. I plan to have figures and numerical data by the time of the symposium.

112. A Hemodynamic Comparative Analysis of Ectasia and Aneurysms in Kawasaki Disease

Student Presenter: Emily Vitale, Biomedical Engineering
Faculty Advisor: Hoda Hatoum, Biofluids Lab

Introduction:

Kawasaki disease is a rare childhood heart condition typically affecting children under the age of 5. The disease causes inflammation of the blood vessels by way of coronary artery aneurysms (CAA), coronary artery ectasia (CAE), or both. Patients with coronary artery dilations are at higher risk of atypical blood flow in these regions which could lead to thrombosis. The research aims to compare flow dynamics between the two dilation types and correlate the differences with clinical outcomes.

Materials and Methods:

Computed tomography (CT) scans of 20 coronary aneurysms and ectasia models as a result of Kawasaki Disease were acquired from Nationwide Children's Hospital under an Institutional Review Board (IRB) approved study. These scans were imported into Mimics Research 23.0 (Materialise, Belgium), and the images were segmented to extract the patient-specific 3D geometry of the left and right coronary arteries. Then, 3-matic software (Materialise, Belgium) was used to smooth out the exterior geometry of the segmented models. Afterwards, the coronary models were imported into Ansys Workbench (Canonsburg, PA) to be meshed in preparation for the computational fluid dynamic (CFD) simulations. Our simulations' endpoints are contour plots that show the distribution of certain key hemodynamic parameters such as time average wall shear stress (TAWSS), oscillatory shear index (OSI) and relative residence time (RRT) on the walls of the affected coronary arteries.

Results and Discussion:

The parameters extracted after CFD simulations are used to determine areas in the coronary arteries with risk of thrombosis due to flow separation and recirculation. Images with velocity streamlines were also utilized to track blood flow in these regions. The average values for each hemodynamic parameter were captured, along with measurements of the coronary artery geometry. This way, correlations can be made between the abnormal geometry of the artery (CAA or CAE) and high risk areas that have potential to develop thrombosis. The study shows that aneurysms are more prone to thrombus formation from a hemodynamic standpoint than ectasia. This is confirmed clinically as ectasia is less susceptible to thrombosis.



113. New Strategy to Solve the Traveling Salesman Problem Using Molecular Dynamic Simulations

Student Presenter: Grant Lambert, Physics
Faculty Advisor: Dr. Issei Nakamura, Physics

Introduction:

This research focuses on relating two different optimization problems. The traveling salesman problem (TSP) deals with minimizing the cost of traversing an entire list of points, and molecular dynamic (MD) simulations deal with minimizing the energy of a system of particles. The primary focus was on trying to describe the relationship between solutions realized by MD simulations and the ideal solution to the TSP. All this said, it is worth noting that this research did not consider the classic cyclic solution (start and end at the same point, traversing all once) but rather the linear solution (traverse every point exactly once). While this alters the problem, research has shown that the additional stipulation of being a cycle does not change the computational cost of the problem. This problem is important because the TSP is part of a class of computing problems which are likely to be impossible to solve using classical computing techniques, and MD simulations tend to scale better with size. So if there is a relationship, it could provide a more efficient means of solving the problem.

Materials and Methods:

The first task was to develop a brute-force solution to the traveling salesman problem (TSP) using Python. I also had to implement a method that generates a random set of points in 3D space to create test problems. The next step was to begin to understand the simulation software LAMMPS that our group uses. Our group has experience using the Stockmayer model which models each particle as a sphere with a dipole moment embedded at the center. Starting with 5 cities, we encoded cost into the van der Waals radius for the Lennard-Jones interactions between each particle and achieved a potential solution for the associated TSP when the simulation maintains a chain structure with aligned dipoles. To facilitate the self-assembly, we applied an electric field to help align dipoles along the same axis and a Langevin thermostat to introduce thermal fluctuations. OVITO's cluster analysis was used to identify the number of frames with only a single cluster, and simulations with many such frames were considered potential solutions to the TSP. All said simulations were collected for analysis.

Results and Discussion:

While we did not find that the simulation produces the ideal solution with any reliability, we did notice that the solution seemed to produce results similar to what a Monte Carlo (MC) solution does. Further analysis is required to understand the distribution of outcomes, but this does imply some promise for the use of MD simulations as a technique for solving the TSP. When considering that MD solutions may scale better than MC in large problem sizes, it could still be worthwhile to use MD simulations for solving the TSP. That said, much more research is required at several problem sizes to make any general claims, and the ongoing project is focusing on larger problem sizes and using MTU's high-performance computing facilities to accelerate the research.

114.  Anishnaabe Restoration Research and Outreach with the Keweenaw Bay Indian Community
Devlieg Foundation

Student Presenter: Erinn McKenney , Applied Ecology and Environmental Science
Faculty Advisor: Valoree Gagnon, Cassandra Reed-VanDam, College of Forest Resources
and Environmental Science in collaboration with Keweenaw Bay Indian Community

Introduction:

Wild rice, or manoomin in Ojibwemowin, holds profound cultural and ecological significance within the Great Lakes Region (6). It is integral to the Ojibwa migration story as the third prophecy directed the Ojibwa people to head West towards “the food that grows out of the water”, here, they would be home (1). Manoomin continues to represent this journey, the Ojibwe relationship to the land, their identity, and culture (2). Manoomin, also recognized for its ecological significance, provides sustenance and habitat for diverse wildlife and waterfowl (3). This generosity must be reciprocated through environmental stewardship practices and guided by Indigenous knowledges.

Materials and Methods:

To build and strengthen the partnership between Michigan Tech and the Keweenaw Bay Indian Community (KBIC), I used auto-ethnography to focus on interacting with and learning from KBIC NRD staff and community members (4). More specifically, I became a participant observer in the community, documenting my experiences at KBIC events including the 2023 Pow Wow and Wild Rice Camp. To build my foundation of knowledge, I reviewed reports and scholarship, and other relevant materials as directed by my mentors, and participated in periodic meetings with KBIC NRD staff. With an enhanced knowledge base, I co-created educational and outreach materials for both manoomin and water quality standards to share at community events, as directed by KBIC. I also engaged in ongoing KBIC manoomin research within KBIC wild rice beds. Field data included collecting surface water, sediment, and pore water samples; measuring pH, water depth, and temperature; and assessing rice stalk density at different plots on each site. This data will contribute to a KBIC watershed analysis to identify potential water bodies appropriate for wild rice growth. Field sites included Lake Plumbago and Sand Point as these bodies of water are culturally significant to the KBIC.

Results and Discussion:

This research resulted in manoomin outreach materials, a timeline infographic for the KBIC Treatment as State Water Quality Standards, and a KBIC NRD website narrative for manoomin. In 2023, the outreach materials were distributed to the KBIC and general public at the annual KBIC Pow Wow, and the timeline was shared at the KBIC public hearing for water quality standards. With the information gathered throughout my community engagement, I wrote and designed a website draft about wild rice and wild rice restoration. Following the completion of my research I had the opportunity to write the text for the KBIC NRD manoomin restoration website page. This will be released along with a full update to the KBIC NRD website in spring of 2024.

Indigenous knowledge is a valuable resource critical to the restoration and sustainability of wetland landscapes. Restoration of wild rice includes the revitalization of traditional cultural practices. In embracing Indigenous knowledge, we embrace an approach to environmental conservation that encompasses not only the physical aspects of the ecosystem but also the cultural and spiritual traditions that are intertwined in the health of manoomin. Manoomin is integral to maintaining a balanced ecosystem responsive to the effects of a changing climate.

115. Elevated Damage-Associated Molecular Patterns/NF-kappa B Signaling in Human Autosomal Dominant Kidney Disease

Student Presenter: Elisabeth Weber, Medical Laboratory Science

Faculty Advisor: Yan Zhang, Biological Sciences

Introduction:

Autosomal Dominant Polycystic Kidney Disease (ADPKD) is a genetic disease caused by mutations in the PKD1 or PKD2 genes. The disease is characterized by the continuous formation of numerous fluid-filled cysts in the kidneys, leading to renal inflammation and fibrosis. Damage-associated molecular patterns (DAMPs) are endogenous molecules that are produced following cell death or extracellular matrix remodeling. DAMPs contribute to tissue inflammation by activating the toll-like receptor (TLR)/NF- κ B pathway. Renal cyst expansion and continuous tissue remodeling can lead to increased release of DAMPs in cystic kidneys. However, their expression and role in ADPKD pathogenesis have previously been unstudied.

Materials and Methods:

We extracted total RNA and protein from normal human kidneys (NHK) and human ADPKD kidneys. Then, qPCR was conducted to quantify the mRNA levels of targets, including DAMPs (HMGB1, biglycan and decorin), TLRs (TLR2 and TLR4), as well as signaling mRNA (NF- κ B and I κ B α). Immunoblot and immunohistochemistry (IHC) were also used to determine the protein levels and localization of DAMPs, NF- κ B, and I κ B α .

Results and Discussion:

Our qPCR results revealed that the mRNA levels of HMGB1, biglycan, and decorin were increased in ADPKD when compared to NHK. Similarly, the mRNA for their receptors, TLR2 and TLR4, were increased, as well as NF- κ B and I κ B α . IHC staining showed that decorin and biglycan had a lower expression in NHK, with the largest concentration in the renal connective tissue. In contrast, their levels were highly elevated in the interstitial area of human ADPKD. The elevated decorin and biglycan were confirmed with immunoblot. Our IHC staining revealed that most of the NF- κ B was localized in the cytosol of NHK. However, in ADPKD, most of the NF- κ B was translocated into the nucleus suggesting increased transcriptional activities. Consistently, our immunoblots showed that I κ B α , the inhibitory protein of NF- κ B, was decreased in ADPKD than NHK.

Therefore, these results suggest that the increased decorin and biglycan in ADPKD could contribute to the activation of NF- κ B and inflammation of human ADPKD. As of now, there is only one FDA-approved drug that can slow ADPKD progression. By better understanding inflammatory pathways behind the development of ADPKD, new therapeutics can be developed to treat patients.

116. The Effects of Collagen Type on Fibril Stiffness

Student Presenter: Laney Fritz, Biomedical Engineering
Faculty Advisor: Sangyoon Han, Department of Biomedical Engineering

Introduction:

Collagen is a vital structural protein in the body. Studying the mechanical properties of collagen, such as the formation and curvature of fibrils and the elastic modulus of individual fibrils, can lead to a higher understanding of their role in the structure of biological tissue. Atomic force microscopy is an imaging technique that utilizes a laser pointed at a cantilever, measuring the deflection of a probe as it scans a material. It can also provide vital information about the elastic modulus of a sample.

Materials and Methods:

To examine the difference between varying collagen types, both collagen I and collagen V will be experimented on using AFM. Three different types of samples will be prepared: 100% collagen I, 100% collagen V, and a blend of 80% collagen I, 20% collagen V. This will be prepared using a stock bovine collagen and diluting it to 1 μ L/mg. This collagen will be pipetted onto a mica disk and left in a humid area overnight to give the collagen time to assemble into fibrils and adhere to the surface of the mica. The excess liquid is pipetted off, leaving a dry sample that can be used for atomic force microscopy experiments.

The AFM (Origin+ AFM in ACMAL) will then be utilized in tapping mode to image a 5x5 μ m area of the sample. The AFM will be fitted with a probe with a force constant similar to that of collagen (5 N/m). Once fibrils are visualized, the AFM can be configured to take a force curve measurement. This will provide data about the stiffness of the individual fibrils. Several experiments will take place with each type of collagen sample in order to have a large sample size of data.

Results and Discussion:

From previous experiments performed by other members of the lab using a scanning electron microscope, it was shown that samples composed of 100% collagen I have a larger fibril diameter and the collagen fibrils have a higher curvature as compared to fibrils containing blends of collagen I and collagen V. This is most likely due to the fact that collagen V has also been seen to assist collagen I with regulating fibril size. This data suggests that the inclusion of collagen V will increase the elastic modulus of the entire fibril. The atomic force microscopy experiments will assist in confirming the hypothesis that the elastic modulus of a collagen fibril increases with the inclusion of collagen V.

117. Viscoelasticity of Collagen Gel

Student Presenter: Sara Goheen, Biomedical Engineering
Faculty Advisor: Dr. Sangyoon Han, Biomedical Engineering

Introduction:

Rheology can be defined as the study of the stress and strain relationship of a material [1]. This is important in determining the viscosity of a material and can be used in biomedical engineering, polymer engineering, and even in the food industry [2]. With a rheometers versatile use, it is a great tool for researchers to utilize when testing and determining the properties of a material. Collagen is vital for the body and plays an important role in rebuilding the extra-cellular matrix. Understanding Collagen's mechanical properties allows researchers to draw conclusions about its important role in the body and various diseases like Ehlers-Danlos syndrome which affects the body's connective tissue. The main goal of the project discussed is to determine the viscoelastic, or stiffness, properties of Collagen gel.

Materials and Methods:

The main method used for this research is cone plate rheometry. Collagen I and a mixture of Collagen I and V were the main material tested. Collagen gel cures at 37°C, so the rheometer plate matched that temperature to allow the gel to cure. Curing time was consistent at 90 minutes while leaving the gel undisturbed. With the method of cone plate rheometry, the gap height from the plate to the rheometer head is fixed at 0.142mm. The main testing completed was a time sweep and a frequency sweep was done if the results were conclusive. With a time sweep, the two conditions of frequency and controlled strain were proved to show best results when kept at 1 Hz frequency and 1% strain. After the 90 minute cure time, the time sweep test was completed for various times established by the user. Longer testing times, could lead to dehydration of the gel, so mineral oil was placed around the head of the rheometer for a prevention method. The aim of the time sweep is to analyze the shear and loss modulus, G' and G'' . These results show the properties of the Collagen gel tested, and allows for conclusions about its viscoelasticity. Results were shown live on the computer and then further analyzed.

Results and Discussion:

This research is still ongoing, but some results have been shown. There has been implications with the gel drying out on the rheometer, producing unstable results on both the shear and loss modulus. With adding the mineral oil, the results have become more stable, but not showing complete curing of the gel which is indicated by a plateau on the shear modulus. There was also implications with the conditions of the rheometer testing and curing, which showed unstable results. That was analyzed and the conditions have now stayed consistent, and the current implication is the dehydration. With the implications of unstable results now due to dehydration, mineral oil will be added to the rheometer head at different stages of curing to try and prevent dehydration while also not interfering with gel curing. Once the results with the mineral oil on Collagen I gel is successful, then various amounts of Collagen V will be added to the Collagen I gel. Overall, these results should show stable curing and provide insight into the viscoelasticity of Collagen gel.

118. A Botanical and Ecological Profile of Isle Royale's Invasive Hawkweed Complex

Student Presenter: Abraham Stone, Ecology and Evolutionary Biology

Faculty Advisor: Tara Bal [1], Erika Hersch-Green [2], Carsten Kuelheim [1], Sigrid Resh [1],
College of Forestry and Environmental Sciences [1], School of Biological Sciences [2]

Introduction:

Invasive orange and yellow hawkweeds (*Pilosella* and *Hieracium* spp.: Asteraceae) have been present in Isle Royale National Park for over 100 years, yet relatively little is known about their biology, reproduction, and newfound niches across their introduced range. On the island, three interbreeding species constitute a large proportion of the wildflower population in state-imperiled volcanic bedrock glades. Considering hawkweed's historical presence and unique evolutionary mechanisms, Isle Royale is therefore an excellent study system from which to learn about both hawkweed population dynamics and ecological position post-establishment. Our study hopes to aid land stewards in bettering management practices in boreal ecosystems.

Materials and Methods:

Four bedrock glade sites dominated by hawkweed colonies on Isle Royale National Park were surveyed over three trips during the summer of 2023. A total of 97 plots of varying hawkweed densities were surveyed with species composition, abundance, and various environmental factors recorded in each plot. A total of 51 hawkweed specimens were collected, comprising three established species (n=42 specimens) and potential hybrids (n=9) as identified by their non-overlapping morphology with described species.

This study can be separated into three sections: (1) morphological trait analysis of hawkweed individuals to determine potential new hybrids, (2) genetic analysis to quantify clonality and hybridization patterns, and (3) a vegetation association study linking hawkweed presence with other species in the volcanic bedrock glade plant community. Sections (1) and (2) are accomplished through principal component analysis; (1) using morphological trait data collected in the field, and (2) using whole-genome amplified DNA sequences through the RADseq method. Both (1) and (2) are informed by chromosome counts measured through flow cytometry. Section (3) will be accomplished through nonmetric multidimensional scaling and indicator species analysis.

Results and Discussion:

Our collections supported the idea that three hawkweed species comprise the majority of the invasion; to our surprise, we also found several variants displaying clear intermediate traits, with one particular variant found at several isolated glades. This phenotype, with remarkably large flowerheads and sparsely toothed leaf margins, occupied a distinct position on a trait-based principal component map of all hawkweed specimens. Flow cytometry confirms this variant to be pentaploid (five copies of each chromosome); the origins of this mysterious entity will hopefully be determined by future genetic work. The upcoming DNA analysis should also elucidate the levels of clonality across disconnected populations, but it is expected that almost all plants, besides hybrids, are part of single species-respective genotypes spreading apomictically (i.e., through clonal seed production). Analysis of the vegetation survey is ongoing; results will be forthcoming in late spring 2024. Preliminary results suggest that grass cover is inversely related to hawkweed cover, and the two yellow hawkweed species, long-assumed to occupy similar niches, may display subtle-but-distinct habitat preferences associated with different microhabitats along bedrock glades.

119. Undergraduate Research Internship Program

Student Presenter: Lance Waise, Biomedical Engineering
Faculty Advisor: Dr. Jingfeng Jiang, Biomedical Engineering Department

Introduction:

Abdominal Aortic Aneurysms (AAA) are abnormal enlargements of the abdominal aorta, often asymptomatic until rupture, which is fatal in most cases. Thrombosis, the formation of blood clots, disrupts blood flow patterns and worsens AAA, contributing to vessel wall degradation. Current screening methods lack precision. Understanding the interaction between thrombosis and blood flow dynamics is crucial for managing AAA and related vascular diseases like atherosclerosis. This study aims to address this gap for better prevention and treatment strategies.

Materials and Methods:

This study analyzed computed tomography angiography (CTA) images from our internal Mayo Clinic database, encompassing 63 patients with abdominal aortic aneurysms (AAAs). Methodologies adhered to relevant guidelines, with approval from institutional review boards. Patient consent wasn't required for secondary data analysis. Segmentation and smoothing of AAA regions were conducted using Mimics and 3-Matic software, ensuring geometric accuracy. Computational fluid dynamic (CFD) simulations, performed using Fluent software, analyzed blood flow velocity and wall shear stress. Velocity data underwent processing to identify vortical structures, quantifying parameters such as vortex volume, overlap, and core number. Statistical analysis and visualization via violin plots provided insights into the influence of intraluminal thrombosis (ILT) on AAA hemodynamics. Combining qualitative examination of velocity streamlines with statistical approaches enhances understanding, guiding future research on AAA progression and management.

Results and Discussion:

The study examined 63 AAA cases qualitatively and quantitatively, revealing significant differences in flow patterns between cases with and without intraluminal thrombosis (ILT). Qualitative analysis via Paraview software showed distinct flow patterns. Cases without ILT exhibited multiple vortices at the start of the cardiac cycle, with a decrease in one-vortex cases over time. Conversely, ILT cases displayed more helical+vortex patterns initially, with an increase in multiple-vortex cases over time. Quantitative analysis revealed higher mean values for ILT cases in vortex volume, overlap degree, and vortical core number. Violin plots further illustrated differences, with ILT cases showing larger volumes and more vortical cores. Discussions highlighted the implications of these findings, suggesting increased turbulence and complexity in ILT cases, potentially contributing to AAA progression. The study underscores the importance of considering ILT's influence on hemodynamics for comprehensive AAA management strategies.

120. Spatial patterning and growth of naturally regenerated eastern white pine in a northern hardwood silviculture experiment

Student Presenter: David Kromholz, Forestry
Faculty Advisor: Christopher Webster, CFRES

Introduction:

Non-dominant conifer species provide valuable resources to wildlife as unique habitat, food sources, and by promoting structural heterogeneity within forested ecosystems[1-2]. The preservation of non-dominant species, such as eastern white pine (*Pinus Strobus* L.) at a stand scale is critical to maintaining forest resilience. Information on spatial patterning of regeneration is needed to help develop appropriate management strategies, specifically in cases of limited seed availability[3]. This project aims to understand the spatial patterning and growth of eastern white pine across varying canopy and soil treatment within a northern hardwood forest.

Materials and Methods:

The study took place in Alberta, Michigan in the College of Forest Resources and Environmental Science's NHSEED project (est. 2016) during October-January, 2024. Parallel transects were walked to search the entirety of the 100 ac NHSEED project area for white pine saplings. Mapping of saplings was conducted using a Garmin GPS unit, compass, and a DME sonic rangefinder. Heights, diameter at breast height, number of whorls, and height from the seventh whorl from the top of the tree were collected. The treatment units surveyed included low and high residual shelter woods, clearcuts, and single tree selections. Additionally, data were collected for all potential seed trees within 60 meters of the project's boundaries. Saplings were divided into two categories: new recruits and advanced regeneration. The resulting GPS data were used to construct maps of the eastern white pine locations and inverse-distance weighted interpolation figures for growth in ArcGIS Pro. Kernel density analysis and Ripley's K Function to analyze spatial clustering were conducted in ArcGIS Pro. ANOVA was conducted using MiniTab.

Results and Discussion:

Initial data analyses suggest that both new recruits and advanced regeneration of white pine are spatially aggregated across a range of spatial scales. Kernel density estimates suggest both advanced regeneration and new recruits are associated with mature white pines that are likely seed trees, with strong effects associated with slope and prevailing wind direction. Interestingly, advanced regeneration and new recruits tended to be associated with different portions of the study area and clumps of potential seed trees.

121. Effects of Boundary Layer Blowing on a Reflexed Camber Airfoil

Student Presenter: Adam VanderMolen, Mechanical Engineering
Faculty Advisor: Kazuya Tajiri , Department of Mechanical Engineering - Engineering
Mechanics

Introduction:

Boundary layer blowing is a method of boundary layer control, a set of experimental technologies for preventing aircraft from stalling; a phenomenon that usually happens at low airspeeds, in which a wing is not able to generate enough lift to stay airborne. Reflexed Camber Airfoils are special types of airfoils (cross-sectional shape of a wing) often intended to eliminate the necessity of a tail and fuselage in flying or blended-wing aircraft designs. This research is intended to determine the effects of boundary layer blowing on a reflexed camber airfoil, for future investigations into its usefulness for blended-wing aircraft designs.

Materials and Methods:

Computational Fluid Dynamics methods and later, a physical model to be tested in a wind tunnel will be necessary to obtain accurate results on a variety of characteristics of the airfoil. The Two most important factors to look at will be the Moment Coefficient and the Lift to Drag Ratio (L/D) of the airfoil. The moment coefficient is important, because it will tell us whether or not the airfoil has a tendency to rotate, and if so, how intense it is. This is significant because the whole purpose of a reflexed camber airfoil is to reduce the rotational movement, so if the moment coefficient changes directions or is exaggerated it could be self-defeating to include in an actual design. The L/D is also vital, because in most prior experiments involving boundary layer control methods on conventional airfoils, the L/D has increased, meaning that they are more efficient. A decreased L/D could mean the same thing as the pitching moment, indicating that it would probably not be worth implementing into an actual design in that case.

Results and Discussion:

The main purpose of this research is to determine whether or not boundary layer blowing could be useful on a flying or blended wing aircraft. As discussed above, the two most significant sources of findings will likely be the moment coefficient and the lift-to-drag ratio of the system. Because a reflexed camber airfoil curves upwards towards the trailing edge, and the blowing slot is positioned in that same region, it is possible that there will be a large, positive (upwards) pitching moment. If this turns out to be true, then a redesigned airfoil with reduced reflex could be investigated. At the same time, an improved lift-to-drag ratio would indicate that it could be a useful technology to implement.

122. Ameliorated mine waste rock for enhanced weathering and as a soil amendment for bioenergy production

Student Presenter: Mackenzie Russell, Applied ecology and environmental science
Faculty Advisor: Dr. Evan Kane, College of Forest Resources and Environmental Science

Introduction:

Enhanced weathering of terrestrial rock material is a promising method for the removal of anthropogenic CO₂ emissions from the atmosphere. However, mining and processing of weatherable rock materials is costly and increases total greenhouse gas emissions. Here we show that an ameliorated silicate-rich mining waste product can be effectively weathered in the soil environment when used as a soil amendment in conjunction with the cultivation of fast-growing willows (*Salix matsudana* Koidz. × *S. alba* L. 'Austree') in a pot study environment.

Materials and Methods:

Willows were grown for 15 weeks in pots with varying mixtures of soil and locally-sourced ameliorated (sulfur-containing minerals removed) mining waste amendment. Leachate fluid was collected by pouring water through these pots every 5 weeks. Alkalinity was measured on this fluid, as this is correlated to bicarbonate and carbonate production in the system and thus the enhanced weathering effect. pH as well as certain anions were measured on this leachate as well, and biomass was measured from dried plant tissue.

Results and Discussion:

Alkalinity and pH generally increased in leachates from treatments containing higher concentrations of mining waste amendment. These results are promising for the potential use of this material as a negative-emissions technology, and as a replacement for other liming agents. Biomass was not significantly different between treatments, likely due to the willows becoming pot bound and/or nutrient limited due to the 15 week duration of the experiment. Sulfate concentrations in leachates were also generally high in treatments with higher concentrations of mining waste amendments. This needs to be accounted for in future studies, especially if this technology is applied in a field trial.

123. Microbial Degradation of Mixed Plastics from MREs

Student Presenter: Adrian Noecker, Biochemistry and Molecular Biology
Faculty Advisor: Dr. Techtmann, Biological Department

Introduction:

Plastic waste typically has a long environmental half life and are stable compounds not easily broken down. Microbes and chemical deconstruction have been studied as pathways for breaking down these pollutants. In this experiment, MRE (Meal, Ready-to-Eat) bags are deconstructed into soluble monomers for microbial communities to degrade. Communities that have degraded PET are grown in cultures with the mixed MRE monomers as the only carbon source. Successful growth of these cultures would indicate that the microbes are capable of metabolizing mixed plastics, potentially eliminating separation steps prior to chemical deconstruction.

Materials and Methods:

Two different kinds of MRE bags (brown and green) were shredded and placed into a chemical deconstruction reactor with a solution of 10% ammonium hydroxide. The reactor was sealed and heated to a temperature of 240°C where it was held for 1 hour. The resulting soluble product from green and brown MRE bags was cooled, neutralized with phosphoric acid, and sterilized. Monomer products from the degradation of polyethylene terephthalate (PET) and polyamides in the MRE bags are expected in the soluble product.

MRE products will be added at an anticipated concentration of 5g/L in Bushnell Haas media to culture microbial communities in triplicates. Growth on products will be tested using enriched microbial consortia and isolates from the genus *Rhodococcus* previously characterized as capable of degrading deconstructed PET. Additionally, new enrichment cultures using compost may be started if adequate growth is not seen from the communities and isolates we plan to test. Growth of the tested communities and isolates will be assessed using spectrophotometry measurements at a wavelength of 600 nm. Measurements will be collected once per day while the cultures grow.

Results and Discussion:

Absorbance results will be used to plot growth curves for each of the communities. This will help determine which cultures have the highest growth rate and generate the most biomass. These results can be used to select the best performing cultures and isolates that can then be further characterized. To further assess the productivity of the best performing cultures, tests to evaluate the presence of degraded plastics may be done. To further understand the metabolic capabilities of the microbial communities and which genus are present, metagenomic sequencing may also be used. Evaluation of the community composition and productivity can enable deeper understanding of specific pathways microbes use to break down the plastic monomers. This may help to provide a basis for future research into more efficient plastic metabolism by microbial communities and characterization of which species are capable of this type of degradation.

124. Mimicking the Dynamics of the Mammalian Cochlea: Kalimba-Inspired Bio-Devices with Novel Frequency Selectivity

Student Presenter: Evelyn James, Mechanical Engineering
Faculty Advisor: Sriram Malladi, Department of Mechanical Engineering-Engineering Mechanics

Introduction:

This research is paramount as it seeks to replicate the extraordinary frequency selectivity inherent in the mammalian cochlea, known for its location-based sensitivity to diverse frequencies. This natural adaptation empowers mammals with precise environmental sound perception. Drawing inspiration from this biological marvel, the development of a Kalimba-key-based broadband vibroacoustic device holds the potential to usher in a new era of bio-devices, including artificial cochlear implants, thereby redefining sensory technology and advancing human experiences through enhanced hearing and perception.

Materials and Methods:

This research hinges on a crucial configuration where dynamic vibration resonators (DVRs) are employed to replicate the frequency-selective behavior exhibited by the mammalian cochlea. To achieve this emulation, a beam structure is integral to the setup, acting as a platform for the placement of 340 DVRs.

Each DVR in this arrangement corresponds to a Kalimba instrument key chosen for its unique vibrational characteristics. These Kalimba keys, when stimulated, mimic the vibrations of the cochlear basilar membrane within the inner ear.

The significance of the 340 DVRs lies in their collective ability to recreate the cochlear's frequency selectivity across a broad spectrum of frequencies. Just as different regions of the cochlear basilar membrane respond selectively to distinct frequencies, the interaction between the beam and the array of Kalimba DVRs allows for precise frequency discrimination. This setup plays a pivotal role in realizing the research's primary objective, which is to replicate the frequency-selective properties of the cochlea. Ultimately, this innovative approach paves the way for developing bio-devices with enhanced sensory capabilities and potential applications in fields such as artificial cochlear implants and advanced sensory technology.

Results and Discussion:

The research's findings, which are still ongoing, hold significant promise in the field of sensory technology and bio-device development. Anticipated outcomes include the successful emulation of the frequency selectivity observed in the mammalian cochlea using Kalimba-inspired dynamic vibration resonators (DVRs) attached to a beam structure. This innovation could revolutionize sensory technology by enabling the creation of artificial cochlear implants and other bio-devices with enhanced frequency discrimination capabilities.

The potential implications of these findings are far-reaching. Successful replication of the cochlea's frequency-selective properties may lead to advancements in hearing aids, implantable devices, and sensory prosthetics, offering individuals with hearing impairments a more natural and precise

auditory experience. Furthermore, this research may have broader applications in fields such as robotics, where mimicking the biological principles of the cochlea could enhance robots' sensory perception and interaction capabilities in various environments. Overall, the research's implications span across healthcare, technology, and robotics, promising significant advancements in sensory enhancement and bio-device innovation.

125. Unsupervised Learning for CRT

Student Presenter: Noah Painter, Acturaial Sciences and Statistics
Faculty Advisor: Weihua Zhou, College of Computer Science

Introduction:

My research is designed to uncover potential variables and trends that will point towards a successful CRT treatment. CRT is a very expensive treatment, so it would be very useful to discover which patients would benefit from the CRT treatment before the treatment is given out.

Materials and Methods:

I used hierarchical clustering with complete linkage and Euclidean distance. This is an unsupervised learning algorithm that generates clusters that have similar characteristics/features. I then used the response rates for varying cluster counts to determine the optimal number of clusters to generate clear and impactful results. After generating the clusters, I analyzed the trends in both the high and low response rate clusters to find variables that relate to CRT.

Results and Discussion:

I am currently working with a PhD student from a local hospital to determine the exact clinical impact of my results, but I did find a variety of variables that could have a link with a successful CRT treatment. We are currently in the process of drafting a research paper which will have all of our methodologies, results, and findings laid out. I will link this paper in the references section of this submission.

126. Approaching GLUT fluorescence labels through tuning probe-GLUT H-bonding interactions in xanthene-based glycoconjugates

Student Presenter: Gabe Bannerman, Biochemistry and Molecular Biology
Faculty Advisor: Dr. Tanasova, Chemistry Department

Introduction:

Facilitative glucose transporters (GLUTs) are membrane proteins that transport sugars into a cell based on its metabolic needs. Cancer and other metabolic disorders have an increased expression of GLUTs due to the increased demand for sugar. This makes GLUTs an attractive target for the development of fluorescent probes. Cancer cells uptake much more fructose than normal cells, which makes the fructose-specific transporter GLUT5 a prime target. This research presents the impact of variable H-bonding of xanthene-based “turn-on” probes conjugated to GLUT5 targeting 2,5-anhydro-D-mannitol on binding vs uptake through GLUT5.

Materials and Methods:

The probes were synthesized based on established procedures and structures were confirmed using NMR spectroscopy and MS spectrometry. UV-Vis spectroscopy and Fluorescence spectroscopies were used to establish probe fluorescence properties. The OriginPro software was used to process spectroscopy data and create graphs. The probes were tested on the MCF7 breast cancer cell line, and mammalian cell culture techniques were extensively used to maintain and treat the cells. MCF7 cells were grown in RPMI media at 37°C. An MTT assay was used to assess the cytotoxicity of the probes. Confocal microscopy was used to image the cells with the probe. The ImageJ software was used to process cell images and quantify fluorescence. Flow cytometry was used to corroborate confocal microscope data, and provided another route for experimentation. Excel spreadsheets were used to process the data and create graphs.

Results and Discussion:

The probes were shown to fluoresce in a pH-dependent manner as expected, showcasing their “turn on” properties. This eliminates the problem of background fluorescence and the need for washing steps, allowing more high-throughput imaging. Probes with decreased H-bonding capacity passed through the GLUT and “turned on” in the cell. The probe with increased H-bonding capacity was shown to bind to the GLUTs and not be taken up. The changes to the probes eliminated the specificity to GLUT5 provided by the targeting moiety. The results show how small changes in bonding of GLUT-targeting probes can have prominent effects on uptake vs. binding of the probes. This demonstrates a proof of concept for rational design of GLUT-labeling probes. Similar probes could be used in cancer diagnostic applications.

127. Using Simulation to Teach Computational Thinking in STEM classrooms.

Student Presenter: Rhys Brockenshire, Software Engineering
Faculty Advisor: Dr. Leo Ureel, Cognitive and Learning Sciences

Introduction:

Many schools lack teachers with a background in computing and coupled with competing demands on curriculum, students often do not have the opportunity to develop vital computational thinking skills through traditional programming-intensive computer science courses. We believe that students engaged in computational modeling and simulation in a science course are already learning and applying computational thinking skills, even in the absence of traditional programming instruction. To test this hypothesis, our research group is developing educational software and a series of computational modeling activities for middle and high school STEM classes.

Materials and Methods:

Our classroom pedagogy is based on constructionism. Constructionism is about learning through tinkering. We planed to extend the modeling environment with the development of a simulator. The combination of modeling and simulation will allow students to design and explore their understanding of a scientific process with variation over multiple iterations. The simulator will enable students to explore scientific concepts, test hypotheses, and develop computational thinking skills. In terms of software development, this project takes a visual approach by presenting a user-friendly interface. The part that I have played in this project is the development of the visual simulation portion of the project, where the reactions that the user models are computed and visually displayed in order to assist in the student's understanding of the mechanisms of whatever reaction they are having demonstrated. The workflow that has been followed during this project has included weekly team meetings, peer review, and active version control. In terms of my personal workflow for the portion of the project that I am in charge of, I have taken on a very visual approach to plan out what I have been doing.

Results and Discussion:

The research is currently ongoing, as the project has yet to come to a full testable state. the simulation portion of the project has seen significant progress in the last semester, but unfortunately the rest of the project has remained relatively stagnant. the research that we intended to conduct using the simulator was going to involve having students using the full program with and without the simulator portion. the results that are expected to be retrieved when we do conduct the research is that the simulator greatly assists in the understanding of the topic being taught.

128. Assessment of flow dynamics and morphological characteristics of coronary artery aneurysms and ectasia

Student Presenter: Emily Hyatt, Biomedical Engineering

Faculty Advisor: Hoda Hatoum, Department of Biomedical Engineering

Introduction:

Cardiovascular diseases (CVD) are the global leading cause of death which the World Health Organization estimates 17.9 million lives annually [1]. Coronary artery aneurysms (CAA) and ectasia (CAE) are local dilations of the coronary artery that are 1.5 times larger, or more, than the neighboring artery diameter [2]. CAAs can lead to angina and myocardial infarction due to thrombosis [3]. The current method to classify CAA thrombosis risk considers size as the main criteria [2]. Many studies have suggested that certain levels of time averaged wall shear stress (TAWSS), oscillatory shear index (OSI), and relative residence time (RRT) can induce platelet activation and inflammatory responses which can result in thrombosis and atherosclerosis [2]. The goal of this research is to simulate flow dynamics in aneurysms and ectasia to better determine the risk of thrombus based on flow dynamics and morphologic characteristics of the dilations.

Materials and Methods:

We began with a central composite design of experiment with 3 morphological factors, the neck diameter, the aneurysm/ ectasia diameter, and the length of the aneurysm/ ectasia. Our goal was to generate an equation using those 3 parameters to determine the TAWSS, OSI, and RRT to better predict the risk of thrombosis. However, our current equation that we came up with doesn't fit the patient specific models as well as we have hoped, so we are going to repeat the same process but use different numbers for the 3 factors to generate a more accurate equation.

For the patient specific models that we received from Mayo Clinic, we started by segmenting the CT scans using Mimics isolating the aorta and coronaries to locate where the aneurysm/ ectasia is. From there we trimmed and exported the 3D model from Materialise 3-matic. After we had the model, we ran Computational Fluid Dynamics using Ansys. We run the analysis to calculate the WSS and then use MATLAB to calculate the TAWSS, OSI, and RRT. From there, we imported the data calculated by MATLAB into Ansys to visualize what the hemodynamics look like. We measure each of the models to determine what the neck diameter, aneurysm/ ectasia diameter, and the length of the aneurysm/ ectasia are to compare how the results vary for each of the patient specific models.

Results and Discussion:

Our equation that we generated based on the results from the simulations we ran of the idealized models, didn't account for the actual length of the patient specific models, so the predictions of TAWSS, OSI, and RRT of the patient specific models using that equation were not accurate. We are redesigning the idealized models to rerun the simulations and will account for the length which will give us a better and more accurate prediction.

Besides the idealized models, we have completed analysis of 10 different patient specific models and are continuing to analyze more. These models have shown us that TAWSS, OSI, and RRT are affected by more factors besides the size. Two of the cases, numbers 5 and 7 for example have similar neck sizes around 3.5mm and slightly different maximum dilation sizes of 9.5mm and

7.8mm and much different lengths at 41.99mm and 67.28mm. The TAWSS for the two models was drastically different at 0.2911 and 3.8. A higher TAWSS means the patient is less at risk and a lower TAWSS suggests the patient is more at risk. So comparing these two patients, one would be more at risk which we wouldn't know if we only based the risk of thrombosis on the diameter of the aneurysms/ ectasias alone without considering the length.

129. Development of Optical Tweezers to Measure and Predict the Behavior of Collagen Networks

Student Presenter: Scott Severance, Biomedical Engineering
Faculty Advisor: Dr. Sangyoon Han, Biomedical Engineering Department

Introduction:

Collagen I and V are the components of collagen fibers, the material attributed to the strength of the skin. When collagen fibers are created in the absence of collagen V, the fibers formed are irregular resulting in loss of strength. Indeed, collagen V influences fiber construction, its exact role remains unclear [1]. In order for the Han Lab to continue its research at the micro level, a set of Optical tweezers needs to be built, programmed, and calibrated. This will give the lab the ability to Measure the mechanical behavior of collagen V-containing architecture with physiological force behavior.

Materials and Methods:

Optical tweezers work on the principle that light can impart a force since photons carry momentum. When the path of a photon changes due to reflection, an opposite force is imparted on the reflective surface. If we orient a high-powered laser focused through a condensing objective lens, the highly focused light forms an “hourglass shape” with a central point where all the beams cross. When a polystyrene microsphere is placed within the beam, the photons are reflected, and an opposing force is generated. A net force is applied toward the center of the trap, making this a stable equilibrium. Now if we move the sample but keep the laser stable, we can impart a force on the microsphere which can be accurately modeled as the force of a spring " $F = K(x-x_0)$ ". Now microspheres are placed in a sample of interest, a single bead is “trapped” in the laser center, and multiple attributes of the sample can now be calculated based on the force imparted by the laser, displacement applied to the sample, and the samples resulting deformation based on said force. With this system in place, Han Lab can investigate fiber formation at the micro level.

Results and Discussion:

The Han Lab is studying the factors that affect local fibroblast migration behavior. The optical tweezers which will aid in this goal have been built over the last year and are intended to run experiments on the nanoscale viscoelasticity of collagen fiber networks with varying concentrations of collagen V. The optical tweezers were built in multiple steps. First, the physical system was constructed with graduate student Mohanish Chandurkar using products provided by Thorlabs. The control software needed to properly use this equipment was developed over a six-month span with faculty member Steve Lehmann. Finally, with help from graduate student Erican Santiago, a flow channel experiment was designed and built to create a force calibration model so the Han-Lab team could use this tool in their ongoing research. During this time, the team has received results from Atomic Force Microscopy (AMF) and Traction Force Microscopy (TFM) experiments. Each technique has given essential information regarding the way collagen networks form in the presence of collagen V. With this final tool, the team can interrogate the process of fibril formation in a way yet available to them.

130. Assessing Impacts of Climate Change on Inland Lakes: Lake Acidification and Clams

Student Presenter: Cailin Bishop, Environmental Engineering
Faculty Advisor: Dr. Noel Urban, CEGE/GLRC

Introduction:

Inland lakes are a major component of the environment facing the indisputable threat of climate change as increases in atmospheric CO₂ and warming water temperatures elicit negative feedback loops within the carbon cycling and chemistry of lakes (pH, Ca²⁺, DO). Calcified shell species (i.e., clams) depend on stable ranges in water quality and are susceptible to climate change. Increases in water temperature and abundance of atmospheric CO₂ decreases lake pH, in turn decreasing the availability of calcium and carbonate ions required to form shells; the anticipated outcome is then decline or extirpation of clam populations.

Materials and Methods:

Historical and measured water quality data were aggregated for thirteen lakes across Houghton, Baraga, Marquette, and Keweenaw counties, and were evaluated for historical trends in water chemistry. The selected sample lakes were then visited using a pontoon boat from the GLRC in June and measured for water quality parameters; water and sediment samples were also collected. Based on results of the first sampling, a subgroup of the initially sampled lakes was selected; clam surveying was conducted in addition to measuring water quality parameters and collecting water samples in a second round of sampling trips in July. Clam abundance, measured parameters, and physical characteristics were investigated to determine ranges suitable for clam survival and what conditions may increase a lake's susceptibility to loss of clams due to climate change.

Results and Discussion:

The inland lakes of the upper peninsula are experiencing impacts of climate change with (30 - 42%) of sample lakes with sufficient historical data records exhibiting statistically significant trends in decreasing pH (5/12 sample lakes) and/or increasing temperatures (3/9 sample lakes). Several lakes lack sufficient historical data (30%) for pH and/or temperature and trends could not be assessed. Lakes exhibiting trends in increasing temperature have relatively deeper depths (>10m), larger surface areas (>5 sq. km), and larger percentages of wetlands in their watersheds (>10%), suggesting that lakes of the same category may be more likely to see similar trends. Clam abundance is also highest in the geographic regions of these lakes (67% in Marquette and 33% in Houghton) suggesting that clam populations in these lakes are more susceptible to experiencing a loss in population as a result of climate change. For lakes exhibiting declines in pH, they share no physical attribute and are unable to conclude which lake groups are more likely to see changes in pH in the near future. The lakes are also distributed across counties, suggesting that lakes across the UP may be equally susceptible to lake acidification.

131. Economic Impact Analysis of Sustainable Fishery Production Increases in Michigan

Student Presenter: Ingrid Sokup, Sustainability Science and Society

Faculty Advisor: Dr. Jenny Apriesnig, MTU College of Business, Economics Department

Introduction:

Given the large potential economic benefit of local seafood operations, current barriers to consumers eating fresh fish in Michigan, a limited amount of state-issued commercial fishing licenses, and the unsustainability of international fishing and shipping practices, aquaculture in Michigan is a possible industry solution. This research serves to evaluate the economic impacts of increases in employment and output across two rural Michigan counties through the expansion of aquaculture in the region. This research will contribute to a larger body of knowledge concerning aquaculture in Michigan and provide insights on opportunities for seafood producers and long-term sustainable food sources.

Materials and Methods:

In this study, the input-output modeling software platform “IMPLAN” was used to generate results. We constructed eight “shocks,” or scenarios, to model and evaluate in IMPLAN. The first four shocks consider either a “realistic” or “optimistic” increase in output, which are based on NOAA and Michigan Aquaculture Association projections, within either Alcona or Delta County. The next four shocks consider the addition of either 5 or 10 employees to the aquaculture industry within either Alcona or Delta County, based on the calculation that there are around 5 employees per current aquaculture operation.

Results and Discussion:

We are still processing and analyzing the results of various economic “shocks” that we modeled, including two focused on employment increases and two focused on output increases. Once our results are processed, we plan to find and organize the value of Employment, Labor Income, Value Added, Output, Taxation, and Affected Industries from a direct, indirect, and induced lens for each shock. We also plan to compare the various economic “shocks” in their implications. These findings will be useful in determining how aquaculture could potentially boost rural, local economies in Michigan, provide insights on opportunities for seafood producers, and aid in the creation of long-term, sustainable food sources for the public. These findings will also likely be used by Dr. Apriesnig’s colleagues at Michigan Sea Grant and MSU to further research in this field.



132. Analyzing Vernal Pool Network Connectivity and Amphibian Presence at Pictured Rocks National Lakeshore

Student Presenter: Zoie Schafer, Wildlife Ecology & Conservation and Applied Ecology & Environmental Science

Faculty Advisor: Dr. Stacy Cotey, College of Forest Resources and Environmental Science

Introduction:

Vernal pools, or ephemeral bodies of water typically found in forested areas, are an integral component of amphibian life cycles. Due to their relatively low dispersal rates and narrow habitat niches, habitat loss and fragmentation pose great threat to amphibians reliant on vernal pool systems. We analyzed the significance of network connectivity at the local, annual dispersal level and at the parkwide network, population level as a driver of amphibian presence at three dispersal distances in vernal pools in Pictured Rocks National Lakeshore (PIRO). Survey and analytical methods were implemented for wood frogs, blue-spotted salamanders, and spotted salamanders.

Materials and Methods:

Seventy-eight potential vernal pools meeting at least two of three Michigan Technological Research Institute mapping criteria were divided into 27 clusters and visited during field surveys in early May. Presence/absence surveys were conducted for the three focal species and habitat data was collected at each pool, including water pH, temperature, positioning on the landscape, canopy cover type, and canopy cover percentage, among other observations. A literature review was conducted to determine average and maximum dispersal distances by species, and these distances were then used in Conefor 2.6, an extension of ArcMap, to conduct connectivity analyses of the vernal pool network at both the local and parkwide levels. The results were used to create Generalized Linear Models using the following connectivity metrics: NC, dA, BC, and EC(IIC), as well as the habitat variables dec (positioned in deciduous habitat) and up (positioned in an upland).

Results and Discussion:

Of the 78 potential vernal pools visited, 52 were field-verified vernal pools. Wood frogs, blue-spotted salamanders, and spotted salamanders were present at 23, 18, and 6 vernal pools, respectively. At the local level, EC(IIC) explained wood frog presence at all dispersal distances (average, maximum, and doubled maximum). BC explained blue-spotted salamander presence at the average dispersal distance, and NC explained spotted salamander presence at the average dispersal distance. At the network level, dA, dec, and up explained wood frog presence at all dispersal distances in models using pools at the center of sampling cluster. Blue-spotted salamander presence was explained by BC at the doubled maximum dispersal distance, and spotted salamander presence was explained by NC at the maximum dispersal distance. Depending on dispersal distance and scale applied, there is greater likelihood of amphibian presence in neighboring pools when a vernal pool network is more connected. Connectivity typically increased when a larger dispersal distance was applied, as broad dispersers tend to experience a less fragmented landscape than that of less-traveled dispersers, or at the very least seem to be more resilient to habitat fragmentation due to greater habitat availability.

133. Vascular Biocompatibility of Multiple Mg Alloys in the Abdominal Aorta of Mice

Student Presenter: Zoe Haase, Biomedical Engineering
Faculty Advisor: Dr. Guillory, Biomedical Engineering

Introduction:

Non-degradable metal stents are the current gold standard in treating patients with coronary artery disease. However, there is an interest in pursuing metal stents made from biodegradable metals such as magnesium (Mg) to minimize long-term complications in patients. Since Mg will be used in the form of metal alloys, it is critical to understand how alloying and microstructure affects biocompatibility in the vascular system. The link between biocompatibility, elemental additions, microstructural evolution, and biodegradation profiles remains elusive for Mg materials, and the goal of this project is to gain further understanding between these relationships.

Materials and Methods:

Using a vascular wire implantation model, we implanted wires of various Mg alloy families (WE43, WE22, Mg-Dy-Zn-Zr, Mg-Y-Li) with as drawn and heat-treated microstructures (only for Mg-Dy-Zn-Zr), and platinum (Pt) control materials into the abdominal aorta of black coat C57 mice. Implants were extracted at 7, 14, and 28 days. After extraction, implants were cryo sectioned with an HM 525 cryostat between -20°C and -30°C at 10µm section thickness. Sections were cold stored at -80°C until further histological processing.

Hematoxylin and Eosin, and Verhoef Van Gieson stains were performed on the tissue cross sections. Using a previously described histomorphometry approach, neointimal area (NA), base neointimal length (BNL), and wire to lumen thickness (WLT) were measured for each cross section. Cellular content and density within the neointima were measured from DAPI stains. Images were processed in image J, and results were tabulated and graphed.

Results and Discussion:

Comparing the quantitative data from the various groups, the base neointimal length, neointimal area, and cell proliferation metrics demonstrate differences in terms of alloy family, microstructure, and time points. Overall, Mg alloys possess higher NA values when compared to Pt wire controls, demonstrating increases in inflammatory reactions. Additionally, the change in WLT dramatically depends on the alloy family being investigated. Mg-Y-Li alloys trended with lower WLT values, and WE series alloys possess on average higher WLT values. Microstructural changes elicited by heat treating Mg-Dy-Nd-Zn alloys also produced large changes in biocompatibility. Drawn conditions of the Mg-Dy-Nd-Zn materials produced the worst biological responses, with heat treating generally resulting in better biocompatibility outcomes. Overall, we find that changes in alloy family and microstructure yield a variety of biological responses in abdominal aortas of mice.

134. Commercialization of Indigenous Representation in Plant-Based Memorials

Student Presenter: Julianna Bartoszek, Anthropology
Faculty Advisor: Mark Rhodes, Social Sciences

Introduction:

Many plants are symbols of collective memory, such as using the names of family members, political figures, or significant people in history in their names. Of these prominent figures, Native American identities have been used in the naming of heirloom and commercialized varieties of fruits and vegetables. This project looks at the development and motivation behind the Indigenous nomenclature of certain crops. Were they named to serve as a commemoration to the person, or is it simply to construct a false narrative of representation [Sleeper-Smith]? How do food varieties with Indigenous names fall within the spectrum of commemoration and commercialization?

Materials and Methods:

I performed an in-depth search of 21 varieties via web scraping. From a total of 329 web pages specifically highlighting these varieties, I scraped any provided information on the person being memorialized and/or the history of the plant, such as dates and developers involved. Discourse analysis was then done on the text in the form of both descriptive and analytical coding. Discourse is the framing of issues within textual data. It studies the impact that linguistics has on social perception. It looks at the way in which a “form of truth” is being communicated and portrayed [Dittmer]. I examined the context in which the text is written. An important step of the process is identifying specific actors and their power. I can then better understand the motivation behind the memorialization.

Results and Discussion:

Of the 21 plants selected only 7 had enough textual data to proceed with further analysis (99 web pages). Sufficient information included descriptions of the person being memorialized and/or the history of the plant. Of the 329 web pages visited, 64 provided a history of the plant and 68 mentioned the memorialized.

The Indian Hannah Bean (recently renamed the Hannah Freeman Bean), Sacagawea’s Bitterroot, King Philip Corn, Red Pontiac Potato, Red Cloud Potato, Pocahontas Strawberry, and the Cherokee Trail of Tears Bean proved to fit the criteria for content and discourse analysis. Descriptive analyses found 70 resources providing official tribal names of the memorialized Native Americans and 46 gave descriptions of the memorialized beyond just their name. Analytical analysis shows that the impact that the specific Native Americans had, had been minimized.

Research is still ongoing, but through the emergent patterns, it is clear that there is a lack of meaningful memorialization. The dominant narrative is that of shallow representation.



135. Targeting Acid Sensing Ion Channel 3 (ASIC3) in Hypertrophic Cardiomyopathy

Student Presenter: Haley Marchese, Medical Laboratory Science with a minor in Pre-Health Professions

Faculty Advisor: Robert A. Larson, PhD , Department of Biological Sciences

Introduction:

Hypertrophic cardiomyopathy (HCM) is the most common genetic heart disorder characterized by abnormally thick cardiac muscle and an increased risk of other potentially fatal conditions including arrhythmias and sudden cardiac death. Previous studies in humans have reported increased cardiac norepinephrine signaling in HCM, yet the mechanisms remain undetermined. We hypothesize that overactivation of excitatory cardiac spinal afferents expressing the acid-sensing ion channel 3 (ASIC3) contribute to the increased cardiac sympathetic drive in HCM. The aim of this study is to characterize ASIC3 expression and function in HCM mice and littermate WT controls.

Materials and Methods:

We utilized qPCR to examine ASIC3 mRNA expression in thoracic (T1-T4) dorsal root ganglia (DRG; cell bodies of the cardiac spinal afferents) of HCM and WT mice. Results are expressed relative to WT mice (n=6 male mice in each group). The effects of blocking ASIC3 were investigated in vivo by measuring left ventricular pressure, HR, and dP/dt max (index of cardiac contractility) in response to a single infusion of the selective ASIC3 blocker, APETx2 in anesthetized (isoflurane 2% in O₂) HCM and WT mice (n=4 female WT, n=4 female HCM, n=2 male WT, and n=2 male HCM). Recordings of left ventricular pressure were collected through the use of a Millar catheter inserted into the left ventricle through the right carotid artery and bolus infusions were pushed through a catheter inserted into the left jugular vein. Data were analyzed with paired t-tests and results are expressed as mean±SE.

Results and Discussion:

ASIC3 expression was significantly increased in the thoracic DRG (T1-T4) in male HCM mice compared to WT (HCM 2.046 ± 0.150 vs. WT 1 ± 0.028 ; $p < 0.05$). Contrary to our hypothesis, infusion of the ASIC3 blocker APETx2 did not significantly reduce maximum systolic pressure to a greater extent in HCM mice compared to WT (HCM -12.7 ± 1.064 mmHg vs. WT -14.48 ± 4.336 mmHg; $p = 0.3579$), nor was the fall in dP/dt max significantly greater in HCM mice compared to WT (HCM -1094 ± 161.2 mmHg/s vs. WT -1594 ± 290.7 mmHg/s; $p = 0.149$). Our results do show a trend for a greater fall in HR in HCM mice compared to WT (HCM -44.09 ± 14.62 beats/min vs. WT -24.43 ± 8.611 beats/min; $p = 0.1809$) in response to APETx2, which is consistent with our hypothesis. Despite the increased ASIC3 expression in the thoracic DRG of HCM mice, our in vivo data thus far does not support the hypothesis that ASIC3 activity is increased in HCM mice. Ongoing studies will increase our sample size and allow us to probe for sex differences.

136. Utilizing Surface Electromyography Analysis to Quantify Deep Tendon Reflexes

Student Presenter: Alexandra Little, Human Biology

Faculty Advisor: Dr. Carolyn Duncan, Kinesiology and Integrative Physiology

Introduction:

Deep tendon reflexes (DTRs) are a fundamental part of neurological examinations. Clinical observations and past studies have suggested that abnormal DTRs are a sign of corticospinal tract abnormalities or dysfunction with other descending pathways that influence the reflex arc. However, there are challenges regarding the interpretation and understanding of reflex excitability in clinical settings. There have been some attempts at using alternative methods, such as electromyography, to mechanically quantify DTRs for interpretation. However, this research has been limited to smaller focused studies and has not been used to examine and characterize DTRs across larger populations.

Materials and Methods:

63 participants (24 men, 39 women); mean (SD) age = 20.2 (1.56) years were recruited from the greater Houghton, MI area. Participants were active roster NCAA DII athletes without an active musculoskeletal or neurological injury that may have affected DTR response. DTRs at the quadriceps, Achilles, biceps, and triceps tendons were measured 3 times at each location using standard tapping technique by a trained member of the research team and graded on a clinical scale of 0 to 4+. Limb muscle activations of the rectus femoris, lateral gastrocnemius, biceps brachii, and triceps brachii were recorded at 2000 Hz using a Delsys Trigno wireless surface electromyography system. Limb and reflex hammer kinematics were recorded at 100Hz using a 7 sensor Noraxon Ultium 3D motion capture system. The collected EMG signals were normalized to maximal voluntary isometric contractions collected prior to DTR testing. Peak EMG activations and corresponding joint angular accelerations for each DTR were manually identified and compared to clinical DTR scales. Data collection and analyses are currently ongoing.

Results and Discussion:

Initial findings suggest there is a clear relationship between clinical EMG recordings and clinical DTR. A positive trend has generally been observed between DTR scale rating and EMG activation, though DTR responses may not produce consistent quantifiable limb accelerations. Our promising initial analyses suggest that surface EMG may be a valuable tool to quantifying DTRs. EMG measures were able to clearly identify the initiation of the DTR, while providing more precision than the widely used clinical rating scale. For both research and clinical practice, EMG may be useful in providing more detailed information about the neuromuscular activation patterns that are associated with DTRs. Motion capture may not be sensitive enough to reliably measure the resulting movements initiated by the DTR, particularly during smaller responses. Further analyses are needed before any conclusions can be made about the relationship between clinical DTR rating, EMG, and kinematics.

137. How personality traits relate to recognition of subtle bias in STEM.

Student Presenter: Mercy Barikor, Human Factors
Faculty Advisor: Lorelle Meadows, Cognitive and Learning Sciences

Introduction:

Exposure to subtle gender bias in a STEM environment can serve as a stereotype cue that can cause women and men undergraduates to assimilate to stereotypical gender roles, lead women to underperform in STEM due to stereotype threat, and give a reduced sense of belonging in STEM fields among women. Research has shown that when exposure to these stereotypes is recognized by individuals in the environment, they can then temper their belief in explicit gender stereotypes which may lead to opportunities to reduce stereotyping in STEM. Making it important to determine the conditions under which participants might recognize bias.

Materials and Methods:

The study was a survey implemented on Prolific. Participants were compensated at \$15.38 an hour. The participants, 45 men and 46 women, including 88 STEM majors with 4 non-STEM majors, were instructed to watch a four-minute video depicting five subtle gender bias events. We evaluated participants on three of the subtle gender bias events. Which included the coined terms; he-repeating, man-interrupting, and mansplaining. They then completed a questionnaire including; open-ended reports of positive and negative aspects of the interactions in the video, a measure of Out-Group Empathy, a sexism sensitivity scale, the 60-item HEXACO personality trait instrument, closed-ended assessments of the video interactions, and demographic information.

Results and Discussion:

Results showed that men and women's recognition of bias in the video was similar with no significant difference between their ratings of the video as positive, negative, respectful, or containing bias. Women who saw the video as less positive (more negative, less respectful, and containing more bias) exhibited higher Emotionality (a trait related to experiencing anxiety in response to life's stresses). Among men, those high in Out-Group Empathy (a sense of empathy for women) saw the video as less respectful and more negative. However, none of the traits for men were significantly correlated with the perception of bias in the video. Thus, while the HEXACO personality trait of Emotionality may play a role in bias recognition for women, for men, a sense of out-group empathy can lead to recognition of bias as a negative or disrespectful behavior, but it does not necessarily lead to recognition of these behaviors as related to bias or stereotyping.



138. RedWater: The Energy Characterization of a Thermal Drill for Martian Mining Applications

Student Presenter: Ellie Zimmermann, Mechanical Engineering

Faculty Advisor: Dr. Paul van Susante, Mechanical Engineering - Engineering Mechanics

Introduction:

Extracting water from the Martian surface is necessary for the human exploration of Mars. Most Martian water comes in the form of subterranean ice glaciers, making it difficult to access. The Rodriguez Well, a terrestrial water extraction technology, offers a potential solution. The Planetary Surface Technology Development Lab developed a simplified model of a thermal drill and tested it in Martian atmospheric conditions. Energy analysis of the system was used to examine the use of heat—rather than drill bit rotation—as the primary actuation method when drilling into the first 1 m of ice during the formation of a Martian Rodriguez Well.

Materials and Methods:

For each test, a block of clear ice was created and stored in a -80°C freezer. All tests were run in an 18in3 acrylic vacuum chamber that was held at a pressure of 7 Torr while the ice block was cooled to -60°C by a liquid nitrogen shroud. The probe that was used for testing consisted of a high-density cartridge heater within an aluminum sheath. During each test, constant power was supplied to the cartridge heater using a variable AC power supply. We utilized two probe assemblies throughout our testing: a gravity-actuated assembly (passive actuation), and a motor-driven assembly (active actuation). During a passive actuation test, the probe was allowed to warm up before it was released to the surface of the ice block via servo motor. As the probe displaced into the ice block under its own weight, a string potentiometer measured the displacement of the probe relative to the top of the ice block. Active actuation tests were run the same way, but with a stepper motor to drive the probe into the ice. Tests were run until the probe reached a depth of 7.62cm, or until it plateaued at the same depth for over an hour.

Results and Discussion:

Given that the passively actuated tests were not capable of consistently reaching the target drilling depth, it would not be sustainable to replace a rotating drill bit with a gravity-actuated thermal probe when drilling into the first meter of Martian glacier ice. Once the drill is situated one meter deep into the ice, however, a highly powered, gravity-driven thermal probe in a pressurized environment may be most efficient for melting the Rodriguez Well itself. For creating the borehole through the first meter of Martian ice, a high-powered, motor-driven thermal probe system may be capable of replacing a motor-driven drill bit for the creation of a borehole. These findings support Honeybee Robotics' use of a pneumatic packer to seal the borehole during the drilling phase of the Rodriguez Well formation and propose new drilling methods for use on the Martian surface.

139. Trophic ecology of Gulf Coast canids: Influence of anthropogenic sources on dietary niche breadth

Student Presenter: Quinn Angus, Biological Sciences

Faculty Advisor: Jill Olin, Biological Sciences

Introduction:

Characterizing the ecological roles of organisms is imperative to ecosystem management and is especially relevant for predators that have undergone declines¹. Red wolves (*Canis rufus*) once inhabited the southeastern United States but were declared extinct in the wild by 1980². Today, this species is listed as highly endangered, though evidence of red wolf ancestry has recently been documented in coyotes of southwestern Louisiana and southeastern Texas³⁻⁷, making these individuals unique hybrids. My research aims to investigate the anthropogenic influence on two distinct populations of these canids to further understand the trophic position of these hybrid canids.

Materials and Methods:

Stable isotope analysis is used to study a species' ecology, most commonly to estimate trophic level and dietary composition of individuals because these tracers integrate both temporal and spatial consumer habitat and dietary resource use^{8,9}. Specifically, carbon isotope values identify primary production sources, and nitrogen isotope values indicate trophic positioning and overall food web structure¹⁰. I will use stable isotope ratios of carbon ($^{12}\text{C}/^{13}\text{C}$; $\delta^{13}\text{C}$) and nitrogen ($^{14}\text{N}/^{15}\text{N}$; $\delta^{15}\text{N}$) from canid scats and hair, as well as environmental samples, to derive estimates of diet and resource use by specifically quantifying the differences in trophic ecology (e.g., trophic niche size and trophic position). To prepare samples for isotopic analysis, the scat matrix will be sieved to isolate species' epithelial cells from the scat matrix. Samples will then be dried, rinsed with 0.1 N HCL to remove carbonate contaminants, homogenized and weighed (~1 mg) into tin capsules, and relative abundances of ($^{12}\text{C}/^{13}\text{C}$; $\delta^{13}\text{C}$) and ($^{14}\text{N}/^{15}\text{N}$; $\delta^{15}\text{N}$) will be determined on a Delta V isotope ratio mass spectrometer coupled with a Thermo Scientific Isolink elemental analyzer in the LEAF facility at MTU.

Results and Discussion:

Sample processing from this project has very recently wrapped up and we are expecting data back from the lab very soon. Samples from both the Louisiana population and the Texas population were processed and sent for analysis. From visual analysis of scats during sample processing I expect that consumption of anthropogenic resources will be greater in canids from urbanized habitats (Texas population) relative to those from rural habitats (Louisiana population). I predicted that the dietary niche of urban canids to be larger than the dietary niche of rural canids with this difference being driven by a more diverse diet with increased availability of anthropogenic dietary resources. The implications of this research would be to see how the presence of humans affects top trophic level predators. This information would be useful in assessing ecosystem management and potentially factor into future protection of these coyote hybrid populations since they possess high amounts of red wolf genetic composition.

140. Electrospinnable and Photocurable Polyester Elastomers to Engineer Bioresorbable Synthetic Grafts

Student Presenter: Christopher Kluka, Materials Science and Engineering
Faculty Advisor: Xiaochu Ding , Chemistry Department

Introduction:

Occlusive artery diseases are the leading cause of death worldwide. A bioresorbable graft has been proposed to replace the occluded arteries for in situ regeneration. A resorbable graft is a porous conduit made from biocompatible and biodegradable polymers. Upon implantation orthotopically, host cells will infiltrate and grow in the porous conduit to transform it into a living conduit as the polymer is gradually degraded and absorbed by the host. The invention of this vascular graft has the potential to completely revolutionize the medical field by improving the operation and implantation of temporary grafts, as well as producing grafts that can regenerate native blood vessels and form native arteries.

Materials and Methods:

The applications within the medical industry expand exponentially with the invention of a resolvable elastomeric scaffold with regenerative abilities. We have been working for the past year to optimize the material properties and the appropriate pair of pre-polymers needed to achieve this feat. To design an efficiently remodelable graft, we hypothesize that the grafts must be designed to simultaneously possess key features of robust elasticity, suitable mechanical properties, and appropriate hydrophilicity and degradation rate. To this end, we have designed a pair of functional polyesters that are electrospinnable and photocurable for engineering a resorbable graft for studies in the rat abdominal aorta interposition model. Pre-polymers POST50 and PCL50-b-PGSA20 are synthesized and used for the creation of this remodelable graft. The prepolymers possess suitable glass transition temperature, melting temperature, and molecular weight to make elastomeric scaffolds after cross-linking. The elastomeric scaffolds are produced using electrospinning by mixing the pre-polymers in solution and collecting the fibers on a spinning mandrel. Samples of 30% weight pre-polymer mix/ volume vs 32% weight pre-polymer mix/volume are of primary focus in this study going forward as this combination of pre-polymer weight vs volume in the solution, yields the most optimized elastomeric scaffolds so far.

Results and Discussion:

This research is still ongoing and there have been many challenges and limitations that we have had to overcome as a team. Although the 32% weight/ volume and 30% weight/ volume grafts that we have produced exhibit sufficient elastomeric scaffolds with tunable material properties, much more work must be done to further optimize these conditions. Once we collect data from the rat abdominal aorta model, we will be able to assess and improve our design. In the future, the goal is eventually to transition to using larger animals such as sheep so we can further progress towards eventual human trials.

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