Michigan Technological University

Undergraduate Research Symposium

2020

Welcome to the 2020 Undergraduate Research Symposium!

The Undergraduate Research Symposium highlights the amazing research being conducted on Michigan Tech's campus by some of our best and brightest undergraduate students. While we weren't able to hold an in-person symposium this year, we still want to celebrate our students and faculty with this compilation of abstracts.

The students showcased here have worked alongside Michigan Tech faculty and graduate students to explore, discover, and create new knowledge. They've spent long hours in the lab or out in the field designing experiments, gathering data, creating new models, and testing hypotheses. They've applied their classroom knowledge in new and sometimes unexpected ways, and developed new skills that will propel them forward in their careers.

Each student was mentored by a faculty member who took great care to guide them through the trials, errors, and successes of research. Through the process, they've built strong relationships that will last a lifetime. I'd like to thank our faculty, our sponsors who have funded much of the work you'll see in this book, the office of the Vice President for Research for originally creating and funding the Summer Undergraduate Research Fellowship (SURF) program, and the Portage Health Foundation, the DeVlieg Foundation and the Michigan Space Grant Consortium for funding the Undergraduate Research Internship Program (URIP).

We miss the opportunity to celebrate our students in person at the Undergraduate Research Symposium. But among the many things we've all come to appreciate this year is the importance of the researchers, the ideators, the analysts, and the problem solvers. Take a few minutes to see the research that's happening every day at Michigan Tech. If you have questions, reach out to the students over email - they'd love to talk about their work. And imagine the impacts that these young researchers are going to make throughout their careers.

Lorelle Meadows
Dean, Pavlis Honors College

Michigan Tech

Pavlis Honors College

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Cataloging NASA's Fermi Satellite's Super-GeV Photons

Student Presenter: Casey Aldrich, Physics
Faculty Advisor: Robert J. Nemiroff, Physics

Introduction:

NASA's Fermi Satellite contains the Large Area Telescope (LAT) that is used to detect gamma-ray bursts (GRBs). Many GRBs have been detected that contain high energy photons. The data for these GRBs is free to the public, but the current online database requires one to put in very detailed information in order to find data on a specific GRB.

Materials and Methods:

I created a catalog of the high energy photons from GRBs that is much easier to sort through. In order to do this, I used Astropy, a Python package that allowed me to read raw data files from NASA's online Fermi LAT database. The created catalog contains information on 146 GRBs with information on each, including its time of detection, redshift, and position in the sky printed in the header of each data table. Each data table provides details on each high-energy photon reported, including its energy, the time it was detected, and its angular separation from the reported position of its respective GRB.

Results and Discussion:

Using this same data, I was able to create scatter plots and histograms of each GRB. This allows for an easier manual identification of patterns as well as quick visual comparisons between multiple GRBs. The data tables are also simple to scan into a program so that the data can be manipulated and used for calculations. One example of this that I explored was creating lists of photons closely paired in time within each GRB. Depending on the physical theory or law that one is exploring, being able to generate information of this type quickly could be useful. The created catalog makes the analysis of the high energy photons detected by LAT simpler and less time consuming.

Anisotropic cardiac-specific extracellular matrix for cardiac patch engineering

Student Presenter: Zachary Alesch, Biomedical Engineering
Faculty Advisor: Feng Zhao, Biomedical Engineering

Introduction:

This project aims to grow a highly aligned extracellular matrix sheet that mimics the unique environment of the myocardium. Such a construct can provide an effective scaffold for cardiomyocyte cells, the dominant cell in cardiac muscle. Generating the components of cardiac tissue using stem cells would enable the engineering of a functional, personalized cardiac patch for repairing myocardium after the heart wall is damaged as in myocardial infarction.

Materials and Methods:

Cardiac fibroblasts derived from induced pluripotent stem cells (iPSCs) were cultured on a nano-patterned polymer surface. The cultured cell sheet was decellularized after 14 days. This extracellular matrix was analyzed to verify its similarity to native cardiac ECM. Immunofluorescent staining and scanning electron microscopy were used to view the alignment and structure of the synthesized extracellular matrix. The content of matrix macromolecules and growth factors was measured using either ELIZA or biocolor assay kits. Induced pluripotent stem cell-derived cardiomyocytes were seeded in the ECM scaffold and cultured for 14 days. These engineered tissues were also stained and viewed with immunofluorescent staining to observe their alignment. Expression of cardiomyocyte-specific genes in the cardiomyocyte-ECM constructs was quantified using PCR.

Results and Discussion:

Extracellular matrices derived from iPSC-derived cardiac fibroblasts displayed a highly aligned structure, comparable to ECM from native cardiac fibroblasts. The iPSC-cardiac-fibroblast-ECM contained weights of collagen, elastin, and fibronectin comparable to or significantly higher than native-fibroblast-ECM and non-cardiac human dermal fibroblast (hDF) derived ECM, indicating the iPSC-ECM was structurally competent. ECM growth factors VEGF, IGF, and Endothelin I were similarly comparable or greater in the iPSC-ECM compared to control ECMs, successfully preserving the biological functionality of cardiac ECM. In the cardiomyocyte tissue constructs, cardiomyocytes displayed highly aligned growth in the iPSC-ECM, only slightly inferior to cardiomyocyte alignment in native-fibroblast-ECM and hDF-ECM. Expression of various cardiomyocyte-specific structural and functional genes on iPSC-ECM mimicked expression of native-fibroblast-ECM, indicating that the stem cell derived ECM did not affect cardiomyocyte behavior differently from a native derived ECM. Engineered cardiac cell sheets displayed slow autorhythmic beating, not comparable to native-myocardium, indicating that cardiomyocyte maturation and behavior can not yet match physiological conditions in the extracellular matrices generated here. The chemical and structural results of the tissue sheets, however, suggest an effective cardiac patch could be developed from induced pluripotent stem cells with further experimentation.

Analysis of Oligomeric HMX/CL-20 Co-Crystal Systems via Quantum Theoretical Methods

Student Presenter: Peyton Bainbridge, Chemistry
Faculty Advisor: Dr. Loredana Valenzano-Slough, Chemistry

Introduction:

A recent co-crystalline energetic material, consisting of HMX ($C_4H_8N_8O_8$) and CL-20 ($C_6H_6N_{12}O_{12}$) in a 1:2 ratio, has shown improved reactivity and detonation velocity, as well as stability, merging the individual properties that HMX and CL-20 alone are known for. These properties make this new material able to fulfill the promise of becoming one of the next most common explosives. Through quantum mechanical computational approach, this project aims at shedding some light on the complexation mechanisms involved in the formation of crystalline nuclei of the end-member materials (i.e., pure HMX and pure CL-20) versus their co-crystal.

Materials and Methods:

Several molecular oligomers of varying molecular compositions were generated starting from their crystalline structure experimental X-Ray refinement (CIF files). In particular, the energetic properties of monomeric, dimeric, and trimeric systems were investigated through the implementation of single-point and geometry relaxation calculations. This approach allowed to determine configuration and complexation energies of the various molecular complexes. Calculations were performed at various density functional theory (DFT) approximations (B3LYP-D3, M06-2X, etc.) in combination with a linear combination of atomic orbitals approach (LCAO) employing 6-311G(d,p), cc-pDVZ, and aug-cc-pDVZ basis sets.

Results and Discussion:

Results obtained from this investigation are expected to provide a quantitative analysis of the stability and reactivity of the molecules and their chemical behavior with respect to the presence of neighboring molecules. From this data, an assessment of the intermolecular forces at play during the assembly process of this energetic co-crystal can be appreciated. This work will enable an understanding of the intermolecular forces involved in the formation of nucleation seeds of organic solids such as energetic materials.

NIH/3T3 Fibroblast Growth on Carbon Nanotube Forests

Student Presenter: Alicia Ball, Chemical Engineering
Faculty Advisor: Parisa Abadi, Mechanical Engineering-Engineering Mechanics

Introduction:

Carbon Nanotube (CNT) Forests are strands of pure carbon, held together by van der Waals forces. Because of their structure and electrical conductivity, they prove to be useful scaffolds for tissue engineering. The scaffolds could be used in various applications including biorobotics and in-vitro models for drug testing. Our research focuses on the growth of 3T3 Fibroblasts into the 3D structure of CNT forests. We investigate the viability, adhesion, and spreading of the cells on the scaffolds. The results show the promise of using CNT forests as conductive scaffolds for tissue engineering.

Materials and Methods:

NIH/3T3 Fibroblasts are a continuous cell line, which originated from embryonic fibroblast cells. The nature of the cells leads to rapid proliferation and proves to be useful for cytotoxicity studies. Our process included passaging the fibroblasts, and seeding them onto CNT scaffolds, glass coverslips, and polystyrene well plates. The scaffolds were coated with 1% (w/v) Gelatin, which allowed the cells to attach more readily to the materials. After seeding, various tests were conducted on the samples to investigate growth rate, viability, spreading, and the levels of gene expression related to adhesion.

Results and Discussion:

Initial testing included making the gel coating for the CNT forests. Two types of gels were tested, Gelatin and Gelatin-Methacryloyl (GelMA). No significant difference between the two coatings was detected. Hence, 1% gelatin was chosen for the rest of the experiments. Different concentrations were also evaluated, and 1% Gelatin was selected to carry out the experiments. Live/Dead staining was conducted, and showed high viability on all samples at a variety of time points. F-Actin staining was also done to show the cytoskeleton of the cells, followed by a DAPI stain to show cell nuclei. These images showed the cells and their attachment to the CNT forests and spreading over the structures, which supported our prior viability assays. Further testing and results are currently scheduled, including scanning electron microscopy and gene expression studies.

Identification of Vapor Pressure Traces of Energetic Materials (EMs) and Nitromusk Molecules via Signature Spectroscopic Properties

Student Presenter: Jason Barr, Chemistry
Faculty Advisor: Loredana Valenzano-Slough, Chemistry

Introduction:

While spectroscopic techniques focusing on the terahertz region of the infrared spectra (0.1-10 THz = 3.33-333 cm-1) have shown the ability to detect explosives in trace amounts, even through fabrics, the low signal/noise ratio requires a better characterization able to provide a more complete and reliable assessment on bands positions and intensity of the vibrational modes. Furthermore, many molecules used for cosmetic purposes have been shown to give false-positives in tests for explosive residues, indicating the need for an investigation of their responses in the THz region able to reliably differentiate cosmetic molecules from explosives.

Materials and Methods:

Density functional theory (DFT) was applied through the electronic structure program Guassian16 to test the behavior of several approximations (B3LYP, B3LYP-D3, the Minnesota family of functionals, etc.) to describe the THz region of the IR spectra of several energetic molecules (TNT, RDX, HMX, PETN, EGDN, and FOX-7) and mitromusk fragrance molecules. In addition, several by-products also became accessible such as relative energy of EM polymorphs, atomization energy, atomic charges, dipole moments, HOMO/LUMO gaps, and thermodynamic properties. Properties were determined for isolated molecules (monomers).

Results and Discussion:

Using quantum mechanical computational approaches, this project aims to address subtle differences in the vibrational spectra of explosives and fragrance molecules with particular attention to their spectroscopic behavior in the THz region of the spectrum. Explosives under investigation include TNT, RDX, HMX, PETN, EGDN, and FOX-7, while a group of fragrance molecules known as “nitromusks” including musk xylene, musk moskene, musk ketone, musk tibetene, and musk ambrette were chosen due to their similarity in structure and functional groups to the EMs being studied. The final objective is to contribute to the compilation of a database of physical-chemical data, which can then be analyzed to distinguish trends and isolate features that allow the identification of each specific molecule. In addition, comparisons across different computational methods are reported, with the expectation being that different methods will produce notable but ultimately predictable variations in the results obtained.

Applied Human Physiology Fitness Trail Project: Benefits for Local Residents and Undergraduate Students

Student Presenter: Thomas Basala, Biological Sciences: Pre-Medicine
Faculty Advisor: Dr. John Durocher, Clinical & Applied Human Physiology Research Laboratory

Introduction:

The Clinical and Applied Human Physiology Laboratory at Michigan Technological University has created a science outreach program with the Chassell Trails Club beginning in the spring of 2019. Based on the data from our local health assessment nearly 30% of all Houghton County residents are obese and 21% are below the poverty line. More than 55% of our local residents stated that lack of affordable facilities and programs for year-round physical activity is a significant priority. The primary aim of this project is to provide free access to trails that allow for quality aerobic, resistance, and balance exercise training.

Materials and Methods:

We worked with a representative of the Trails Club to secure funding from the Portage Health Foundation to replace a bridge on the 4-kilometer fitness trail, and to purchase and install ten pieces of equipment from Outdoor-Fitness. We then confirmed plans to make exercise technique videos (to be posted on the township's website) and laminated posters for each exercise station so that residents will know how to safely and effectively use all equipment. An undergraduate student in our laboratory is proposing a Summer Undergraduate Research Fellowship (SURF) to perform an energy expenditure study on the course. Upon acceptance of a grant, we will utilize our new Cosmed K5 expired air analysis system to quantify energy expenditure and exercise intensity around the course while walking only, and while adding the additional ten resistance and agility exercises.

Results and Discussion:

Research is ongoing, however outcomes already achieved include: 1) the bridge replacement in conjunction with the Chassell High School shop class, 2) installation of the equipment to target all major muscle groups, 3) pictures posted on the township's website and social media sites to increase awareness, and 4) purchase of a new Cosmed K5 system for our exercise intensity and energy expenditure portion of this project through the Portage Health Foundation Infrastructure Enhancement Research Excellence Fund at Michigan Tech. Collaboration between faculty, undergraduate students, and the community has brought awareness to the trail system, increased motivation to use the trails on a regular basis, and provided tips on how to safely engage in regular exercise. Specifically, this outreach program has been working to promote accessibility and to provide free educational resources to community members for safe and effective exercise.

Analysis of Lunar Thermal Protective Structures for Rover Storage and Maintenance

Student Presenter: Robert Beggs, Mechanical Engineering
Faculty Advisor: Paul Van Susante, Mechanical Engineering

Introduction:

The first step in NASA's plan to return to the moon is using commercial lander services to bring rovers to the surface to explore and prepare the site for a human presence, determine exact mineralogy, and ice content. Throughout a lunar day, temperature changes from 127 to -173 degrees Celsius, which causes thermal contraction/expansion cycles that can reduce structures' and vehicles' lifespan significantly. Initial missions will utilize rovers, and creating unpressurized structures can protect rovers from radiation and thermal cycling.

Materials and Methods:

First, a 3d model of the surface, a rover proxy, and a rover hangar are created in NX. Then the model is meshed and imported into NX Space Systems Thermal. The differences between each model include hangar shape, thickness, material, terrain, and latitude. Hangar shapes include straight walls, curved walls, arch slabs, cylindrical, submerged structures circular and parabolic domes. Materials being tested include Mylar, bulk Regolith, cast/sintered Basalt, cast regolith, Lunar Glass, and Rock Wool. These materials were chosen because they can be made in situ or because of their low density. For each model, the surface temperature of the rover is evaluated for lunar day/night cycles until steady state. The hangars that keep the rover between -40 and 40 degrees Celsius (Curiosity rovers' electronics operating temperature) will be examined further. Those hangars will have total structure volume and minimum structure thickness calculated, with the ideal hangar having the smallest structural volume and thickness.

Results and Discussion:

Previous work includes creating one and two-dimensional models of the lunar surface. Current work is focused on mesh structure and sizing for full-scale three-dimensional simulations. Once the mesh is properly sized, comparisons of each structure can be made. Previous studies have shown that a .3 m thick regolith radiation shield would be thick enough to protect astronauts from the extreme temperatures on the lunar surface, so the results should show for an unpressurized hangar less material is needed to protect a rover. With a better understanding of a hangared rover's thermal response to each structure, a rovers expected practical life could be increased, in situ resource utilization can be tested in a low-risk mission scenario, and rovers thermal protection can be decreased which will save crucial mass during a mission.

Quantum Chemical Determination of Molecular Crystals Single Molecule Atomization Energies

Student Presenter: Steven Beuther, Chemistry
Faculty Advisor: Loredana Valenzano-Slough , Chemistry

Introduction:

In the past decade a more accurate understanding of physical chemical properties such as equilibrium structures, stabilities, and reactivities of single molecules in molecular crystals has become paramount in materials science and engineering. Examples of these materials (also known as organic solids) are high energy materials (explosives), active pharmaceutical ingredients, and crystalline polycyclic aromatic hydrocarbons (PAH). In order to guide and engineer the behavior and performances of the finite materials, an understanding of their physical chemical properties at the quantum mechanical level, such as the description of the formation of nucleation seeds and their subsequent crystal growth mechanisms is necessary.

Materials and Methods:

The linear combination of atomic orbital (LCAO) software package Gaussian16 is used to determine equilibrium structures, and energies of several PAH single molecules. Together with the determination of the energy of the atoms constituting the molecules, atomization energies for the monomeric structures are determined at various density functional theory approximations and in combination with several basis sets. Results are compared across the methods and with respect to available experimental data to determine trends in the performance of the adopted approximations. In addition, composite model chemistry methods are used to determine atomization energies within chemical accuracy (±1.0 kcal/mol = ±4.184 kJ/mol).

Results and Discussion:

The research is ongoing. Results obtained so far are in good agreement with the available experimental observations. The comparison between results obtained with 6-311G and aug-cc-pVDZ basis sets, confirms the importance of adopting higher quality basis set (as the latter is) to more reliably describe atomization energies. It is observed that for PAHs with comparable chemical structure and level of conjugation, the substitution of carbon and hydrogen atoms for nitrogen atoms increases the atomization energy (defined as a positive value), creating a more stable structure. The change in energy due to the substitution of one nitrogen atom in place of a CH group, lowers the atomization energy by approximately 300 kJ/mol.

Mapping Mercury and Copper Contamination from Stamp Sands in Keweenaw Bay

Student Presenter: Julia Boscarino, Environmental Engineering
Faculty Advisor: Noel Urban, Civil and Environmental Engineering

Introduction:

Local copper mining deposited ~six billion pounds of stamp sands that leach copper, mercury, and other harmful chemicals. Mercury bioaccumulates to harmful concentrations in fish that we eat. Copper is toxic to fish and benthic organisms. Extreme weather events have mobilized the sands to cover the natural sand beaches at Sand Point, restricted a river outlet that serves as a harbor of refuge, and are impacting an important lake fish spawning reef and nursery near Gay, MI. Mapping locations of stamp sands is a first first step towards finding a means to remove this source of mercury and copper contamination.

Materials and Methods:

Sediment cores were taken from Keweenaw Bay; they were extruded in 1-cm increments, dried, ground with a mortar and pestle, and combusted using a muffle furnace. A portion of sediment from each 1-cm slice of each core was kept in vials in its dried, ground state. This is the material used to perform the mercury and copper analyses. Mercury was measured with the Direct Mercury Analyzer (DMA-80). Copper analysis required acid digestion of the dried and ground sediments in a microwave (Ethos 900), and subsequent measurement using a flame atomic absorption spectrophotometer. The metal concentrations indicate whether stamp sands are present. The results were mapped in GIS to show the areas where stamp sands are present.

Results and Discussion:

The mercury concentrations in the sediment cores range from 20 to 200 ppb, while preliminary measurements of copper range from background to 900 ppm. Concentrations of copper greater than 400 ppm are toxic to benthic organisms. Elevated mercury concentrations in deeper parts of Keweenaw Bay suggests that the finer portions of stamp sands are traveling farther than initial estimates. Where stamp sand contamination is present, concentration profiles show low background concentrations deep in the profile overlain by a large peak in concentrations that then decreases toward the sediment surface. Similar profiles are seen for both mercury and copper. In areas where we do not see this mercury profile, the copper concentrations are expected to be low. The copper concentrations, in areas with high mercury concentrations, are expected to be at toxic levels. It is not yet clear if concentrations have declined below toxic levels at the sediment surface where benthic organisms live.

Generative Adversarial Networks: Computer Generated Music

Student Presenter: Jessica Brown, Computer Science
Faculty Advisor: Dr. Timothy Havens, Data Science

Introduction:

Generative Adversarial Networks (GAN) are at the forefront of Machine Learning. Created in 2014 by Ian Goodfellow, two neural networks simultaneously train to produce computer-generated data that is indistinguishable from real-world data. This type of neural network framework has many uses, from recognizing handwritten digits to creating fake images or video. The question I propose to answer is whether GANs can generate realistic sounding music by training on recorded audio.

Materials and Methods:

The materials needed for this project are mainly software based. To code this project, Spyder will be needed, which is a Python coding platform. Tensorflow will also be necessary, which is an open-source library for a variety of programming needs, including machine learning with GPUs. A dataset of real-world recorded songs will also be needed to train the neural network.

The first step in this project will be to collect real-world song samples for the training dataset. Complex music may be too difficult for a network of this magnitude to decipher, so the dataset will consist solely of different meditation/relaxation songs---i.e., slowly varying waveforms. After this, the main step is creating the neural network architecture. I will need to modify existing GAN software to take an input of sound clips, outputting a generated sound clip. Once this is completed, I will test the generated waveforms by playing them for people. A survey instrument will be used to judge the overall believability and quality of the generated sound. After I have settled on a given network architecture and hyperparameter setting, I will run with the training data and record the results as an audio track.

Results and Discussion:

This research is still currently outgoing, so there are currently no results available. The anticipated outcome of this project though is a "decent"-sounding audio track. A computer lacks the ear of a human to determine if it sounds good or not, so there is a chance the output could be more similar to noise than music. We believe that by simplifying the input by using meditation/relaxation music, which lacks note and temporal complexity, maximizes the probability of a pleasing-sounding output.

This research is important because it provides an example for how versatile neural networks are, specifically GANs. They can be used to create almost anything: music, imagery, videos, human faces, etc. As trivial as a meditation-music-generating GAN may seem, it is just a simple example of what these networks can do. With the capability to generate unlimited instances of data given the correct input, their possibilities of use are endless.

Characterization of Aqueous Two-Phase Extraction Systems for Virus Purification

Student Presenter: Ethan Burghardt, Biochemistry (Chemistry)
Faculty Advisor: Dr. Caryn Heldt, Chemical Engineering

Introduction:

Current techniques for large-scale vaccine production are hindered by low yield and throughput and were designed to purify proteins. Aqueous two-phase extraction (ATPE) is a technique that draws viral particles harvested from a cell broth across a fluid interface into one phase, while leaving protein and DNA impurities behind. Viruses vary in size and surface characteristics, requiring extensive development to purify each vaccine or gene therapy candidate. An understanding of the driving forces of ATPE allows for prediction of appropriate systems to purify specific viruses.

Materials and Methods:

This project focused on understanding the interfacial tension of different ATPE systems. The partitioning of the virus has been studied previously and it was hypothesized that the interfacial tension may play an important role in determining the partitioning. Systems containing polyethylene glycol (PEG) with an average molecular weight of 12 kiloDaltons and citrate solutions were prepared at 35 and 25 (w/w%) respectively. The binodal curve, generated in previous work, using the turbidity method, was used as a guide to determine which systems to study. Each phase component was measured out in 50 mL aliquots and diluted as needed with deionized water. Confirmation of the system composition was determined by measuring the conductivity of the citrate phase. Each system was homogenized for 60 seconds using a vortex mixer. The systems were then centrifuged at ~12,300 xg for 5 minutes to ensure complete phase separation. Interfacial tension was measured using a platinum Wilhelmy plate (Krüss PL01). The plate was selected so that the contact angle at the interface was 0 degrees. Interfacial tension is compared to the binodal curves to confirm our hypothesis that interfacial tension plays a role in virus partitioning in an ATPE system.

Results and Discussion:

In theory, the binodal curve will dictate the interfacial tension of each system. Provided that each system separates as expected, it is our hypothesis that the PEG-citrate system will hold consistent with this theory. The findings of this study will help broaden the understanding of the driving forces involved in ATPE. This understanding will better enable for the prediction of systems that can be used for the purification of different vaccines or gene therapy candidates. Providing this understanding will also allow for the adoption of ATPE in industry.

Seasonal Variation of Hydrocarbon Biodegradation Rates and Microbial Community Composition in the Great Lakes Region

Student Presenter: Emma Byrne, Applied Ecology and Environmental Science
Faculty Advisor: Stephen Techtmann, Biological Sciences

Introduction:

The Great Lakes are vulnerable to oil spills from the Enbridge Line 5 pipeline. Microbes are a proposed ecological tool for bioremediation of spills. In marine environments, these interacting assemblages are responsive to in-situ environmental factors, thus we hypothesize that freshwater microbial community activity varies under selective pressures across seasons. Currently, no oil biodegradation rates have been measured for the Great Lakes region. The objectives of this project were to determine if oil breakdown rates varied seasonally, to assess seasonal shifts in microbial communities, and to determine if crude versus refined oil invokes a different response in biodegradation rates.

Materials and Methods:

We determined oil biodegradation rates by measuring carbon dioxide production (a byproduct of metabolism) using gas chromatography-Flame Ionization Detector over the course of six weeks. Microcosms were enriched with 100 ppm of Bakken oil, Diesel oil, or acted as a control. Winter replicates were incubated at 4°C to simulate seasonal conditions. To assess differences in the microbial communities, we filtered water from microcosms and extracted DNA from the filter's resulting biomass. We sequenced the V4 and V5 portions of the 16s ribosomal RNA gene from samples across seasons and exposure to two oil types, Bakken and Diesel. High-throughput sequencing results were analyzed using packages in RStudio.

Results and Discussion:

Overall, we found that oil-enriched microcosms had significantly higher carbon dioxide production (indicating more biodegradation activity) relative to control replicates. The highest breakdown rates occurred during the spring, likely due to changes in in-situ environmentals factors such as nutrients and temperature. Diesel-enriched microcosms resulted in higher overall biodegradation rates relative to those enriched with crude Bakken oil. The microbial communities differed significantly across seasons, with spring and summer microcosms diverging significantly from those of fall and winter.

The results of this study present oil biodegradation rates for a currently understudied region. Previously, oil breakdown was primarily studied in marine environments. These findings indicate that, in the case of a spill, bioremediation activity is most observable during the spring, and in spills involving refined oil. These results also indicate that freshwater microbial communities are dynamic in response to in-situ environmental factors that vary across seasons.

Avian Malaria Presence in Michigan's Keweenaw Peninsula

Student Presenter: Rachel Christensen, Wildlife Ecology and Management
Faculty Advisor: Dr. Kristin Brzeski and Dr. Jared Wolfe, Forest Resources and Environmental Sciences

Introduction:

As climate change continues to persist, the geographic range of many parasitic diseases is increasing. This allows for expansion of these diseases into areas that can contain naive hosts such as arctic and boreal climates. Avian malaria is a parasitic disease in birds caused by protozoans belonging to the genera Plasmodium, generally vectored by mosquitoes. Michigan's Keweenaw peninsula offers both an abundance of freshwater for vector abundance, and a large bird population both migratory and resident, making it a prime location for avian malaria.

Materials and Methods:

Birds were captured in mist nets at two core banding sites, one urban and one rural, and several satellite banding locations located throughout Houghton and Baraga counties. One captured, individuals were bled from their brachial nerve and banded in compliance with the federal banding program. DNA was then extracted from these blood samples and PCR techniques were used to determine presence of avian malaria.

Results and Discussion:

We expect that we will find avian malaria at infection rates similar to those found in other studies found throughout the state--ranging from 2.6% to 44.3%. This holds the potential for great management implications due to the devastating nature of this pathogen. Avian malaria is best known for its critical role in the extinction of native Hawaiian Honey creepers following the introduction of mosquitoes to the island. While the effects of the disease were compounded in this case due to isolation, the same concept of naive hosts can be applied to our boreal bird species. The disease is also known to be restricted by many ecological factors including temperature, altitude, proximity to water, and host density, all of which will need to be considered in management for a landscape including avian malaria.

Balance Recovery to Simulated Optic Changes

Student Presenter: Adison Cook, Exercise Science
Faculty Advisor: Carolyn Duncan, Kinesiology and Integrative Physiology

Introduction:

Falls are a leading cause of fatal injury in our society. Visual, vestibular and somatosensory information has been proven to assist in maintaining balance by providing information about body movement and relative position, however little is known about how the absence of one of these systems can limit the body from successfully preventing a fall when faced with a balance destabilizing event. The purpose of this study examined how individuals are able to recover their balance in situations with limited visual inputs due to decreased lighting.

Materials and Methods:

Five healthy, young individuals (mean age 21.2± 0.84 years, height 1.71± 0.08 meters, mass 75.74 ± 8.53 kg) with no experience in balance recovery studies were recruited for this study. Participants performed a series of lean-and-release trials in three different lighting conditions: normal lighting, a nightlight, and complete darkness. During these trials, participants leaned forward in a harness that was tethered to the wall. While leaning forward the tether was released causing the person to stumble forward. The lean angle during each condition was increased in 2-degree increments until the participant could not successfully recover their balance. During all trials, three-dimensional kinematics and lower muscle activations (tibialis anterior, medial gastrocnemius, rectus femoris, and biceps femoris) were collected. The maximum lean angle and stepping temporal-spatial parameters (step length, step width, and stepping time and velocity) were recorded as well.

Results and Discussion:

Temporal spatial parameters and maximum lean angle of release did not differ between conditions. The unchanged stepping mechanics across all conditions suggests that young, healthy individuals have the ability to reweight input from the vestibular and somatosensory systems to execute similar compensatory stepping responses when visual input is reduced. Researchers are unsure of how the aging process, sensory limitations, or unfamiliar environments may yield conflicting results. Future projects following the completion of this study look to answer many unknowns in the balance recovery field and how the visual, vestibular, and somatosensory systems play a role.

Exploring Substrate Selection by Fructose-Specific Transporter GLUT5 for Development of GLUT-Specific Inhibitors

Student Presenter: Andrew Cooper, Chemical Engineering
Faculty Advisor: Marina Tanasova, Chemistry

Introduction:

Enhanced uptake of fructose has emerged as a defining characteristic for cancer development and progression. Subsequently, fructose transporters have gained much attention as targets for medicinal research. Fructose transporters belong to the family of facilitative membrane transporters – GLUTs. Among several fructose transporters, only GLUT5 is specific to fructose. GLUT5 has limited expression in normal tissues, it is overexpressed in various cancers and appears to be an excellent therapeutic target. Despite significance of GLUTs as a biomedical target, there is limited understanding their substrates specificity. This project was designed to assess the substrate preferences of GLUT5 and develop high-affinity GLUT5-specific probes.

Materials and Methods:

The research plan involves the synthesis of 2,5-anhydro-D-mannitol (2-AM) conjugates of quinolinones (ManQuins). We will obtain: 1) quinolinones functionalized at C4 position as direct mimics of already tested coumarins, 2) amide functionalized quinolinones, and 3) chimera (i.e. C4 and N-functionalized) quinolinones as fluorophores for our studies. The diversity in substitution type and position will help to assess the impact of functionalization and geometry on GLUT5-probe interactions. All fluorophores will be conjugated to 2-AM to obtain probes for GLUT5. Probes will then be assessed for uptake by having cells treated with solution of probes and I will use confocal microscope to observe ManQuin-induced fluorescence in cells. I will also perform a experiments that are designed to visualize layers of cells and assess whether the probes are inside the cells or are associated with cellular membrane. These studies will be performed for all produced compounds and will be done initially in MCF7 cells as these cells are known to express GLUT5. Once cellular localization is established, we will move forwards to validating the GLUT5-specificity of ManQuins. For this part, I will perform a series of competitive inhibition analyzes using fructose and will use cytochalacin B as a glucose inhibitor transporters GLUTs 1-4.

Results and Discussion:

The research is still ongoing but so far, we have been able to synthesize nine compounds and are working on the final set advanced probes currently. All compounds have been characterized using standard tools such as nuclear magnetic resonance and high-resolution mass spectrometry. The fluorescent properties of the probes have been determined using UV and Fluorescent spectroscopy. They have been tested as potential kinase inhibitors. We have begun early stages of cellular studies and our anticipated outcomes are that we will explore what functional groups allow for stabilizing H-bonding and hydrophobic interaction with the protein, in order to obtain high-affinity probes. Through the outlined research we will gain a better understanding of this disease-relevant transporter and produce essential tools that will support future studies of cancer-nutrition connections. Furthermore, high-affinity specific probes are also needed for biochemical and biomedical research exploring nutritional modulation as a strategy for cancer treatment and prevention.

3D-Printing Prosthesis and Other Applications Using Recyclable Material and Open-Source Technology

Student Presenter: Samantha Dertinger, Biomedical Engineering
Faculty Advisor: Dr. Joshua Pearce, Material Science and Engineering

Introduction:

With technology, such as 3D-printing, becoming increasingly more popular, the possibilities of what can be done are endless. The technology from the typical, factory manufactured printers have created open-source printers known as RepRap printers. These printers can bring 3D-printing to a new level. With this technology, using materials, for example broken up windshield wipers and plastic bags, can be used to create applications such as prosthesis and medical devices. This idea can lower the cost dramatically of medical applications, be implemented in underdeveloped countries, and decrease the amount of litter that has piled up throughout the years.

Materials and Methods:

Windshield wiper pellets were inserted through a device known as the Recyclebot to create a roll of filament that would be able to run through a Lulzbot Taz 6 3D-printer as if it was brand name filament. The temperature on the printer started at 240°C and was increased to 290°C. After testing this process, varying sizes of windshield wiper pellets were inserted into an injection molding device that was created from students in the Michigan Tech Open Sustainability Technology Lab. The injection molder was set to a constant temperature of 270°C using an Inkbird temperature controller. The pellets were then melted and injected into two molds that were created using open-source software, such as OpenSCAD, Blender, and the Lulzbot Cura slicer. These molds represented fingertips for a prosthetic hand and the hammer portion of a reflux hammer that is commonly used during physical examinations. The rest of the prosthetic hand was 3D-printed using a Lulzbot Taz 6 and PETG filament, along with the holder for the hammer. The windshield wiper fingertips were then epoxied onto the PETG hand. Regarding the reflux hammer, the hammer portion easily slid into the holder to complete a functional device.

Results and Discussion:

The windshield wiper filament did not function properly through the Lulzbot printer due to the varying diameter of the filament. The pellets also contained different material properties due to the composition of windshield wipers. This made it difficult to print at a specific temperature since some portions of the filament melted at higher temperatures when compared to other sections. The injection molding process worked significantly better in regard to results. This process shows that windshield wiper material can be injector molded at a constant temperature of 270°C to create functional applications.

Correlation Between Grade Crossing Roughness and Driver Behavior

Student Presenter: Kyle Dick, Computer Science
Faculty Advisor: David Nelson, Rail Transportation Program

Introduction:

The importance of this research was to explore different ways to increase safety at grade crossings outside of installing gates and lights.

Materials and Methods:

Methods were to calculate the average speed change at each crossing to see if drivers were responding to the roughness. The roughness of the crossing was calculated by finding the average change in Z-Acceleration.

Results and Discussion:

The findings showed that there is a minor link between driver's speed change and the roughness of the grade crossing. Drivers are more likely to slow down before crossing the grade crossing.

Comparison of Two Different Decellularization Methods for Development of Cardiac Fibroblast ECM

Student Presenter: Alex Fetner, Biomedical Engineering
Faculty Advisor: Dr. Feng Zhao, Biomedical Engineering

Introduction:

Decellularization is an important process to generate highly biological extracellular matrix (ECM) scaffolds from cell sheets for various tissue engineering applications. One such application includes development of cardiac fibroblasts (CF) derived ECM scaffolds for cardiac tissue engineering. Human pluripotent stem cells (hPSCs) are a reliable and renewable cell source that can be further differentiated in CFs. However, it is important to maintain integrity of the ECM during the decellularization process to maximize the effectiveness of the collected ECM. The objective of this study was to compare the effectiveness of two different decellularization methods and determine the integrity of the hPSC-CF derived ECM scaffolds.

Materials and Methods:

hPSC-CFs derived sheets were decellularized using two different methods: (1) Ethylenediaminetetraacetic acid (EDTA) + sodium dodecyl sulfate (SDS) and, (2) Sodium Deoxycholate (SD) + DNase. In EDTA + SDS method, cell sheets were treated with a solution 1 (1M NaCl + 10mM Tris + 5 mM EDTA) and subsequently solution 2 (0.1% SDS + 10mM Tris + 25 mM EDTA). In SD + Nuclease method, cell sheets were treated with solution 1 (0.25% Triton X + 0.25% SD) and subsequently treated with solution 2 (100 µg/mL RNase + 150 IU/mL DNase). Components of decellularized ECM were further quantified using standard kits (for structural proteins or macromolecules) and ELISA (for GFs).

Results and Discussion:

Both groups were able to remove cell nuclei, as can be observed in the immunofluorescent staining. The amount of collagen and insulin-like growth factor (IGF) remaining after decellularization of hPSCCF sheets was significantly higher for SD + Nuclease, while all other proteins showed less than a 10% difference between the two methods. The SD + Nuclease method showed a 20 % increase in collagen levels and a 30% increase in IGF. Moreover, hPSC-CF derived ECM sheets generated by SD + Nuclease decellularization showed non-significantly higher amount of vascular endothelial growth factor (VEGF) and glycosaminoglycans (GAGs).

3-D Printing Prosthesis and Other Applications Using Recyclable Material and Open Source Technology

Student Presenter: Nicki Gallup, Biomedical Engineering, Mechanical Engineering
Faculty Advisor: Dr. Joshua Pearce, Materials Science Engineering

Introduction:

With technology, such as 3D-printing, becoming increasingly more popular, the possibilities of what can be done are endless. The technology from the typical, factory manufactured printers have created open-source printers known as RepRap printers. These printers can bring 3-D printing to a new level. With this technology and the use of materials such as broken up windshield wipers and plastic bags, various applications can be created such as prosthesis and medical devices. This idea can lower the cost dramatically of medical applications, be implemented in underdeveloped countries, and decrease the amount of litter that has piled up throughout the years.

Materials and Methods:

Windshield wiper pellets were inserted through a device known as the Recyclebot to create a roll of filament that would be able to run through a Lulzbot Taz 6 3D-printer as if it was brand name filament. The temperature on the printer started at 240°C and was increased to 290°C. After testing this process, varying sizes of windshield wiper pellets were inserted into an injection molding device that was created from students in the Michigan Tech Open Sustainability Technology Lab. The injection molder was set to a constant temperature of 270°C using an Inkbird temperature controller. The pellets were then melted and injected into two molds that were created using open-source software, such as OpenSCAD, Blender,

and the Lulzbot Cura slicer. These molds represented fingertips for a prosthetic hand and the hammer portion of a reflex hammer that is commonly used during physical examinations. The rest of the prosthetic hand was 3D-printed using a Lulzbot Taz 6 and PETG filament, along with the holder for the hammer. The windshield wiper fingertips were then epoxied onto the PETG hand. Regarding the reflux hammer, the hammer portion easily slid into the holder to complete a functional device.

Results and Discussion:

The windshield wiper filament did not function properly through the Lulzbot printer due to the varying diameter of the filament. The pellets also contained different material properties due to the composition of windshield wipers. This made it difficult to print at a specific temperature since some portions of the filament melted at higher temperatures when compared to other sections. The injection molding process worked significantly better in regard to results. This process shows that windshield wiper material can be injection molded at a constant temperature of 270°C to create functional applications.

Evaluating Antimicrobial and Wound Healing Properties of a Hydrogen Peroxide Microgel

Student Presenter: Maureen Hennenfent, Environmental Engineering
Faculty Advisor: Rupak Rajachar, Biomedical Engineering

Introduction:

Battlefield injures can become easily infected and lead to sepsis. Currently, the most common topical antimicrobial, silver, does not directly induce wound healing and can exhibit cytotoxicity. There is a need for a safe, portable treatment that is actively antimicrobial and wound healing in character. Hydrogen peroxide is being considered as a topical wound healing agent due to its antimicrobial and wound healing properties. However, a means to deliver hydrogen peroxide on demand does not exist. The aim of this work is to develop a dry catechol containing microgel that releases controlled amounts of hydrogen peroxide during wound healing.

Materials and Methods:

First to evaluate hydrogen peroxide (H_2O_2) stability in culture, a stock 0.03% H_2O_2 solution was serially diluted and added to standard culture media composed of DMEM, 0.5% Pen Strep and 10% Fetal Bovine Serum. The rate of H_2O_2 decomposition was determined using a colorimetric FOX assay at incubation times of 15 minutes, 1 hour, 6 hours and 24 hours in culture media with PBS used as a standard. H_2O_2 releasing microgels were generated by copolymerizing catechol with N-dimethylacrylamide and N-hydroxyethyl acrylamide monomers using emulsion polymerization and methylene bisacrylamide as a cross-linker. Microgels were sterilized and cultured with dermal fibroblasts using a transwell culture system. Cell viability and proliferation behavior were evaluated using standard live/dead fluorescence imaging.

Results and Discussion:

Preliminary testing confirmed that passive and active degradation of H_2O_2 occurs in culture. Passive degradation was a result of media components while active degradation was likely caused by catalase produced by cells to control reactive oxygen species. Catalase converts H_2O_2 to water and oxygen. In addition, the transwell model was developed and used to expose cells to H_2O_2 produced by microgel over a 24-hour period. Cells were exposed to 0, 5, 7.5, and 10mg of 0.02% microgel. While the cell viability was not affected by different dosages of microgel, cell density was significantly lower when exposed to the highest dose (10mg) for 24 hours. These results set an upper limit for microgel dosing. Ongoing experiments include a scratch wound model to characterize the viability, proliferation, and migration of cells exposed to H_2O_2, along with assessing the effect of H_2O_2 on VEGF and Prdx6 expression to determine the microgel ability to enhance angiogenesis and cytoprotection against oxidative damage. In addition, the antimicrobial effects of continuous released H_2O_2 and the release profiles able to prevent attachment of gram-negative and gram-positive bacteria are being determined.

Comparing Rooting Depth of Jack Pine from Different Post-Harvest Site Preparation Treatments Using Stable Water Isotope Signatures of Source Water

Student Presenter: Riley Hibbard, Applied Ecology and Environmental Science
Faculty Advisor: Molly A. Cavaleri, Ecophysiology

Introduction:

In 2004, following the clear-cut harvest of a jack pine (Pinus banksiana) stand within the Baraga Plains in the Upper Peninsula of Michigan, four different site preparation treatments were applied: control, anchor chain, prescribed fire, and anchor chain + prescribed fire. Currently, there is lack of literature about the effects of post-harvest site preparation treatments on rooting depth, and we investigated this question through the use stable water isotopes.

Materials and Methods:

Branch and soil samples were collected from two replicates of each treatment during June and August. In addition, tree bole core samples were collected to compare with branch samples. Liquid water was extracted from these samples using cryogenic vacuum extraction, and $\delta^{18}O$ and $\delta^{2}H$ were analyzed using the Los Gatos liquid water isotope analyzer (LWIA).

Results and Discussion:

Our data suggest that, in June, the soil water isotope signatures became more depleted with depth, while no difference was seen across depth in August. Additionally, the isotopic signatures in the soil were more enriched at the surface and more depleted at depth in treatments that used prescribed fire. When branch samples were compared with the soil, all treatments from June showed that rooting depth was around 10-30 cm. We also compared a subset of $\delta^{18}O$ signatures from soil, branch, and core analyzed two different ways: the Los Gatos LWIA and a ThermoFinnigan Deltaplus Continuous Flow-Stable Isotope Ratio Mass Spectrometer. The signatures from each correlate very well in both soil and core samples (R^2= 0.95 & 0.82 respectively), but poorly in branch samples (R^2=0.32), possibly because they are emitting organic volatiles that are interfering with the Los Gatos method. These findings reveal that site preparation treatments did not affect rooting depth but did affect isotopic signatures of soil water. Additionally, our findings will help us to determine appropriate applications for the Los Gatos LWIA.

Intelligent Robotics Research

Student Presenter: Natalie Hode, Elecrical Engineering
Faculty Advisor: Dr. Jungyun Bae, MEEM

Introduction:

In past decades, dramatic advancement has been made in autonomous vehicles. However, according to a recent ABC news article on the Tesla autonomous vehicle crash, dangers still exist that are inevitable [1]. Further research could minimize these dangers. Intelligent Robotics research aims to add to this danger minimization and development of autonomous vehicles. The goal of the research is to improve hazard detection, collision avoidance, and path following with small robots. Expanding upon the already known, the overall objective is to find a solution that creates a reliable algorithm for the autonomous movement.

Materials and Methods:

Using a system of eight motion capture cameras, obstacles, and iPad mini-sized robots, called JetBots, Intelligent Robotics research creates a model of an autonomous car and the road. The first step of this model was to assemble all twelve of the JetBots. After that, each JetBot was given a marker with different configurations of metallic paint similar to how a model of a molecule looks. Designed to reflect light, the metallic paint can be seen on the motion capture system and the location of the JetBots can be tracked. Next is the training process. Training involves using the JetBot's mono camera to generate a labeled image dataset that identifies obstacles and trains using a neural network. This has to be done image by image for hundreds of images for the JetBots' movement to be accurate. Accuracy is key because this process allows the JetBot to know when to reroute. Then, a move based node in ROS (Robot Operating System) will be written to enable the JetBot to move along a predefined "road". With the code and wireless connection, the JetBots can move around freely in the environment along the simulated road avoiding any stationary or moving obstacles (other Jetbots).

Results and Discussion:

The research is still ongoing, but the expectation is that over time the robots will be trained to both follow the path and avoid any obstacles placed in its path. The JetBot will be able to use the camera and its knowledge from trained behavior and code to stay on the roadway. This road can be straight or curved, but the expectation is that the JetBot will still follow that path. When any obstacle is in its path, the JetBot will reroute around the obstacle not hitting it or anything else. The ideal behavior is that the JetBot will take the fastest pathway or the path with the least amount of turns where the JetBot travels the most minimal distance. After avoiding the obstacle, the expectation is that JetBot will return to the path and continue on the path. These findings are closely related to autonomous cars and robots. Autonomous cars use cameras and other sensors to stay on the road and avoid obstacles such as other cars, animals, stop signs, and pedestrians. While autonomous cars rely on various sensors, JetBots use a single mono camera for its navigation.

Characterization of a New Bioactive Compound with Therapeutic Potential

Student Presenter: Michael Hromada, Biochemistry and Molecular Biology (Chemistry)
Faculty Advisor: Tarun Dam, Chemistry

Introduction:

Throughout history, numerous plant-derived compounds have been used for drug discovery and development. On occasion, these compounds may be directly used as drugs, or as lead compounds that could be modified into active drug molecules. These natural therapeutics have major contributions to many disease therapies and treatments, such as chemotherapy, pain management, malaria treatment, and cardiovascular disease treatment. In cases such as chemotherapy, some drugs, called cytotoxic agents, are capable of killing undesirable cells. While searching for bioactive compounds or potential drug leads, our lab has discovered a novel cell lytic and agglutinating compound termed as Hemolysin X (HelyX).

Materials and Methods:

HelyX was extracted in an organic solvent system and resuspended in aqueous buffer. The extracted crude was purified through size exclusion chromatography, and its hemolytic activity was monitored through the use of rabbit erythrocytes. Following size exclusion chromatography, the optical density of each fraction was monitored using UV-VIS spectroscopy at an absorbance of 214 nm. To ensure the isolated compound was HelyX, ligand binding assays were completed with predetermined ligands and compared to preliminary results. The molecular mechanisms of cell disruption by HelyX were explored and visualized through Field Emission-Scanning Electron Microscopy (FE-SEM) and Atomic Force Microscopy (AFM), where HelyX treated cell surface structures were analyzed.

Results and Discussion:

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Reducing UAV Noise by Using Unique Propellers on a Bi-Copter

Student Presenter: Benjamin Hubbard, Mechanical Engineering
Faculty Advisor: Dr. Andrew Barnard, Mechanical Engineering

Introduction:

The purpose of this research is to explore sources of drone noise and the potential to reduce drone noise by using unique propellers on a bi-copter. Drone noise is predominantly generated by propellers. Noise is compounded when multiple propellers produce similar noise, causing the sound to sum coherently. This sound may be reduced by causing each propeller to produce unique sound profiles. While previous studies have experimented with the effects of uneven blade spacing on propeller noise, this study tests the acoustic effect of having a different number of blades on each propeller.

Materials and Methods:

In order to test the hypothesis that unique blade counts on a bi-copter's propellers reduce the overall noise produced by the drone, propellers for acoustic testing were 3D printed out of PLA. 3D printing ensures that the propellers share the exact same blade shape and size, making the number of blades the only variable. These blades were mounted on a small electric motor powered by an ESC-20A motor drive. The acoustic signature of each propeller was measured in an anechoic chamber using Siemens Testlab Signature Acquisition. The measurements track the rotation speed of the propeller using an optical tachometer. The thrust output with relation to speed for each propeller was measured in order to estimate speed ratios for different prop pairings (in flight applications, thrust must be balanced in order to maintain control of the drone). Several configurations of props were tested in pairs, comparing overall level and noise spectra to the baseline of two identical props, using both 1:1 speed ratios and those determined from thrust comparisons.

Results and Discussion:

This study is ongoing. It has been shown that the sound profiles of the propellers are unique by speed, which was expected. Previous studies found during literature review have shown that incoherent noise produced by uneven blade spacing tends to reduce tonal noise of propellers, but can increase the broadband noise produced by the props, mitigating noise-reducing effects. It is possible that the effect will be similar for varying blade counts. Previous hobby projects published online have shown that a drone can fly with different blade counts on each propeller, and that the speeds of the propellers must vary in order to balance the thrust and angular momentum of the drone. These projects rely on the drone's onboard black-box PID controller to manage those speed ratios. Building or utilizing a controller is outside the scope of this project, so the speed ratios are estimated based on the thrust profiles of each propeller. In further development, thrust and angular momentum balancing must be given deeper consideration.

Changing Food Consumption to Lower Phosphorus Flows in Houghton, MI

Student Presenter: Carly Huggins, Environmental Engineering
Faculty Advisor: Dr. Noel Urban, Environmental Engineering

Introduction:

Nutrient cycling occurs naturally in ecosystems. Nutrients such as phosphorus (P) are taken from soil or water by producers, move through the food chain, and pass to and from primary and secondary consumers until returned to the soil or water by decomposers. The flows into and out of the ecosystem are small compared to the cycling within the ecosystem, approximating a closed loop. Humans cause major disruption to P cycling; human communities tend to be flow-through systems. The main objectives were to identify major P inputs and outputs for one rural community and to identify means of reducing P imbalances.

Materials and Methods:

A conceptual model was made to identify the inputs and outputs to the system. A map of the system boundary was obtained and translated into arcmap GIS. The population of the area was estimated using 2010 Census data from social explorer and arcmap GIS data. The flows were identified using data collected by the Portage Lake Water and Sewage Authority (PLWSA) of the flow, influent P, effluent P and the P in the biosolids. A phosphorus diet estimated for average U.S. adults was broken down into food groups and subgroups and combined with P content in foods to determine the sources of P consumed. The average diet was compared to recommended diets for health.

Results and Discussion:

The local population size multiplied by the per capita dietary P intake closely equals the amount of P flowing into the wastewater treatment plant. The food group and subgroup contributing the largest amount of P are Dairy and Cheese. To reduce P flows significantly by changing diet, dairy consumption needs to be reduced. Reducing protein foods would reduce the carbon footprint, but a vegetarian diet would not significantly reduce P flows. The P import to the community in foodstuffs flows through food suppliers to households to the wastewater treatment facility. There the P is split between the effluent discharged to the lake (~1%) and the biosolids that are applied to local land holdings (99%). Thus local land parcels receive P subsidies much larger than the natural inputs and create localized P imbalances. As community size increases, the imbalance increases leading to an inability of the local ecosystem to assimilate the nutrient inputs. For a non-farming rural area, food consumption may not be the right way or the only way to reduce the P imbalance. To reduce the P imbalance, the excess P in the system needs to be reduced or eliminated by returning P to the locations of food production.

Investigations of the Thermal Saturation Limits of Enclosed Carbon Nanotube Speakers

Student Presenter: Matthew Jacobson, Mechanical Engineering
Faculty Advisor: Dr. Andrew Barnard, Mechanical Engineering / Engineering Mechanics

Introduction:

There has been much exploration of the noise cancellation potential of carbon nanotube(CNT) speakers. One of the most promising explorations has been within the automotive industry. To be used within the confines of a vehicle in operation, it is important to understand the CNT loudspeakers will react in different environments. With this in mind, I present a test performed to better understand the durability of the CNT speakers. The test presented is an investigation of the thermal saturation point of the CNT speakers, seeing how the rising temperature of the enclosed speakers would affect the performance i.e sound pressure level output.

Materials and Methods:

To perform the experiment, CNT was wrapped along a series of electrodes which allow for current to flow through. This electricity allowed for the rapid change in temperature required for the CNT to operate as a speaker. This newly wrapped speaker was then surrounded with an enclosure composed of Teflon blocks and metal plates. Then to run the test, measurements were taken of the power sent to the CNT from an amplifier, the current/voltage needed to find the resistance across the CNT, the sound pressure level through a probe microphone to measure speaker performance, and the temperature inside the enclosure taken from a thermocouple.

Results and Discussion:

Knowing that the CNT the CNT film acts as a conductor, we assume the resistance across the speaker should drop with an increase in film temperature. However, we were able to see that even with the CNT speaker enclosed within a small space with temperatures up to approximately 140 degrees celsius, the difference in temperature between the film and the area within the enclosure was not changed significantly enough to drop the sound pressure level output of the CNT loudspeaker. Therefore it can be concluded that CNT can still perform within an enclosed space at high temperatures. Future studies may benefit in exploring the actual application of the CNT within these enclosed spaces found in the automotive vehicle, such as in the exhaust system or air control system.

Synthesis of Hydrogenated Graphene for Energy Storage Devices.

Student Presenter: Jonah Jarczewski, Material Science and Engineering
Faculty Advisor: Yun Hang Hu, Material Science and Engineering

Introduction:

Hydrogen energy is a prospective substitute for fossil fuels with a theoretical efficiency 3x higher than that of gasoline. The DOE has set an adsorption-desorption limit of 6.5 wt% hydrogen for this fuel to be commercially viable. Currently, the production of hydrogen energy is expensive and the storage mechanisms are inefficient. In this work, hydrogenated graphene, synthesized from CO2 and alkali hydrides, have been developed as a potential energy storage component.

Materials and Methods:

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Results and Discussion:

This research is ongoing. The results of XRD showed the expected reaction taking place. Honeycomb structures were captured in FE -SEM, further suggesting the formation of graphene sheets. Further findings from this research will be applicable to the automotive and aerospace companies utilizing carbon nanomaterials for hydrogen storage devices.

Yeast and Cell Fermentation

Student Presenter: Jailynn Johnson, Chemistry
Faculty Advisor: Rebecca Ong, Chemical Engineering

Introduction:

Yeast and cell fermentation is one aspect of a larger project that is being researched. The main project is studying how switchgrass is used to produce biofuels. The issue at question is how the ability to turn switchgrass into useable fuel can be affected depending on whether or not the switchgrass was grown during a drought season. Answering this question requires an understanding of what exactly is inhibiting the switchgrass from being able to fermentate properly. The fermentation process is where a lot of this question will likely be answered.

Materials and Methods:

To solve the problem at hand, this experiment is designed to extract components of both pretreated and untreated switchgrass to identify what is causing and/or contributing to any microbial inhibitions. Untreated switchgrass is extracted using different solvents including water, ethanol, ethyl acetate, and n-hexane. The extract is then analyzed while the remaining components go into enzymatic hydrolysis and then fermentation. During fermentation, a yeast strain (Y330) is used and the samples are set to 30 degrees Celsius. This reaction typically takes 72 hours. The targeted components of extraction throughout this process includes, but is not limited to; sugars, peptides, polysaccarides, glycoproteins, and enzymes. The results are then quantified by mass spectrometry and liquid chromatography techniques. For pretreated switchgrass, the process is the same except that the 'untreated ' switchgrass is first treated with alkaline before starting the extraction process.

Results and Discussion:

This research is ongoing. The main potential outcome of this research is that there is a greater understanding of what is inhibiting switchgrass that is grown during drought season from being able to successfully complete the fermentation process. On a grander scheme, having a better understanding of how switchgrass fermentation works is worthwhile for the world of biofuels because it can grow in more marginal lands that would not typically be considered "agriculture ready".

Mercury Concentrations in Local Soils from Historical Copper Smelting

Student Presenter: Anna Johnson, Environmental Engineering
Faculty Advisor: Dr. Noel Urban, Civil and Environmental Engineering

Introduction:

Historical copper smelting on the Keweenaw Peninsula emitted considerable mercury to the atmosphere and may have contributed a significant component of the mercury concentrations in the local soils. Whether this mercury is still being actively cycled in ecosystems remains unknown and is important to investigate as it can cause further contamination within the ecosystem.

Materials and Methods:

To begin to investigate this issue, soil samples were collected from forests located different distances from the smelters. The soil, sampled at three different horizons, was tested for both mercury concentration as well as for organic carbon content.

Results and Discussion:

Results to date show that most mercury is concentrated in the topmost soil horizon, and concentrations of mercury in all soil samples are proportional to organic matter content. More analyses are needed to determine if there is a significant impact on local soil Mercury concentrations from the now inactive smelters that could cause more serious ecosystem disruption.

Self-regulation, Self-Compassion and Grit in Higher Education

Student Presenter: Hannah Kariniemi, Psychology
Faculty Advisor: Susan Amato-Henderson, Cognitive and Learning Sciences

Introduction:

Self-regulated learners (SRLs) take control of and evaluate progression in their own learning. SRL factors have been used to understand academic success. The concept of grit, or perseverance for long term goals, has been linked to long-term academic success. A new concept recently brought into academics from therapeutic practice is self-compassion (SC), or how one treats themselves when facing hardships. The three positive factors of SC are: self-kindness, mindfulness, and common humanity. This study examined the role of SRL in understanding SC, grit, and GPA in students along with student satisfaction and confidence in their major.

Materials and Methods:

Subjects were solicited from a Michigan Technological University through the Sona Systems psychology subject pool. Participation was anonymous. Data was collected online via Survey Monkey. The scales used included: The Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich & DeGroot 1990), the Self-Compassion scale (Neff, 2003), and the 12-Item Grit scale (Duckworth, 2007). Upon completion, 173 respondents participated. Two-thirds of the participants were lowerclassmen, the remaining were upperclassmen. The respondents were largely male (63.9%) and Caucasian (86.9%).

Results and Discussion:

Interactions and main effects of gender were examined prior to further analyses. No significant differences were found based upon gender. A median split score using the total MSLQ score was used to create two groups: one high in SRL and one low. Using independent sample t-tests, significant differences were found in overall GPA, major GPA, grit, the self-compassion scores of mindfulness and self-kindness, confidence in completing major, and major satisfaction. Those who scored high in SRL also scored significantly higher in grit, mindfulness, and self-kindness; had higher GPAs, and were more satisfied and confident in completing their major.

These findings indicate that students who can self-regulate may perform better academically, be more confident in themselves, and have better abilities to withstand hardships. In the future, understanding how SC and grit vary across degree progression and curriculum type may be beneficial to understanding student self-views and degree completion rates. An intervention study to teach students how to be more self-regulatory and the importance of showing themselves self-compassion may also aid students through increased retention and success.

Looking Up or Looking Down: Examining the Effect of Perspective and Collaboration on Plan Evaluation

Student Presenter: Elizabeth Keysor, Mathematics
Faculty Advisor: Elizabeth Veinott, Cognitive and Learning Science

Introduction:

Teams, from software to engineering to crisis management, must generate plans and make predictions. Research has shown that individuals and teams are overconfident in predicting the effectiveness of their plans. Referred to as the planning fallacy, Buehler et al. (1994) suggest that this results from motivated reasoning.

Materials and Methods:

We conducted two experiments to examine different factors of the phenomenon. Seventy-two participants across two experiments, evaluated an IT cybersecurity plan, rated their confidence in the plan and forecasted potential problems. Findings suggest that the analytic frame (premortem focusing on failure vs. promortem focusing on success) and whether the analysis was collaborative affected confidence.

Results and Discussion:

In experiment 1, motivated reasoning seems to be related to the fallacy as participants in a promortem condition were more confident, and similar to the control condition, than those in the Premortem condition. In experiment 2, groups adjusted their confidence and forecasts more than individuals. This research contributes to our understanding of effective collaborative analytic methods to support planning.

Development and Validation of a Fast and Facile Method for Protein Purification

Student Presenter: Jessica Krycia, Chemistry- Biochemistry and Molecular Biology
Faculty Advisor: Dr. Tarun K. Dam, Chemistry

Introduction:

Purified forms of proteins such as lectins are necessary when researching their biological properties in a laboratory setting. Current methods of purification, such as affinity chromatography, ion-exchange chromatography, and size-exclusion chromatography, are equipment-intensive, time-consuming, and require larger volumes of crude sample. There is a need for a more streamlined purification technique. We developed a technique called Capture and Release (CaRe) that utilizes multivalent ligands as a capturing agent. Captured lectins are released by monovalent competitive ligands and the lectin can then be separated via membrane filtration.

Materials and Methods:

Human recombinant galectin-3 was purified using the CaRe method. Capturing agents (thyroglobulin, chondroitin sulfate-A, and chondroitin sulfate-C) were chosen for the lectin based on binding specificity discerned by plate-based inhibition assays using rabbit red blood cells (RBCs). The capturing agent was added to a crude solution containing the protein of interest. Complex formation between the target protein and capturing agent was monitored by UV-VIS spectrophotometry at 420 nm. The complex was then stored at 4 °C to ensure maximum complex formation, and then the mixture is centrifuged at 10,000 rpm for 10 minutes and was washed using cold buffer to remove impurities. 200µL of competitive ligand (600mM β-lactose) is used to dissolve the complex, then the complex components—the protein of interest (native galectin-3), the multivalent capturing agent (thyroglobulin, chondroitin sulfate-A, and chondroitin sulfate-C) and the competitive ligand (β-lactose)—were filtered out by Amicon filtration. The separated lectin was further characterized by SDS-PAGE and other biochemical assays.

Results and Discussion:

Human recombinant galectin-3 was purified to homogeneity by the CaRe technique. The purity of the lectin was confirmed by SDS-PAGE. The applicability of CaRe to other lectins was validated by purifying other lectins. CaRe is a time-saving, precise, and effective method for purifying lectins and glycoproteins, even from small volumes of crude samples. In addition to purifying known proteins, it can also be used to purify and discover unknown proteins. The majority of known proteins are glycoproteins. The ability of CaRe to purify glycosylated proteins and their receptors makes the technique widely-applicable.

Experimental Investigation of Non-Reacting Spray Characteristics for High Reactivity Gasoline in Comparison to Diesel and Gasoline Using a Heavy-Duty Single-Hole Injector.

Student Presenter: Trevor Krygier, Mechanical Engineering
Faculty Advisor: Dr. Jeffery Naber, Henry Schmidt, MEEM William Atkinson, APS Laboratories Spray and Combustion Lab

Introduction:

The transportation industry has interest in using a gasoline-compression ignition (GCI) technology because of similar thermal efficiencies, reduced soot and NOx emissions in comparison to diesel compression ignition. Prior experimental work shows high reactivity gasoline benefits the GCI process for heavy duty engine applications due to its high volatility and low aromatic content. This study aims to compare high reactivity gasoline (RON 58.8) to ultra-low-sulfur-diesel (ULSD) and the addition of market gasoline (RON 92) for high temperature, non-reacting conditions relevant to heavy duty engines to compare the thermo-physical properties as part of the FUELCOMM II Research Project.

Materials and Methods:

The tests were conducted in a constant volume, optically accessible combustion vessel using a modified Cummins ISX single-hole fuel injector. A parametric investigation was used to vary a range of temperatures (800-1200 K), fuel pressures (1000-2500 bar), and charge gas densities (17.3-25.9 kg/m^3) relevant to in-cylinder heavy duty engine conditions for the three fuels. The vessel was electrically heated to 180 °C and a pre-burn combustion process was used to achieve the desired conditions. The pre-burn process consisted of a Helium, Acetylene, O2N2, and Nitrogen mixture blended to have stoichiometric combustion with 0% Oxygen leftover to prevent combustion for the testing event. Data collection occurred via a high-speed camera set at 60,000 fps using near simultaneous, hybrid Mie Scattering and Shadowgraph diagnostics for a time resolved evolution of the injection. A light source was setup for each diagnostic and pulsed alternatingly, timed with the camera's frame rate. These videos will be post-processed in Matlab for the results.

Results and Discussion:

Post-processing in Matlab will be frame by frame to extract time resolved metrics such as vapor penetration, cone angle, liquid length for each fuel. These results will then be compared between all three fuels to determine whether the high reactivity gasoline's thermo-physical properties are more like regular gasoline or diesel. This comparison could be a good indicator of how the high reactivity gasoline will behave in compression ignition combustion. The next steps associated with this study will be to conduct a similar parametric investigation for combusting conditions. The ultimate outcome of the FUELCOMM II Research Project is to fully characterize high reactivity gasoline in comparison to common fuels.

Purification of Viruses Using Anion Exchange Membrane Chromatography

Student Presenter: Jacob LeBarre, Chemical Engineering
Faculty Advisor: Dr. Caryn Heldt, Chemical Engineering

Introduction:

There is a constant constraint on the supply of available vaccines. Companies are exiting the market due to multifactorial production issues leaving countries without access to vaccinations for months. Vaccine manufacturer's ability to make pure and potent vaccines depend directly on the capability to purify viruses with a high yield. Currently, chromatography is the most commonly used method of purification because of its versatility. Improved methods of purification are needed to bring new vaccines and gene therapy vectors to address the demand-supply discrepancies.

Materials and Methods:

3M Emphaze anion exchange (AEX) Hybrid Purifier were a kind gift from 3M (Saint Paul, MN) and the objective was to test the purification efficiency of viruses and develop a purification process. Multiple strategies were employed for different viruses to develop the process. The pH of system was varied around the isoelectric point of the virus to control the surface charge of the virus. AEX allows the negatively charged viruses to bind to the positively charged quaternary ammonium salt functionalized. An increasing stepwise salt gradient was used to elute the contaminant proteins and virus particles off the chromatography surface. The negatively charged salt anions will competitively bind to the chromatography surface, forcing the virus particles to elute out of the column. Three different viruses, the enveloped herpes simplex-1 (HSV1), and pseudorabies (SuHV) viruses, and the non-enveloped porcine parvovirus (PPV), were tested to determine the versatility of the purification method. Recovery was determined by measuring the infectious virus titer. The Bradford assay was used to quantify contaminant protein removal, along with an SDS-PAGE to visually confirm the separation of proteins.

Results and Discussion:

A chromatogram was generated to display the elution of virus from the AEX filter as a function of salt concentration. More than 99% of the contaminant proteins were removed from all the model viruses used in the study. Using the chromatogram, the process can be optimized by reducing the number of elution steps, thus decreasing cycle time. Further development of this method will be to increase the recovery of the viruses by using elution gradients that vary in salt concentration and pH simultaneously.

Processing of Porcine Internal Mammary Arteries for Human Bypass Graft Applications

Student Presenter: Kelsey LeMay, Biomedical Engineering
Faculty Advisor: Dr. Jeremy Goldman, Biomedical Engineering

Introduction:

This project aims to create a human compatible bypass graft from the porcine internal mammary artery through selective decollagenization and decellularization of the artery. This processed native graft offers an alternative to using a patient's endogenous saphenous vein or internal mammary artery. Decellularization minimizes the negative immune response from the foreign graft and increases the shelf life. Through selective decollagenization and removal of the basal lamina, the internal arterial surface gains optimal blood contacting characteristics by exposing a pure elastic lamina to blood flow, yet without impairing the mechanical properties provided by collagens present in the medial and adventitial layers.

Materials and Methods:

This ongoing research focuses on the first step of artery processing, decollagenization. Luminal surface collagens are removed from the artery with 70% glycolic acid gel without dissolving collagen from the medial layer, thus maintaining the structural and mechanical integrity of the artery. For treatment, the porcine arteries were held vertical, with the bottom end sutured or clipped closed. The room-temperature 70% glycolic acid gel was pipetted into the top opening of the arteries, which were then kept at room temperature. Each artery was closely monitored and any depletion of the gel was promptly replaced. At the specified treatment end point, the gel was removed, the arteries were rinsed with deionized water and snap frozen with liquid nitrogen. Samples were cross sectioned with a cryo-microtome at a thickness of 8µm and placed on microscope slides. Histological samples were stained with Verhoeff–Van Gieson (VVG) and Anti-Laminin antibody to identify laminin, elastin, and collagen within the vascular layers. Each sample was imaged with a light microscope to determine the effects of acid gel processing on the surface collagens and structural integrity of the artery. Quantitative assessment of collagen coverage was conducted with Olympus CellSens software.

Results and Discussion:

The optimal time for acid gel treatment was determined to be 20 hours. The process was found to selectively deplete surface collagens and laminins while the medial wall retained its compact layering and collagen. After decollagenization, multiple freeze/thaw cycles will be used to decellularize the grafts by disrupting cellular DNA. The effectiveness of removing cell DNA will be assessed by DAPI staining and statistical comparisons among the control and treated arteries. After removing collagen and cellular components, we will test the grafts using several methods. Mechanical testing, including tensile and burst pressure, will be compared statistically between grafts that received treatment and an untreated control graft. An ELISA (enzyme-linked immunosorbent assay) will be used to quantify the amount of collagen retained in the grafts. A platelet activation test will be implemented to test the collagen-depleted surface for quantification of the clotting responses. After the full processing protocol is developed, and an optimal graft is created, we will implant them using a rat vascular engraftment model.

With this processing strategy, a natural shelf-stable vascular graft will be created with optimal mechanical and suturing properties to serve as a replacement blood vessel in urgent cases.

Aggregation of Gold Nanoparticle and Virus Complexes with Osmolytes

Student Presenter: Ellie Lucier, Chemical Engineering
Faculty Advisor: Dr. Caryn Heldt, Chemical Engineering

Introduction:

Detecting viruses is difficult because they are some of the smallest microorganisms in the world. Typical detection requires expensive reagents and highly trained personnel. One alternative method is through the use of citrate capped gold nanoparticles (AuNPs) and osmolytes. When in the presence of osmolyte, we have shown virus-AuNP complexes will aggregate due to hydrophobic interactions, increasing the hydrodynamic diameter of the complexes. They can then be detected using dynamic light scattering (DLS). The research conducted consists of multiple trails using both 15 nm and 40 nm AuNPs to detect the behavior of aggregation with two viruses.

Materials and Methods:

AuNPs were synthesized by reducing gold (III) chloride trihydrate using trisodium citrate. The size of the synthesized AuNP was confirmed using dynamic light scattering (DLS), which measures size and UV-Vis absorbance, which shows a unique absorption spectrum for different sized AuNPs. Next, the virus was purified via dialysis with 1000 kDa dialysis tubing in 4.3 mM pH 7.2 phosphate buffer (PB), followed by size exclusion chromatography. Once purified, 5 decreasing concentrations of virus were coated onto AuNPs. AuNPs were coated by rotating for 20 hours. Once coated, a benchmark measurement was taken before aggregation. To aggregate, the coated samples were spun down, the supernatant was removed, and the samples were resuspended in either 1 mL of 1 M glycine, mannitol, or sodium chloride. Finally, the aggregated samples were measured using DLS. Additionally, 1 nM and 1 µM bovine serum albumin (BSA) in 4.3 mM PB were coated onto AuNPs as controls to show that osmolyte aggregation is specific to virus coated AuNPs and not in the presence of protein coated AuNPs.

Results and Discussion:

Two viruses were used to test AuNP's ability to detect virus. Different concentrations of porcine parvovirus (PPV, diameter 18-26 nm) with 15 nm AuNPs showed aggregation when 1 M mannitol was added; the limit of detection was 5 log PPV MTT50/mL. Bovine viral diarrhea virus (BVDV, diameter 40-60 nm) with 15 nm AuNP showed concentration dependent aggregation with 1 M mannitol as well. These samples had a limit of detection at 4 log BVDV MTT50/mL. PPV and BVDV with 40 nm AuNP showed moderate aggregation in the presence of 1 M glycine. Both viruses had a limit of detection at 5 log MTT50/mL. It is concluded that the use of larger particles did not increase the sensitivity of the assay. Current optimization of the virus detection assay is utilizing 5 nm AuNPs to decrease the limit of detection. These smaller particles have shown aggregation in the presence of osmolytes alone as well as aggregating protein controls. Due to the unexpected behavior of 5 nm AuNPs a new osmolyte, alanine, will be tested. While more experimentation is needed to lower the limit of detection, the limit of detection of viruses using 15 nm AuNPs is lower than standard virus detection methods.

Predict the Elastic Modulus of Tissue-mimicking Breast Material

Student Presenter: Zonghan Lyu, Biomedical Engineering
Faculty Advisor: Jingfeng Jiang, Biomedical Engineering

Introduction:

Tissue-mimicking materials are widely used in modern healthcare, ranging from medical treatment to clinical diagnosis. In this study, we are particularly interested in using softened Polyvinyl chloride (PVC) materials for calibrating ultrasound elastography, which has been widely used for breast cancer imaging. Consequently, we need to adjust PVC materials to accurately represent normal and cancerous breast tissues. In the past, trial and error approaches have been used to find both formulations to achieve a particular elastic modulus value for the PVC material and those approaches are tedious and prone to large uncertainties. In this feasibility study, a response surface technique was used to determine the relationship between chemical composition and resulting elastic modulus values.

Materials and Methods:

During our synthesis of softened PVC materials, plasticizers (Dioctyl Phthalate) [DOP] and Bis(2-ethylhexyl) adipate [DEHA] were added together with PVC. The materials were added together in a hot bath and stir for 15 minutes for fully mixing. The liquid plasticized PVC material mixture was cast into a silicone mold to create cylindrical specimens with 1.2cm diameter and 1.2cm height. The elastic modulus of the specimens was tested using the ElectroForce 3200 mechanical testing machine. By controlling the ratio of DOP and DEHA add with PVC, the elastic modulus of synthesized PVC material varies in a range from 10 kPa to 200 kPa. All collected elastic modulus data were processed with different curve fitting methods to generate a proper response surface curve.

Results and Discussion:

Based on our testing, the response curve method can accurately predict the targeted elastic modulus value (approximately 10% discrepancy) using a reconstructed response curve, given data investigated. In conclusion, we found that the proposed response curve method is useful to accelerate the manufacture of tissue-mimicking materials. Our future work includes incorporation of acoustic properties during the process and 3D printing of tissue mimicking breast phantom.

Interlocking Architectured Materials

Student Presenter: Donald Marwin, ME-EM
Faculty Advisor: Dr. Trisha Sain , ME-EM

Introduction:

The ever-increasing demand for identifying materials with multiple functionalities drives the current trend in materials research. The concept of architectured materials offers unprecedented opportunities for multifunctionality by tailoring the architecture and combining ideal constitutive base materials. Our hypothesis is that introducing weak interfaces with a well-designed interlocking geometry simultaneously improves the toughness and promotes effective stress transfer through frictional contact mechanics. Based on this hypothesis, the objective of the research is to determine an optimal interlock design and incorporate this design in lattice architectures to achieve high toughness while maintaining the stiffness at low density.

Materials and Methods:

By using fused filament fabrication, interlocking samples were created with PLA and ABS plastics. A variety of design parameters were then created and tested in uniaxial tension.

Results and Discussion:

With the aid digital image correlation, preliminary results have shown that adding hierarchical structure to an interlocking architectured material can improve both toughness and stiffness. Our work will continue by finalizing our results in uniaxial tension and proceed with three-point bend testing and continuing on by using the best design in lattice structures on a two dimensional plane.

Distributed Manufacturing of After Market Flexible Floating Photovoltaic Modules

Student Presenter: Pierce Mayville, Materials Science and Engineering
Faculty Advisor: Joshua Pearce, Materials Science and Engineering

Introduction:

The combustion of fossil fuels is increasing atmospheric CO2 and driving climate change. A substantial amount of land is needed for PV to replace all current fossil fuel generated electricity and this creates competition for limited land resources between food and energy. One approach is the concept of floating photovoltaics or FPV. PV in FPV are physically positioned close to or immersed in water reducing the operational temperature, which raises power conversion efficiency. FPV also reduces water evaporation by 70-85%. Thin-film flexible FPV without ridged pontoon supporting structures are extremely simple, cost-effective and potentially better suited for challenging aquatic environments.

Materials and Methods:

Three Uni-Solar PVL-68 modules were converted into FPV devices using with three different floating materials: 1) neoprene ½", 2) minicell T200 ¾", and 3) polyethylene 1.2 lb ½" based on their buoyancy. These foam materials were chosen by calculating the height, h, that the PV module would rise above the water using fluid density, foam density, the area of the PV module, the thickness of foam, and the mass of the panel. The PV panels are coated in peel and stick roofing tar. This was used to adhere approximately 50 mm foam strips along the length of the panels and six clear polyethylene tarp strips centred over the grommets to the panels. Foam strips were adhered to the tarp strips with 3M 5200 adhesive. The tarp strips were used to connect the three panels to each other and to mooring. The system underwent indoor tests for floatation and wave resistance. Outdoor testing was performed with temperature monitoring to test the cooling effect and resistance to algae accumulation for each foam material. The system was deployed in the Keweenaw Waterway in the upper peninsula of Michigan to simulate how these arrays could be used seasonally because of their ease of deployment.

Results and Discussion:

Testing flotation in the indoor pool found that the measured height was lower than the calculated value but was the closest for PE. After it was deployed at the GLRC, algal growth was obvious on the tarp but not on the top surface of the modules. On the underside (foam side) there was significant algal growth. The neoprene had mostly solids stuck to it. The Mincel T had the thickest algal layer and was challenging to remove. The PE experienced a similar amount accumulation to mincel, but also had internal accumulation. The temperature reduction from the FPV was between 10-20oC compared to the same modules on land depending on the solar conditions. The foam racking would reduce the costs of racking to $0.37-0.61/W, which is significantly lower than raft-based FPV racking. The PE foam racking decreased the cost by 40% compared to land-based racking. As examples three locations were selected where a large-scale FPV plant could be installed and remain in use year-round rather than this partial use case. The Navajo Lake in New Mexico, the Sobradinho Dam in Brazil, and aquaculture (fish) farms in Taiwan. The results indicate that foam-backed FPV is exceptionally promising and should be investigated further.

Assessing contaminant bioaccumulation and offloading among Lake Superior Lake Trout morphotypes

Student Presenter: Hannah McKinnon Reish, Biology-Ecology
Faculty Advisor: Gordon Paterson, Biological Science

Introduction:

Mercury (Hg) and other contaminants are responsible for fish consumption advisories throughout the Great Lakes basin. Little is known regarding the extent to which Hg is offloaded by fish into their gametes and possibly pose health risks to young fish. In Great Lakes food webs, Hg biomagnifies placing top predators such as Lake Trout (Salvelinus namaycush) at greatest risk. In Lake Superior, there are four known morphotypes, Lean, Redfin, Humper and Siscowet. This provides the unique opportunity to contrast patterns of pollutant transfer from fish to reproductive tissues among different morphotypes, helping assess the risks to young Lake Trout.

Materials and Methods:

Samples of whole Lean (n=10), Redfin (n=9), Humper (n=12) and Siscowet (10) Lake Superior Lake Trout were provided by the Michigan Department of Natural Resources and collected from waters offshore of Isle Royale in May 2019. Fish were collected by gillnet and were shipped frozen on dry ice during transport to the laboratory for subsequent storage at -20°C.

Biological data collected was from the Lake Trout (prior to processing for PCBs and Hg) included; total, fork and standard lengths (cm), body mass (g) and sex, with calcified structures (fin rays and otoliths) being removed from each fish for aging. Gonad tissues and dorsal muscle were excised from individual fish for PCB and Hg analyses. Hg analysis was completed on oven-dried (60°C) sub-samples (10-30 mg) of gonad tissue using a GLRC supported Milestone Direct Mercury Analyzer (DMA) instrument. A certified Hg reference material was analyzed with every 10 lake trout samples for results accuracy and precision.

Results and Discussion:

Research is currently ongoing, but early findings see a correlation between gonadal Hg concentration and whole-body tissues, where some samples the gonadal Hg concentration was double the whole-body. This indicates that some amount of offloading has occurred, however specific numbers and statistical tests are still in progress. The data also indicates that the Redfin and Siscowet morphotypes have higher concentrations of Hg then the Humper or Lean morphotypes. These preliminary findings indicate that young fish may be at risk of higher mercury exposure as early as the spawning event.

Acute and Overnight Arterial Stiffness Responses to Binge Alcohol Consumption

Student Presenter: Isabella G. Menzel-Smith, Biological Sciences Pre-Physician Assistant
Faculty Advisor: John Durocher, University Sleep Lab

Introduction:

Acute binge alcohol consumption is known to increase blood pressure, whereas chronic heavy alcohol use and alcoholism is associated with hypertension. A known contributor to hypertension development is arterial stiffness, or the elastic nature of the arterial division of the cardiovascular system. The purpose of this study is to determine the impact of one night of binge alcohol consumption on arterial stiffness. Therefore, we hypothesized that arterial stiffness would be elevated the morning after binge drinking.

Materials and Methods:

Participants were 21-40 years old, non-obese, and had at least one binge drinking occurrence within the past six months. All were nonsmokers, free of cardiovascular disease, and any alcohol use disorder. Participants arrived at 4:00pm for baseline arterial stiffness measures, and then were provided a standardized meal according to their body mass. In a randomized order, participants received a binge alcohol dose or fluid control. Two alcohol or fluid control doses were administered between 8:00pm and 8:15pm, and 9:00pm and 9:15pm. The beverage consisted of a 1:3 mixture of 190 proof ethanol and fruit juice. 30 minutes post-consumption of each beverage, arterial stiffness was recorded via applanation tonometry using SphygmoCor. A tonometer was placed at the radial artery for pulse wave analysis, and, while gated to a three-lead electrocardiogram, at the carotid and femoral arteries for pulse wave velocity. Fifteen minutes following 8-hours of sleep, arterial stiffness was reassessed. Statistical analysis was performed using repeated measures ANOVA with a condition level of 2 (i.e., alcohol vs. fluid control) and 4 time points (i.e., baseline, post drink 1, post drink 2, and morning). Means were considered significantly different when $p<0.05$.

Results and Discussion:

Mean arterial pressure was not different between alcohol and fluid control (condition × time: $p = 0.204$). However, aortic augmentation index normalized to 75 heart beats (AIx@75) was significantly different from baseline following the alcohol condition (time: $p = 0.006$). Post-hoc paired t-tests revealed AIx@75 was significantly reduced after the first dose of alcohol consumption (-8±11%), but significantly increased in the morning (6±7%) compared to baseline ($p = 0.005$ for both). Alcohol consumption also exhibited a significant time effect on carotid-femoral pulse wave velocity (cfPWV), often considered the gold-standard assessment of aortic arterial stiffness ($p = 0.028$). Post-hoc paired t-tests revealed that cfPWV was increased after fluid control ($\Delta 0.28 \pm 0.12$ m/s; $p = 0.035$) and alcohol ($\Delta 0.36 \pm 0.14$ m/s; $p = 0.021$), when morning values were compared to baseline. In summary, our results indicate binge alcohol consumption depressed AIx@75 in the evening, but increased the following morning post-alcohol consumption. cfPWV was also increased the morning after alcohol consumption and fluid control. Evening binge alcohol consumption elicits an effect on indices of arterial stiffness, where increased vascular stiffness is associated with heightened cardiovascular disease risk.

Potential of Distributed Recycling from Hybrid Manufacturing of 3-D Printing and Injection Molding of Stamp Sand and Acrylonitrile Styrene Acrylate Waste Composite

Student Presenter: Theresa Meyer, Environmental Engineering
Faculty Advisor: Joshua Pearce, Materials Science and Engineering

Introduction:

Over 500 million tons of copper rich rock were removed from mines in the Upper Peninsula and treated in a chemical bath to extract more copper, then dumped into the areas surrounding Lake Superior. These chemicals have damaged ecosystems around Lake Superior by harming native fish and damming stream outlets.

The Great Lakes have also been negatively affected by plastic pollution. One study detailing plastic particles on Lake Huron's beaches found 2,984 pellets, 108 fragments, and 117 pieces of Styrofoam, over an area of only 85 m2 . In Lake Superior, there is also a significant amount of microplastics.

Materials and Methods:

Stamp sand was acquired from North Canal Township Park, MI. Recycled ASA was provided by McDonnough Plastics, Fenton MI. The particle size characteristics of the stamp sand and recycled ASA were quantified using Fiji/ImageJ software.

Mixtures of stamp sand and recycled ASA were made of 0%, 10%, 20% 40% stamp sand: ASA. The percentages were determined by mass. The mixtures were compounded using a recyclebot waste plastic extruder and pelletized. To find the density of the stamp sand a Micromeritics AccuPyc 1330 was used.

Tensile bars molds were fabricated with a 3-D printer. The molds were then covered in aluminum foil. The mixture was poured into the heating tube of an injection molding system. The injection molding system was set to 280C , and the composite material was heated for approximately 15 minutes. The mold was screwed to the end of the heating tube and a push rod was pressed into the top of the tube. 100% Extra Virgin Olive Oil Cooking Spray was used as a mold removing agent.

Tensile testing was completed five times for each sample percent of stamp sand ASA composite material. The specimens were pulled until failure using a 10,000 lb. load cell.

Results and Discussion:

In low percentages (until around 40%) the sand tends to stick to the plastic pellets and remain relatively well mixed. This allowed the tensile bars to be more reliable because the mixture was homogeneous and the sand did not settle to the bottom of the molds or pool within the melted plastic.

As can be seen in Figure 5, the tensile strength is reduced with the inclusion of stamp sand, but then saturates as more stamp sand is added. Upscaling this processing system is important to utilize the large quantities of recycled ASA and stamp sand available. Unfortunately, industrial injection molding machines would not be able to handle the grit of the stamp sand. However, a similar system injection molding system can be designed and used to create larger parts.

The most efficient way to scale up production of stamp sand ASA composites would be to move towards a compression or temperature molding system. This way, bricks or side walk tiles can be produced in large quantities. This process would greatly increase output of stamp sand and ASA composites, which would remove those materials from the environment at a faster pace.

A Group Contribution Method to Predict the Mass Transfer Coefficients of Organic Compounds Through a Commercial RO Membrane for Potable Reuse

Student Presenter: Benjamin Mohrhardt, Environmental Engineering
Faculty Advisor: Daisuke Minakata, Civil & Environmental Engineering

Introduction:

Reverse osmosis (RO) is a membrane technology used to separate dissolved constituents from water. RO is commonly applied in the removal of chemical contaminants for potable reuse of water, which involves the reclamation of wastewater to drinking water standards. With the presence of numerous influent chemical contaminants and inefficient rejection of low molecular weight neutral organic compounds by RO, there is a need for a model to predict the rejection of various organics.

Materials and Methods:

In this study, a group contribution method (GCM) was developed to predict the mass transfer coefficients of low molecular weight neutral organics by fragmenting their structures into small pieces that each interact with the RO membrane. Bench-top batch experiments were performed to obtain the rejection of 54 compounds and 14 compounds were obtained externally from literature. Overall, 68 organics including 40 halogenated, oxygenated, and nitrogen-containing alkanes, 8 alkenes and 20 alkyl and halobenzenes were used to determine 47 parameters, representative of their functional group interaction with the RO membrane. Parameters were determined by minimizing an objective function representative of normalized squared error using genetic algorithm in Fortran. The chosen membrane for the GCM was the ESPA-2LD due to its prevalence in industry.

Results and Discussion:

In total, 49 compounds (72%) from calibration and 7 compounds (87.5%) from prediction were within the error goal of ±5% of the experimental rejection. 96% of all calculated rejections fell within ±10% of the experimental rejection. The prediction set of compounds consisted of data for four haloalkanes under different experimental conditions and four N-nitrosamines through another RO membrane using the boron mass transfer coefficient as a conversion factor. Calibrated parameters were then compared with Taft constants and steric constants to evaluate the roles of each functional group (i.e., electrostatic or steric hindrance). Linear correlations were observed for both Taft constants and steric constants.

Discovery of alloying elements and processing parameters that impart improved biocompatibility of zinc-based medical implants

Student Presenter: Lea Morath, Biomedical Engineering
Faculty Advisor: Dr. Jeremy Goldman, Biomedical Engineering

Introduction:

Conventional metal stents remain in a treated artery for the lifetime of the patient. The permanent presence of foreign material is associated with harmful side effects. Bioresorbable stents that provide mechanical support during the healing phase and then harmlessly degrade may avoid the long term side effects. The interdisciplinary research team at Michigan Tech has been developing bioresorbable zinc alloys for stenting.

Materials and Methods:

An in vivo rat arterial implantation model was used to evaluate the biocompatibility of four new zinc alloys, two of which were thermal treated to improve structural characteristics. The explants were collected at six months, cryo-sectioned and histologically stained with H&E and VVG. Each cross section was measured for base neointimal length, protrusion of the implant into the lumen and neointimal area, metrics used to characterize the in vivo response.

Results and Discussion:

Results revealed favorable vascular responses to selected zinc alloys and thermal processing as compared to pure zinc.

Analysis of Financial and Operating Liability Leverages and the Components Therein

Student Presenter: Seth Mosentine, Finance
Faculty Advisor: Dr. Joel Tuoriniemi, Dr. Heather Knewtson, College of Business

Introduction:

Firms may borrow capital through engaging in financial leverage (banks/bonds) or operating liability leverage (vendors/customers). Nissim and Penman (2003) investigated the effects of financial leverage compared to operating liability leverage on a firm's return on equity from 1963-2001. In our research, we replicate the Nissim and Penman paper for a new timeframe (2002-2018) in order to examine how the financial landscape has changed. We also add to the body of existing literature by decomposing operating liability leverage into accounts payable and deferred revenue components to investigate potential differences between the two.

Materials and Methods:

Our materials consisted of COMPUSTAT data from 1963-2018, separated to two time periods - 1963-2001 and 2002-2018. Analysis consisted of decomposing a firm's return on equity into an operating and non-operating component. For each time period, we computed relevant variables and winsorized the data to address unintended effects of outliers on the model. Regression analysis was performed and focused first on comparing the 1963-2018 time period to the 2002-2018 time period. Second, our analysis focused on the effect two separate components of operating liability leverage (accounts payable and deferred revenue) had on a firm's stock price for the 2002-2018 time period. Specifically, we examined the impact on stock price across two types of firms, those with high and low change in accounts payable (using revenue as a proxy). The analysis was then repeated using change in deferred revenue.

Results and Discussion:

The fundamental equation being examined is that return on equity, ROE, = ROOA + OLLEV*OLSPREAD + FLEV*FLSPREAD. From period 1 of 1930-2002 to period 2 of 2003-2018, we found that return on operating assets, ROOA, decreased significantly by approximately 25%. However, ROE decreased only marginally, from 11.0% to 10.7%. Our findings show that this occurred because firms were able to make up the difference primarily through borrowing, increasing the operating liability leverage OLLEV and financial leverage FLEV. This is significant because it suggests that firms are masking worsening returns through increased leverage, both operating and non-operating. As to the second part of the research, the hypothesis was that deferred revenues were fundamentally better than accounts payable. Appropriately, we hypothesized that firms with a high change in deferred revenue would have higher abnormal returns than those with a low change in deferred revenue, and that those with a high change in accounts payable would have lower abnormal returns that those with a low change in accounts payable. We found that both higher deferred revenue and accounts payable increased returns, but that for the most part there was not a significant difference between the two.

Exploring the impact of GLUT5 inhibition on cancers and cancer therapy

Student Presenter: Molly Niska, Biomedical Engineering
Faculty Advisor: Marina Tanasova, Chemistry

Introduction:

Sugars are the key nutrients for cells. They are taken up through facilitative glucose transporters known as GLUTs. Alterations in sugar uptake are linked with various metabolic disorders, including cancer. It is established that breast cancer particularly, depends on fructose for development, progression, and metastasis. Fructose specific transporter GLUT5 is expressed in breast cancer cell lines but not in their normal counterparts thus providing an avenue to specifically target the disease. Our group came up with GLUT5 specific fructose mimics, the ManCous (2,5-anhydro-D-mannitol-coumarin), which enables fluorescent based screening and the ability to induce fructose deprivation in cancer cells.

Materials and Methods:

ManCou probes were used as fructose uptake inhibitors to measure cytotoxicity of MCF7 and MDAMB-231. The cells were seeded in 96-well plates, allowed to adhere for 12 h, and then treated with varying concentrations of ManCou probes for 24 h. After 24 h, cytotoxicity was measured using a commercial MTS assay that reports cell survival based on cellular metabolism. The data was then normalized over the control (cell+media) and the average from two independent experiments responses using established assays. GLUT 5 expression was observed by using established immunocytochemistry techniques to visualize the localization of the GLUT5 protein.

Results and Discussion:

This research primarily aimed at understanding the impact of nutrient deprivation in cancer cells using ManCous as fructose uptake inhibitors. Cell cytotoxicity studies revealed significant cell death in GLUT5 expressing breast cancer cells in the presence of ManCous. The level of cytotoxicity varied based on the stages of cancer and levels of GLUT5 expressed. While MCF7 primary tumor type breast cancer cells were more prone to toxicity under nutritional stress, MDAMB-231 which is a later stage of cancer had a much more stable response. Through immunostaining of GLUT5 in ManCou treated MCF7 cells, a spike in GLUT5 expression was observed, thus portraying the nature of adaptability of early stage breast cancer cells under nutritional stress. CTCF calculated from ManCou probe uptake lined with the observations from immunostaining thus proving the ability of ManCous to act as reporters of GLUT5 activity and expression. Further we plan to explore the impact of ManCou-mediated fructose uptake inhibition in multiple cancer types across various stages. I will also explore whether the global fructose deprivation on MCF7 cells impacts the cytotoxicity of cisplatin.

The impact of working outside the home on breastfeeding in Michigan's Upper Peninsula

Student Presenter: Lianne Novak, Mathematics
Faculty Advisor: Kelly B. Kamm, Kinesiology and Integrative Physiology & Kui Zhang, Mathematical Sciences

Introduction:

Working outside of the home is associated with a shorter duration of exclusive breastfeeding (EBF). It is unclear if this relationship exists in rural populations where the workplace environments may differ. Michigan's Upper Peninsula (U.P) is an exclusively rural region with limited access to medical services, which varies greatly across the 15 U.P. counties. According to Michigan Vital Statistics, breastfeeding initiation across the 15 U.P. counties is low, (range 13-82%, median 44%). We explored the relationship between maternal employment outside the home and a) EBF at 6 months and b) duration of EBF in the UP.

Materials and Methods:

This study is a secondary analysis of a cross sectional study conducted in 2017-18. Mothers of children <5 years old residing in the U.P were eligible to complete a self-administered survey. The outcomes of interest were EBF at 6 months (Y/N) and duration of EBF (months). The primary exposure was working outside the home (Y/N) during the baby's first year. Logistic regression was used to assess the association between working outside the home and EBF at 6 months (SAS v. 9.4). An Analysis of Covariance (ANCOVA) was used to compare the duration of EBF among mothers who worked outside the home in the first year to those who did not. Confounders were retained in each fully-adjusted model if the odds ratio (logistic model) or coefficient of the primary exposure (ANCOVA) changed by >10% using forward selection.

Results and Discussion:

After adjustment for mother's education, age, and delivery distance, in the logistic model, mothers who went back to work are less likely to EBF for ≥6 months compared to mothers who did not. These results were not statistically significant (OR=.718, 95% CI: 0.39, 1.33). Adjusting for these and household income, and birth class attendance, in the ANCOVA model, there is a 0.39 month increase in EBF duration for every additional month she stays home (p-value = 0.03).

This data shows that in the U.P. , a rural region with limited lactation services, working outside the home in the first year after birth negatively impacts length of EBF. Although this is a similar trend as seen in urban populations, the reasons for the relationship may differ in rural areas suggesting the need for place-based policy for breastfeeding support in workplaces.

Optimizing Motor Learning in Aging: Intrinsic Motivation, Autonomy Support and External Focus of Attention

Student Presenter: Via Ouellette-Ballas, Psychology
Faculty Advisor: Dr. Kevin Trewartha , Cognitive Learning Sciences & Kinesiology and Integrative Physiology

Introduction:

Our aim is to apply proven motivational and attentional factors as short-term interventions to facilitate motor learning and performance among older adults. To date, motivational techniques like enhanced expectancies, external focus of attention, and autonomy support have been used to improve learning and performance only among younger adults. The effectiveness of this technique has not been verified in sensorimotor adaptation tasks, despite the fact that they are a gold standard for studying motor learning. In addition, to date this technique has been tested only in healthy younger adults and it is unknown whether these effects are generalizable to other age groups or clinical populations. The first goal of this project is to establish whether this intervention works for improving learning in a sensorimotor adaptation task in younger adults. The second goal is to establish whether older adults are differentially affected by the intervention. If validated, this technique offers a quick and easy intervention to improve motor learning across a broad age group. This research will pave way for a novel, effective yet simple method to enhance learning and performance across various fields including rehabilitation, training, education, sports across age groups.

Materials and Methods:

We recruited 36 younger adults between ages of 18-25 and plan to recruit an additional 4 younger adults and 40 older adults between the ages of 65-80. Each group will be randomly subdivided into optimized (experimental) and non-optimized (control) groups with a goal of 20 participants in each group. All 4 groups will be given a visuomotor rotation task in which participants reach towards visual targets using a robotic device with a cursor representing their hand position during the reach. The VMR task is comprised of 3 blocks: for Block 1, participants reach for targets with veridical feedback about hand position from the cursor. In Blocks 2 and 3, a visuomotor rotation will be applied such that the cursor is rotated by 45 degrees relative to the participant's hand path. Participants of the optimized group receive instructions that will be a combination of the motivational and attentional paradigms before performing Block 2 while the non-optimized group will receive standard instructions. The participants will then proceed to Block 4, wherein they will again do the visuomotor rotation task, but with an opposite rotation (where the cursor will be rotated by 45 degrees in the opposite direction). Before the motor tasks, all participants will be administered a demographic and health questionnaire followed by a set of cognitive tests which will measure individual differences across cognitive flexibility, implicit and explicit memory to examine the cognitive mechanisms underlying the ability to learn the visuomotor rotation and handle proactive interference. The cognitive tasks will be implemented using the Psychology Experiment Building Language (PEBL: Mueller and Piper, 2014). Emotion regulation technique (ERQ: John et al., 2008), emotion management ability (STEM-B: Allen et al., 2015), personality (BFI: John et al., 2008), achievement motivation (Cassidy and Lynn, 1989) and perceived stress (PSS-10; Roberti et al., 2011) will also be measured using relevant standardized psychometric instruments to ascertain their role in skill acquisition and performance.

Results and Discussion:

This is a first of its kind study that will examine effectiveness and applicability of these techniques in older adults. In this study, our first step is to assess if this technique enhances sensorimotor adaptation in younger adults. We recruited 36 younger adults between ages of 18-25 and plan to test 40 older adults ages 65-80 to test the hypothesis that this intervention would boost sensorimotor adaptation compared to the control group. Their performance will also be compared between groups to see if there was an effect on learning. The overarching goal is then to compare the younger adults and older adults to see if this intervention differentially affects these two groups.

Our hypothesis include: the optimized participants in both age groups will learn a visuomotor

rotation task (VMR) better than their non-optimized counterparts; the comparative level of improvement displayed by optimized older adults will be equivalent to the optimized younger adult group; the optimized group will be less susceptible to proactive interference when learning an alternate form of the VMR task. We will also study whether the extent to which older adults benefit from the optimization procedures for motor learning is related to a number of other cognitive variables including, memory processes (implicit and explicit memory), cognitive flexibility, emotion regulation, emotion management ability, intrinsic and extrinsic achievement motivation, and personality.

Absorption Desorption Thermal Battery

Student Presenter: Douglas Pedersen, Mechanical Engineering, Mathematics
Faculty Advisor: Dr. Sajjad Bigham, Mechanical Engineering Engineering Mechanics

Introduction:

Current climate control technologies employed in electric vehicles (EVs) significantly reduce the battery mileage. A thermal battery will eliminate the need for a separate energy-intensive vapor-compression refrigeration (VCR) system and will both heat and cool the cabin with little-to-no power consumption. State-of-the-art thermal energy storage techniques however, suffer from low thermal storage capacity (i.e., low energy density) and/or poor heat and mass transfer characteristics (i.e., low power density), thereby under-performing VCR systems powered via lithium-ion batteries. The thermal battery being developed will help solve the problems while also helping lower the environmental impact of the EVs.

Materials and Methods:

The two main processes that occurring during the life cycle of the battery are absorption and desorption. During the charging of the thermal battery water, which is in a vapor state, travels from the evaporation chamber to the sorption bed. The temperature for the sorption bed is kept quite hot while the evaporation chamber is kept quite cold. The salt in the sorption bed then starts hydrating which, is called absorption. This process can be completed in a matter of minutes. The cooling phase of the battery happens in this phase with the condensation bed.

The next process is discharging. Where cold water is run through the sorption bed and hot water is run through the condensation chamber. During this process the salt in the sorption bed dehydrates (desorption) which, releases energy in the form of heat which, heats the water flowing through the sorption bed.

Results and Discussion:

The initial results are promising, they show a significant increase over the current technology available which, we were able to reproduce in the early stages of the research. Research is still being conducted into shorting the time and efficiency the thermal battery takes to charge and discharge, as well as new methods to increase the energy and power densities. Simulations have shown that with continued research we will be able to greatly increase the power and energy densities of thermo-chemical batteries.

Development of a semi-autonomous exoskeletal arm device for use in mountain climbing and training

Student Presenter: David Plumley, Mechanical Engineering Technology
Faculty Advisor: Paniz Khanmohammadi Hazaveh, Electrical Engineering Technology

Introduction:

This senior project is developing an upper torso exoskeleton device that aids the user in closing their fingers around an object of any orientation. This device is intended to be used in a sports application to aid the user in training their hand and arm strength, as well as providing a safety factor during use in mountain climbing activities.

Materials and Methods:

Design and Manufacturing Processes - The design of this device is critical as the first major prototype of the device will be printed using the stratasys 3D printers in the M&M machine shop.

Coding Processes - Using C++ programming language we are developing a code to run this device. Utilizing the same electrical signal used to activate the gripping muscles in the forearm, we will be able to engage the small motors mounted on the device to increase gripping power.

Results and Discussion:

We have no results as we are not a research group. Discussions could be listed as possible uses for similar types of devices. How devices such as these could influence the intended sports applications

A robotic object hit and avoid task comparing cognitive-motor interactions between participants with cognitive impairment and healthy controls

Student Presenter: Brooke C. Poyhonen, Psychology
Faculty Advisor: Dr. Kevin Trewartha , Cognitive Learning Sciences & Kinesiology and Integrative Physiology

Introduction:

Those who have Alzheimer's disease experience a variety of symptoms which can include both motor and cognitive impairments. These impairments can lead to a decreased quality of life as they are unable to perform daily tasks appropriately. However, Alzheimer's patients have rarely been researched using realistic task situations that involve both a motor and cognitive component. The aim of this study is to compare changes in performance between healthy young adults, healthy older adults, and cognitively impaired older adults.

Materials and Methods:

Fifteen healthy older adults and 25 healthy younger adults act as controls in the study compared to 6 cognitively impaired adults. All participants performed two tasks on a bilateral robotic system (KINARM). The object hit task involves subjects hitting targets away from them within the workspace using virtual paddles attached to both the left and right hands. The second task involves all the elements of the object hit task but also involves a selective attention component in the form of distractor objects. Subjects are instructed to hit away virtual target objects while avoiding all other objects within the workspace. The use of a bilateral robotic system allows for a continuous, quantitative measurement of sensorimotor performance.

Results and Discussion:

Data collection is ongoing in the present study, but our hypothesis is that both the cognitively impaired subjects and healthy older adults will show more impairment in rapid selection, sensorimotor and cognitive performance compared to the healthy young adults with healthy older adults seeing less of a decline than cognitively impaired adults. Possible implications of this study could be individualized rehabilitation customized to fit the patient's exact sensorimotor performance, predictions of daily life activity ability, and future prediction of the patient's disease prognosis.

Catechol-Containing Microgel for Generation of Reactive Oxygen Species

Student Presenter: Max Reaume, Biomedical Engineering
Faculty Advisor: Bruce Lee, Biomedical Engineering

Introduction:

Contaminants such as organic dyes, heavy metal ions, and antibiotics present in industrial wastewater are hazardous to human health. Additionally, the presence of organic compounds from agricultural waste cause the growth of bacteria and other microorganisms. Wastewater may be treated with reactive oxygen species (ROS). ROS include oxygen free radicals that are highly reactive, which allows them to degrade organic compounds and microorganisms into benign degradation products. In this research, a dopamine methacrylamide (DMA) microgel containing catechol was developed that releases ROS via a metal-catechol interaction with iron magnetic nanoparticles (FeMNP).

Materials and Methods:

Dye Degradation - 2.5-10 mg of FeMNP and 25 mg of microgel were incubated in different dye solutions containing Alizarin Red S, Rhodamine B, Crystal Violet, or Malachite Green for up to 24 hours. At different time points for the duration of incubation, the solution was diluted and examined using UV-vis spectroscopy to determine residual dye concentration.

Antibiotic Degradation – 5 mg of FeMNP and 25 mg of microgel were incubated in a solution with up to 0.45 mM of an antibiotic drug ciprofloxacin. The concentration of ciprofloxacin after incubation was determined with UV-vis spectroscopy.

Metal Ion Removal – 25 mg of microgel was incubated for 24 hours in a solution with 1 mL of a 5-40 mM solution of metal ions made by dissolving metallic salts. After 24 hours, microgels were collected, dried, and tested with inductively coupled plasma optical emission spectrometry to determine ion concentration in solution.

Antibacterial Properties – 10 mg of sterilized 40 mol % microgel and 2 mg FeMNP were incubated with 500 mL of S. aureus and E. coli at 37° C for 4,8 or 24 hours, streaked onto agar plates, incubated for 24 more hours. A live/dead stain was used and examined under fluorescence microscope.

Results and Discussion:

Organic Compound Degradation – When combined with FeMNP, DMA-containing microgels degraded and reduced the concentration of organic dyes, especially Rhodamine B. A 40 mol % DMA microgel and FeMNP successfully degraded >99% of Rhodamine B for concentrations up to 3 mM over 24 hours, and over a wide range of pH. The DMA-containing microgels were also capable of removing an antibiotic drug, ciprofloxacin (CIP). For an initial concentration ≤ 0.23 mM, 40 mol % DMA microgel successfully degraded 99% of CIP.

Metal Ion Removal – The DMA-containing microgel removed heavy metal ions from solution and used the metal ions to generate ROS. When 40 mol % microgel was incubated with metal ions, >85% of Fe^{2+}, Ni^{2+}, Cu^{2+}, and Co^{2+} ions, as well as >65% Pb^{2+} ions, were removed from solution.

Antimicrobial Properties – 40 mol % DMA microgel killed 91-94% and 91-95% of a gram positive (S. aureus) and a gram negative (E. coli) bacteria, respectively. After 24 hours of incubation, 40 mol % DMA microgel in the presence of FeMNP killed more E. coli than when in the absence of FeMNP (99% vs. 91%).

Temperature Regulation System for re:3D's Gigabot X Pellet Printer

Student Presenter: Matt Reich, Materials Science
Faculty Advisor: Joshua Pearce, Materials Science

Introduction:

Previous experiments with re:3D's Gigabot X shows that a part cooling system positively impacts its overall print quality. Due to the Gigabot X's heated auger extruder, cooling fans cannot be traditionally mounted, and therefore makes it difficult to implement a temperature regulation system. This study focuses on the design evolution of part cooling and heating fan, and how the system affects print quality of recycled PET pellets/flakes.

Materials and Methods:

Autodesk Fusion 360 was used to design the multiple prototypes of the temperature regulation system, and a TAZ 6 printer was used to print the designs out of PETG filament. Various hardware and electronics were also used in the design of the system. A prototype of re:3D's Gigabot X printer was used to test the cooling capabilities of the system by printing overhang, infill-cover, and stringing test standards out of recycled PET pellets and flakes.

Results and Discussion:

The project is still currently underway, and the temperature regulation system has not yet been tested on the printer. The hopes of this experiment are to improve the overall print quality of PET on the Gigabot X, which will open the door for a new form of direct recycling for disposable plastic water bottles.

Stress and Strain Rate Dependent Pressure Relief Mechanisms in Glass-like (Amorphous) Solid-State Electrolytes

Student Presenter: Maria Rochow, Materials Science and Engineering
Faculty Advisor: Erik G. Herbert, Materials Science and Engineering

Introduction:

Solid-state lithium batteries are the Holy Grail of energy storage. The most significant roadblock hindering the development of lithium metal cells is the formation and growth of lithium dendrites originating at the critical interface between the lithium anode and the solid electrolyte. To provide stress relief at the critical interface and prevent the formation and growth of dendrites, here we examine the ability of an amorphous glass to plastically deform by short-range molecular diffusion. The results show that glass-like electrolytes can alleviate pressure, but in a manner that depends on the magnitude of stress and the imposed strain rate.

Materials and Methods:

Nanoindentation experiments were performed on a bulk specimen of fused silica (amorphous glass) using the iMicro (Nanomechanics, Inc., Oak Ridge, Tennessee). The imposed state of stress and strain were controlled through a prescribed load-time history and the use of two diamond indenter tip geometries: the Berkovich, which is a 3-sided pyramid that imposes a nominally fixed value of strain regardless of the applied load and, a 30 µm radius sphere, which enables the strain to transition from elastic to elastic-plastic with increasing load. Fused silica's deformation mechanisms were effectively isolated by measuring its response to the applied load as a continuous function of stress and strain rate within the elastic and elastic-plastic deformation regimes. Various combinations of stress and strain rate were examined with targeted arrays of 25 measurements (5 x 5 arrays with 20 µm spacing between test sites). Analytical models applied to the continuously recorded load-displacement data were used to determine the mean pressure (stress) and the imposed strain rate. Meaningful comparisons were further enabled by a custom Matlab script developed to read the exported Excel files and average the more than 9000 data points per test site by discretizing the data into discrete intervals of time.

Results and Discussion:

Experimental results obtained from small volumes (≤~5 µm^3) of an amorphous glass subjected to a complex state of hydrostatic compression at room temperature are found to be consistent with stress relief mechanisms (localized densification) enabled by the short-range molecular rearrangement or diffusion of SiO_2 molecules. At stresses below a critical threshold for irreversible densification, the deformation is found to be elastic (reversible) and time independent. Above the threshold, data show the magnitude of pressure supported by the glass depends predominantly on the strain rather than the strain rate. Conversely, data show that stress relief under a constant state of stress depends significantly on both the strain and strain rate (history dependence). Once the stress is reduced, the stress relief mechanism becomes inactive and the irreversible densification stops. Collectively, these experimental observations provide new insight into the mechanisms by which an amorphous glass solid electrolyte can control the state of stress at the critical interface with a metallic lithium anode.

Investigation of Optimal Cutting Regimes to Minimize Rhizomal Carbohydrate Storage in Japanese Knotweed

Student Presenter: Rebecca Rooney, Ecology and Environmental Science
Faculty Advisor: Sigrid Resh, Forest Resources and Environmental Science

Introduction:

Japanese knotweed (Fallopia japonica) is an invasive species that can vegetatively propagate from rhizomes to form dense monocultures that displace native communities and degrade ecosystems. Rhizomal carbohydrate storage in knotweed increases late in the season to allow for initial growth the following year. Manual management by cutting shoots is thought to inhibit rhizomal carbohydrate storage, as cutting initiates carbohydrate use for aboveground regrowth. Cutting shoots at regular intervals throughout a season induces knotweed to repeatedly use carbohydrate stores. While this management process is thought to result in long-term removal of knotweed from infested sites, its effects have yet to be experimentally demonstrated.

Materials and Methods:

In this preliminary study, we developed a method to probe at carbohydrate allocation using the stable isotope carbon-13 to examine the effects of two different cutting regimes relative to an uncut control plot. The study was carried out in Houghton, MI along Cemetery road. The study area was divided into 3 sections: treatment 1 (monthly cutting), treatment 2 (bimonthly cutting), and a control (uncut). Seven days after cutting shoots (to allow for regrowth), pulse labeling with 99 At% 13CO2 gas occurred across treatments. Gas was injected via a syringe into low-density polyethylene plastic enclosures (90% transmittance). Two days were given for carbon allocation before harvesting. During harvesting, stem regrowth features such as length, diameter, and leaf count were measured. In the lab, δ13C values were obtained by plant component (leaf, stem, and rhizome) per treatment. These procedures were carried out first in July, to test field methods, and again in August, as a full sampling campaign.

Results and Discussion:

Analysis of August data showed a significant difference between δ13C uptake in treated versus uncut knotweed. Additionally, a significant difference was found in carbohydrate allocation between plant components, with treated leaves containing significantly higher levels of 13C relative to uncut knotweed. Repeated cutting was found to significantly alter stem length, diameter, and leaf count. Further investigations are required to better understand these relationships, and expanding the size and scope of the study will be necessary to provide greater insight. Quantifying the effectiveness of management techniques is critical in developing a successful integrated pest management program. Advancing our understanding of how cutting alters Japanese knotweed physiology serves to aid in efficient and effective management.

Mercury bioaccumulation in two deep-water Tilefish species, Lopholatilus chamaeleonticeps & Caulolatilus microps

Student Presenter: Hunter C. Roose, Biological Sciences
Faculty Advisor: Jill A. Olin, Great Lakes Research Center

Introduction:

Mercury (Hg) concentrations in fish from the Mid-Atlantic Ocean pose concern due to the importance of the harvest for U.S. fisheries. Two species from this fishery, Golden (Lopholatilus chamaeleonticeps) and Blueline (Caulolatilus microps) Tilefish are designated as smart seafood choices owing to sustainable management and fisheries practices. These species are slow growing, long-lived with much of the juvenile and adult life-histories spent in close association with deep-water marine sediments. Such biological and ecological characteristics, however, increase the risks associated with Hg bioaccumulation in fish. Currently, little is known regarding the extent of and potential spatial patterns of Hg bioaccumulation in Mid-Atlantic tilefish stocks.

Materials and Methods:

Study Sites & Sampling - Muscle tissue samples were collected from Golden (n = 485) and Blueline (n = 64) Tilefish (size: 25-110 cm total length) as part of a fishery-independent longline survey of the mid-Atlantic Ocean conducted from Georges Bank to Cape Hatteras in 2017 (Frisk et al. 2018). Muscle tissue samples were obtained from each fish and stored frozen at -20oC in the field and in the laboratory.

Analytical Techniques - To prepare muscle tissue samples for Hg analysis using the Direct Mercury Analyzer (DMA-80), frozen tissue (50 samples/species that range in size and age; total n = 100) will be dried at 60oC in a drying oven for 48 hours and then ground into a fine powder. Samples will be weighed (~30 mg), transferred to metal weigh boats and run on the DMA-80 to obtain total Hg concentrations. Certified reference material (NRC DORM-4) will be measured after Tilefish samples (n = 10) to provide a measure of instrument accuracy and precision. Hg concentration (reported as µg Hg g-1 muscle on a dry weight basis) data will be extracted from the DMA-80 into excel spreadsheets and checked for data entry errors prior to data analysis.

Results and Discussion:

We found that mercury content varies significantly among regions of Tilefish stock in the atlantic ocean, however overall concentrations were higher in Blueline relative to Golden Tilefish. Total mercury concentrations positively correlated with body size in both species. Total mercury concentrations also increased with isotopic nitrogen values which shows as Tilefish eat prey higher in the food chain they will exhibit greater concentrations of mercury. When concentrations were plotted in GIS Pro concentrations were greater in the southern regions possibly due to the colder gulf stream of the south. THg concentrations positively correlated with animal fork length, body mass, and δ15N values suggesting size- and trophic level-related bioaccumulation. Regression slopes between THg and body size do not differ between species suggesting similar rates of bioaccumulation. THg concentrations of North Atlantic Tilefish stocks are below the EPA (0.5 µg/g w.w.) guideline for consumption and are lower relative to Gulf of Mexico conspecifics. Additional sampling in 2020 will confirm species and spatial patterns in NW Atlantic Tilefish THg bioaccumulation.

Polydopamine Functionalized Silicone Gel Substrate for Usage in Traction Force Microscopy (TFM)

Student Presenter: Shaina Royer, Biomedical Engineering
Faculty Advisor: Sangyoon Han, Biomedical Engineering

Introduction:

Traction Force Microscopy (TFM) is an assay used to determine the mechanical force exerted by cells. The force reconstruction is based on quantifying the deformation of a soft gel by tracking fluorescent beads attached to the gel surface. Bead coating on the gel is typically done by amine-silanizing surface so that carboxylated beads can form covalent bond with the surface. This silane coating, via vapor phase deposition, is time consuming and has shown spatially irregular bead distribution. Here, as an alternative method, we investigated possibility of using Polydopamine which has emerged as versatile coating method for many kinds of material.

Materials and Methods:

A variety of different variations of the base protocol were assessed for bead coating on the silicone gel. The silicone gel was prepared by mixing base and crosslinker together, spin coating on a glass coverslip and being cured in an oven at 100°C for 2 hours. As a base protocol of polydopamine-based bead coating, 1 µL of fluorescent beads are added to 5 mL of 10 mM Tris-HCl, followed by sonication for 15 minutes and addition of 50 mg of dopamine, making pre-bead-dopamine mixture. Within this pre-mixture, the cured silicone gel was submerged for 10 minutes, followed by rinsing off with PBS. This base testing trials were repeated with the various amount of time of submerging, 10 minutes to 4 hours. Separate coating method: the gel was submerged in the dopamine solution (without beads) for 4 hours followed by rinse-off, then submerged in polydopamine-bead mixture for 10 minutes followed by rinse-off. In a final variation, dopamine was added to the bead solution, then whole bead-dopamine solution was sonicated before the silicone was submerged in it. The quality of bead coating was assessed by FITC (red) epifluorescence microscope imaging of AF562-coated beads.

Results and Discussion:

Of the various protocols tried, the base protocol worked by far the best in terms of regular bead coating. However, it was still vastly inferior to the results achieved by coated with conventional silanization method, which resulted in the beads being evenly and densely attached to the gel with the occasional small clump. The base protocol resulted in scattered clumps of large beads, implying bead-to-bead attraction has exceeded bead-to-dopamine attraction. The separate coating method did not result in improvement from the base method, suggesting that bead clumping has occurred already within bead-dopamine mixture. Increasing the amount of time of submerge in the bead solution increased bead clumping on the silicone gel surface, demonstrating that bead-to-bead attraction can accumulate over time. Further, the more time of incubation of the bead-dopamine mixture solution caused the more severe clumping to the point that there would only be a handful of large clumps on the gel. These results represent that within polydopamine solution, beads are unable to overcome hydrophobic-hydrophobic interaction between themselves, which in 1-Ethyl-3-(3-dimethylaminopropyl)carbodiimide solution could be overcome via sonication. Taken together, the sticky, viscous but still water-soluble nature of polydopamine appears to make it unsuitable for bead coating in TFM application.

WUPOR: The Western UP Economic Outlook Report

Student Presenter: John Ruf, Mechanical Engineering, Economics, Electrical Engineering
Faculty Advisor: Emanuel Oliveira, College of Business

Introduction:

In this report we summarize the major trends in the Western Upper Peninsula, including trends in disconnected youth, personal income, and several other socio-economic variables to be determined. Furthermore, we will reveal the results of a general survey customized to match University of Michigan's ubiquitous consumer confidence index.

Materials and Methods:

The data collected is gathered from a variety of sources, including the Bureau of Economic Analysis, the US Census Bureau, The US Federal Reserve System, and the Bureau of Labor Statistics. To determine the trends in our major variables we will construct auto-regressive forecasts to signal the outlook of the Western Upper Peninsula. Furthermore, we will take the weighting procedure used by University of Michigan's consumer confidence index to compute the U. P's consumer confidence relative to the Midwest and to the nation broadly.

Results and Discussion:

Our research is ongoing, so we do not yet have results. However, we plan on being able to show the results of the consumer confidence survey and determine the differences in consumer confidence for different demographics. We also plan on being able to show and discuss the meaning of our autoregressive forecasts for our major variables such as income per capita, and the performance of major local industries such as retail trade and hospitality and tourism. This research will have important implications for citizens looking to start businesses in the U.P, as well as local policymakers looking to provide avenues for sustainable development of the region.

Accurate Theoretical Prediction of Anharmonic Infrared (IR) Spectra of Neutral Polycyclic Aromatic Hydrocarbons (PAHs)

Student Presenter: Collette Sarver, Chemical Physics
Faculty Advisor: Loredana Valenzano-Slough, Chemistry

Introduction:

The presence of chemically complex molecules such as polycyclic aromatic hydrocarbons (PAHs) in the interstellar medium and in circumstellar environments, have recently elevated the potential for carbon-based Life outside Earth. While IR spectroscopy allows for the indirect observation of PAHs, the complexity of these molecules makes the interpretation of their spectra challenging. The ultimate goal of this project is to contribute to the NASA Ames PAH IR spectral database by determining quantum mechanical anharmonic IR spectra of neutral PAHs with less than twenty carbon atoms.

Materials and Methods:

In this project, state-of-the-art electronic structure methods will be used to determine and interpret accurate anharmonic IR spectra of neutral PAHs. The accuracy of the calculated IR spectra will be compared with spectra reported in the NASA Ames IR Spectral Database. The Gaussian16 software will be used to perform quantum chemical calculations at various levels of theory to provide the scientific community with solid indications about the best theoretical approaches to use for future investigations. Both post Hartree-Fock (HF) wavefunction-based methods (Moller-Plesset second order perturbation theory -MP2) and density functional theory (DFT) approximations (B3LYP, M06-HF, and M06-2X) will be employed in combination with several atomic localized basis sets. Each molecule will be first relaxed at the various levels of theory to find its equilibrium geometry. Harmonic and anharmonic IR spectra will then be determined and compared to the currently calculated and experimental spectra available at the NASA Ames IR PAH Spectral Database.

Results and Discussion:

When the James Webb Telescope is deployed in 2021, new high-resolution spectroscopic evidence will be available, and more accurate spectra data on various PAHs will need to be interpreted. The ultimate goal of this project is to contribute to the NASA Ames PAH IR spectral database by determining anharmonic IR spectra at higher levels of theory. For each PAH, the following original information will be delivered: equilibrium geometry at various levels theories and basis sets, determination the harmonic and anharmonic IR spectra, comparison of results with experimental data available at the NASA Ames PAH IR spectral database, and impact of molecular symmetry on the spectra. Original results from this project will provide for new and more accurate theoretical spectroscopic data which will be used to compare, analyze, and interpret spectra collected by the James Webb Telescope.

Analyzing the Impact of Economic Factors on Semiconductor Prices by Utilizing Data Science Methods

Student Presenter: Lydia Savatsky, Josh Jaskolski, Vidhan Khanal, Ethan Davani, Jordan DeYonker
Mathematics - Business Analytics, Computer Science - Data Science, Management Information Systems, Statistics
Faculty Advisor: Ulrich Schmelzle, Ray Molzon, Mathematics

Introduction:

Electronic and computer components are increasingly used to manufacture automotive equipment. Companies within the automotive industry purchase various computer components manufactured by electronic industries. Our research provides insight to companies within the electronics industry to assist them in making purchasing decisions. We are analyzing various factors within the economy that may impact both contract and spot semiconductor market prices.

Materials and Methods:

First, we collected the data by searching for various semiconductor products on DRAMExchange.com. We then purchased the historical price data for these products. In order to analyze the data, we are using the R programming language. After collecting the data for these products, we began restructuring the data so that we could easily analyze the data with economic factors. We are utilizing various business analytics and data science methods and packages such as tidyverse, ggplot, and Principal Component Analysis (PCA).

Results and Discussion:

We anticipate that we will discover at least one economic factor that impacts semiconductor prices. Some economic factors that we are currently analyzing include the GDP of U.S., European Union, Japan, and South Korea; U.S dollar to Euro exchange rates, population, unemployment, international trade, industry trade, and environment and energy.

Variation in Carbon and Nitrogen Cycle Processes Along a Forested River Continuum

Student Presenter: Renn Schipper, Biology
Faculty Advisor: Amy Marcarelli, Biology

Introduction:

Stream ecosystems are controlled and constrained by the environment that surrounds them. Terrestrial tree canopies block light that drives gross primary production (GPP) in streams, and supply organic matter that is decomposed by invertebrates and microbes, fueling ecosystem respiration (ER). GPP and ER are the two main components of energy flux in ecosystems. New sensor technology and modeling approaches are lending fresh insight into these processes. Nitrogen transformations can also contribute to energy fluxes in streams, but they are less understood and studied.

Materials and Methods:

We conducted a study of carbon and nitrogen cycle processes at five stream locations from headwaters to downstream in the Pilgrim River watershed, located in Houghton County in the Upper Peninsula of Michigan. The hypotheses for this experiment were 1) GPP rates would increase as the stream widens due to reduced terrestrial canopy cover, 2) ER rates will increase as the stream widens due to an increase in autotrophic respiration, but heterotrophic respiration will remain similar due to similar organic matter concentrations, 3) Decomposition rates will decrease as the stream widens due to the higher rates of GPP, 4) Denitrification rates will decrease as the stream widens due to increasing concentrations of dissolved oxygen, 5) Nitrification rates will increase as the stream widens due to the increasing concentrations of dissolved oxygen, At each site we deployed Minidot O2 sensors (PME instruments, Vista CA) for thirty days, and used the data to calculate daily GPP and ER using the Stream Metabolizer package in R. Quantile regression analysis was then used to partition autotrophic and heterotrophic respiration rates from ER. Decomposition rates were measured using cotton strip assays. Denitrification was measured using the acetylene block method, while nitrification was measured using nitrapyrine-inhibition.

Results and Discussion:

GPP and stream size were positively (?) related ($p = 0.0064$, $r=0.9695$), but GPP was not related to canopy cover ($p = 0.4499$, $r=-0.4475$). We are still conducting the quantile regression analysis to test hypothesis two.There was no relationship between GPP and decomposition. Additionally, our results show no support for hypothesis four and five, with no correlation observed between nitrification, denitrification, and dissolved oxygen. These results will provide a better understanding of the relationship between both carbon and nitrogen-based energy flux processes along a river network, which is a long-standing area of study in stream ecology. A particularly unique contribution is our analysis partitioning autotrophic and heterotrophic respiration to understand how they may vary together or independently along a river continuum.

Silphid stomach content as a tool to measure small mammal biodiversity

Student Presenter: Katherine Schneider, Applied Ecology and Environmental Science
Faculty Advisor: Dr. Tara Bal and Dr. Kristin Brzeski, Forest Resources and Environmental Science

Introduction:

Invertebrate DNA (iDNA), is the use of insects as a source of vertebrate DNA, extracted from the stomach contents of invertebrates that feed on vertebrates. This novel tool has been developed for flies, ticks, and a few other species, but no current research indicates that Silphids have been used as an iDNA tool. We set out to prove the viability of Silphids as an iDNA tool, specifically as a tool to study small mammal biodiversity due to the specialization in the feeding habits of burying beetles, a group of beetles in the family Silphidae.

Materials and Methods:

Beetles were collected in the field using pitfall traps baited with decaying raw meat and with a mesh covering the bait to avoid contamination. Pitfall traps are small containers or cups buried in the ground with the top level to the soil surface. In the field, beetles were swabbed externally for a field sample, then the beetles were taken back to the lab to be frozen until they could be dissected to extract their stomach contents. By doing this we hope to compare the effectiveness of the two sampling methods to determine if dissection is necessary to obtain iDNA. DNA extractions were done using a Qiagen DNeasy tissue DNA extraction. Next, we conducted polymerase chain reaction (PCR) with universal mammal primers to amplify only the target DNA. Sanger sequencing was then done to help identify what the beetles were feeding on, along with a BLAST search to determine what the sequences of DNA belong to. Analysis can be conducted after these steps.

Results and Discussion:

Currently, we have been unable to optimize our PCR, but we should be successful and have our results on the viability of Silphids as an iDNA tool in the next month. If DNA extractions and PCR can be successful, we would be proving a novel iDNA techniche and enable future research into small mammal communities without invasive sampling methods. If the external swabbing method is viable, there could be important research conducted on the diets of the endangered American Burying Beetle, not found in our sampling region. Determining if the species has a host preference would greatly aid in conservation efforts. Additionally, being able to use Silphids as an iDNA tool could contribute to studies on the death rates of what they are feeding on. If species that they are on are endangered, or hard to study, this technique could fill an important knowledge gap.

Micro-Mechanical Study of Exfoliated Vermiculite

Student Presenter: Jason Seeterlin, Materials Science and Engineering
Faculty Advisor: Dr. Bowen Li, Materials Science Department

Introduction:

Exfoliated Vermiculite has found use in civil engineering as an aggregate in lightweight concrete, packing material, fireproofing aggregate, and general insulator. The microstructural changes of exfoliating vermiculite, and their effect on properties such as hardness, are not yet well understood. This research aims to more accurately measure the mechanical properties of exfoliated vermiculite. More specifically, the differences in mechanical properties between vermiculite that has been exfoliated through microwaves versus that exfoliated through a vertical furnace.

Materials and Methods:

Most critical to measuring the mechanical properties of the vermiculite is managing to prepare a sample that can be tested using nanoindentation. Nanoindentation is useful in this application because of how small the flakes of vermiculite are. Most exfoliated vermiculite is below 1 or more cubic centimeters in size, and the laminated structure makes traditional hardness tests unreliable. A drawback to nanoindentation is the amount of sample preparation necessary to ensure precise measurements. Typically the sample surface must be polished to within fractions of a micrometer. Traditional sample prep methods also fail when applied to materials that are as incredibly soft as exfoliated vermiculite.

Results and Discussion:

I anticipate that the true fruit of this research will be exploring the types of sample preparation methods that exist for soft materials, and the nanoindentation testing method. The implications of a greater understanding of exfoliated vermiculites mechanical properties could see its use expanded in areas where lightweight insulators are needed, especially in bulk. Vermiculite has an advantage in its inexpensive bulk cost, and the differences in physical properties between microwave and vertical furnace exfoliation could change how it is widely processed.

Quality of Dissolved Organic Matter Under Ice in a North Temperate Bog

Student Presenter: Mady Sherman, Pharmaceutical Chemistry
Faculty Advisor: Trista J. Vick-Majors, Biological Sciences, Great Lakes Research Center

Introduction:

Dissolved Organic Matter (DOM) is a complex mixture of organic molecules that comprise a vital energy and carbon source for microbial life. DOM enters aquatic environments from external sources (allochthonous) and is generated internally by primary producers (autochthonous sources). The quality of DOM is influenced by its sources, biological processing, and physical processes such as photooxidation, but these are most often considered only during summer under open-water conditions. Here, we investigated the quality of DOM under the ice of a fresh-water bog during winter.

Materials and Methods:

Samples were collected through an augered 7" hole in the snow-free ice cover of South Sparkling Bog in Northern Wisconsin near the University of Wisconsin-Madison Trout Lake Station. Water samples collected via a peristaltic pump into HDPE bottles in the field. In the lab, water was filtered through combusted glass-fiber filters into acid-washed glass vials or conical polypropylene tubes and stored at 4 oC until analysis. A scanning fluorescence spectrometer (Aqualog, Horiba) was used to investigate the fundamentals of the fluorescent portion of DOM. This method uses the excitation-emission characteristics of classes of molecules to determine the quality of DOM. The resulting EEMs (Excitation-Emission Matrices) allow us to characterize DOM that is present in this environment.

Results and Discussion:

Aquatic environments in temperate regions are often influenced by the formation of ice cover during winter. Light penetration can be limited by the formation of ice cover and overlying snowpack, decreasing the activity of primary producers and limiting the photochemistry that acts on DOM. In this study, we expect to identify the mixture of fluorescent dissolved organic compounds present in South Sparkling Bog and to find linkages between the mixture of compounds present and the biological and physical sources and sinks for DOM. This work will contribute to a fuller understanding of DOM biogeochemistry during the winter season in the absence of snow-cover.

Methods of 3D Printing High Temperature Materials

Student Presenter: Noah Skrzypczak, Mechanical Engineer
Faculty Advisor: Joshua Pearce, Material Science

Introduction:

The purpose of my research is to find a method of 3D printing high-temperature engineering materials with a machine build that is repeatable. To find this method, I designed and built a 3D printer that takes into account normal issues many 3D printers have with attempting to 3D print high-temperature materials.

Materials and Methods:

My initial results show that methods that include a space heater and a high temperature heated bed inside of a closed chamber are much more successful. I also found that it is beneficial to have the electrical components, such as motors, outside of the heated chamber to keep them from overheating and negatively affecting print quality. The last method that was tested was having the tool head stationary relative to the rest of the printer. This implementation allowed the rest of the system to work while leaving room for testing other ideas for tooling such as pellet extruders or continuous fiber printing.

Results and Discussion:

Since my research is still in progress, more test prints are expected to show an increase in quality as the machine is tuned and tested. It is also expected that the final design will be altered slightly as issues appear. After verification, this method of printing can then be used to answer the question of what 3D printed engineering materials can be used for in the future.

Influence of nutrition on the interplay of fertility, fecundity, and longevity in Drosophila

Student Presenter: Tessa Steenwinkel, Biochemistry and Molecular Biolgoy
Faculty Advisor: Thomas Werner, Biological Sciences

Introduction:

It is well known that a healthy diet is an essential part of a healthy lifestyle. However, diseases, such as obesity and Type 2 diabetes, have reached epidemic levels. Much of this can be attributed to hectic lifestyles and a lack of a proper diet. One of the things majorly affected by an unhealthy lifestyle is the mammalian target of rapamycin (mTOR) signaling pathway. This pathway integrates environmental cues into organismal growth and homeostasis. Here we used model and non-model Drosophila species to show the influence of diet on the mTOR-regulated processes of fertility, fecundity, and longevity.

Materials and Methods:

Drosophila melanogaster, Drosophila guttifera, Drosophila tripunctata, and Drosophila deflecta stocks were maintained and population-controlled in 250 mL-bottles at room temperature on standard food containing cornmeal, sugar, Brewer's yeast, agar, and tegosept.

To collect the experimental flies, the population bottles were emptied of flies at 8 am. At 2 pm, any newly emerged flies were collected, thus providing a 6-hour window for eclosion. These flies were transferred to a basic sugar-agar plate for overnight acclimatization.

At 8 am, the surviving flies were anesthetized and sorted. For each experimental setup, 20 flies (10 males, 10 females) were placed in a small Petri dish with a basic sugar agar plus 0, 12.5 nL, 25 nL, 50 nL, or an overabundant amount of Baker's or wine yeast powder per fly. Each nutritional condition was repeated thrice. The flies were kept in an incubator at 22°C with 60% humidity on a 14:10-h day-night cycle. The flies were anesthetized every 24 hours to determine any deaths, and the survivors were transferred onto a new plate. The eggs in the used plate were counted and kept for 48 hours to determine hatching percentages. This process was continued until all flies had died.

Results and Discussion:

The purpose of this study was to establish the effect of nutrition on fertility, fecundity and longevity on diverse Drosophila. This was done to establish physiological phenotypes in diverse fruit flies that model human lifestyles. We found that the number of laid eggs (fecundity) increased as a function of available yeast. In contrast, there was no correlation between the number of eggs laid and the amount of viable offspring; the hatch rate was ~60% regardless of the yeast quantity (fertility). The total numbers of laid eggs varied largely among the four tested Drosophila species, from ~300 to almost two thousand total eggs. Additionally our long-term data showed that in all four species, the average female lifespan was much longer than that of males (longevity). The next step is to manipulate the mTOR pathway to test direct causation and see if these physiological phenotypes change in response to mTOR inactivation. The results are expected to have implications on human health issues connected to a poor diet and misregulation of mTOR due to disease.

Sustainable Hydroponics

Student Presenter: Lexy Steve, Mechanical Engineering
Faculty Advisor: Jay Meldrum, Administration, Sustainability

Introduction:

Aquaponics has a bigger start up fee and potentially a larger continuous fee over all. Most businesses are more familiar with the hydroponics method and therefore that's what they implement it. It's an easy system to get started, where it may take aquaponics up to a year before it will produce yield up to its full potential, hydroponics needs almost no sit time. A well functioning aquaponics system never needs to have it's water flushed out, whereas hydroponics does. Depending on how big the system is, that can lead up to a huge amount of water waste. That led me to the question, "Can hydroponics be fully sustainable without fish?" Or in other words, is there a way to reuse the water indefinitely without fish, but without harming the plant system?

Materials and Methods:

To start this project, I wanted to be able to have my own system to run tests on. I built the system in October 2019 after some research on the best methods. From there, I wanted to create a typical environment, so I planted a few different types of plants, bought nutrients and most of the start up equipment. From there I continued online research on different possibilities of creating a system with different plants and nutrients. Looking at different possibilities in how often the plants are being water, salt content, and length of time plants have been hooked up to the same water cycle.

Results and Discussion:

Currently the research is ongoing. A lot of time has been taken up by actually implementing the system and preparing it and researching the best and simple system to use. From there, I researched what makes it impossible to keep using the same cycle of water. The biggest hurdle is removing the salt build up in the system because it keeps the plants from getting the proper nutrients. Unfortunately, it does not look like there is any possibility to remove the salt cheaply and without boiling the water, but I am continuing to look at and test different methods to waste the least amount of water possible. I did run some test runs to see how the plants would hold up without changing the water and it definitely stunted it's growth.

The Effects of Upper and Lower Body Resistance Exercise on Pulse Wave Velocity and Tilt Table Test Performance

Student Presenter: Grant Thivierge, Biological Sciences Pre-Professional
Faculty Advisor: John J. Durocher, Biological Sciences

Introduction:

Pulse wave velocity is a gold-standard estimate of arterial stiffness that tracks the velocity of the forward traveling pulse waves generated by cardiac contraction. Orthostatic tolerance is the ability to maintain normal blood pressure during gravitational stress. We hypothesize that an acute increase in PWV via resistance training will help to improve orthostatic tolerance assessed via tilt test. We further hypothesize that increases in PWV will be greater following upper body resistance training than after lower body training. This study is significant because few studies have been conducted comparing the two types of exercise, especially related to orthostatic tolerance.

Materials and Methods:

Six participants (4 male; 2 female) have completed this study so far. During an orientation session we assessed height, weight, body fat, and baseline measurements of pulse wave velocity and supine blood pressure. After arterial stiffness tests we conducted a tilt table test while continuously monitoring blood pressure, heart rate, and participant symptoms. After the tilt table test, we determined the ten-repetition maximum resistance for three lower body resistance exercises and three upper body exercises. The lower body exercises were lunges, squats, and standing calf raises. The upper body exercises were bench press, bicep curls, and lat pull-down. Two testing sessions (conducted in a randomized order) consisted of three sets of the ten-repetition maximum for each exercise, with 90 seconds rest between sets. Before the participants exercised, their baseline blood pressure, heart rate, and arterial stiffness were measured after a supine relaxation period followed by the tilt test. These same tests were repeated fifteen minutes after the resistance exercises were completed, with the arterial stiffness tests immediately followed by a 70° tilt table test for up to 20 minutes (as tolerated). Analyses included repeated measures ANOVA with 2 conditions and 2 times. Means were considered significantly different when $P \leq 0.05$.

Results and Discussion:

Aortic augmentation index normalized to 75 heart beats / min, an overall estimate of arterial stiffness, was not significantly changed via upper body or lower body resistance training (time effect $P = 0.25$). Carotid to femoral pulse wave velocity (cfPWV; an estimate of aortic arterial stiffness) was significantly changed by resistance training (time effect $P = 0.05$). cfPWV increased from 5.2±0.2 up to 5.6±0.3 m/s by upper body resistance training, and from 5.2±0.2 to 5.4±0.2 m/s by lower body resistance training. Leg PWV (an estimate of leg arterial stiffness) was not significantly changed by upper body (7.4±0.6 vs. 7.4±0.2 m/s) or lower body (7.3±0.4 vs. 7.2±0.5 m/s) resistance training. The modest changes in cfPWV did not significantly change tilt table tolerance time in this small group of pilot participants. However, the tilt table test duration did increase by 1.5 minutes after upper body resistance training in our initial study participants. It is possible that increases in cfPWV, and maintenance of leg PWV, after upper body resistance training will help to significantly improve orthostatic tolerance once we reach our anticipated sample size of about 20 participants.

Investigation of Novel Mg-Zn-Ca Alloys for Bioresorbable Orthopedic Implants

Student Presenter: Emily Tom, Materials Science and Engineering
Faculty Advisor: Dr. Jaroslaw Drelich, Materials Science and Engineering

Introduction:

Magnesium (Mg) is being investigated for its use in bioresorbable orthopedic implants due to its biocompatibility and desired mechanical properties close to that of bone. Bioresorbable Mg alloy implants would replace traditional, permanent implants for open reduction with internal fixation (ORIF) of fractures and reduce risks associated with the use of permanent implants such as a higher chance of infection and late onset pain. However, pure Mg corrodes too fast to maintain the implant's mechanical integrity in vivo. To reduce Mg corrosion, Mg-calcium (Ca)-zinc (Zn) alloys are under development in this project using novel, non-equilibrium high plastic deformation metallurgical techniques.

Materials and Methods:

Mg-Ca-Zn alloys were cast at 710°C using permanent mold casting in an electrical resistance furnace under a protective atmosphere of CO2 and SF6. For the melt spinning process, the melt spinner chamber was pulled to a vacuum of 2x10-5torr and then backfilled to 350torr with 99.99% Ar gas. The Mg alloy was placed in a graphite crucible with a 1mm orifice for melt ejection and heated to 900°C for 5min. The melt was injected onto a rotating copper wheel with a speed of 30m.s-1 for rapid solidification. Fine ribbons were then compacted into cans, and then consolidated through extrusion at 380°C with an extrusion ratio of 10:1. Following extrusion, equal-channel angular pressing (ECAP) of the alloys was carried out at temperatures between 250-300°C. Following the processing of these alloys, the microstructure was investigated through optical and electron microscopy. As the next step, grain size and distribution of precipitates will be evaluated using optical and electron microscopy. Then, mechanical testing will be performed to determine the mechanical properties of the alloys as well as hardness. Finally, corrosion degradation rate and uniformity will be assessed through open circuit potential, cyclic polarization, and electrochemical impedance spectroscopy analyses under a simulated physiological fluid.

Results and Discussion:

In this project, novel Mg-Ca-Zn alloys with improved mechanical and corrosion characteristics are under development and testing for medical applications as bioresorbable implants. It was already confirmed that the rapid solidification of the formulated alloys through melt spinning increases the solubility of Ca and Zn elements in Mg matrix creating a non-equilibrium single phase in the alloy. The ECAP process further induces grain refinement and produces precipitates with sub-micron sizes, uniformly distributed throughout the Mg matrix. Initial optical and electron microscopy has shown ultra-fine grain structures after ECAP processing. Preliminary testing confirmed that the refined microstructure leads to a reduction in corrosion rate of Mg alloys in a physiological fluid. The investigation into how Mg composition affects mechanical properties and corrosion performance of novel Mg alloys will conclude with an optimum alloy composition that is suitable for bioabsorbable orthopedic implants.

Correlation of Water Column Stability and Primary Production in Goose Lake

Student Presenter: Libby Umlor, General Engineering
Faculty Advisor: Cory McDonald, Environmental Engineering

Introduction:

Goose Lake is a shallow, polymictic lake with a mean depth of 3.6 meters located within Marquette County, Michigan. Shallow lakes present a unique management challenge as they have a tendency to mix irregularly, making water quality unpredictable. Goose Lake is known for its history of algal blooms and odor problems causing it to be on the impaired waters list. In this work, we are trying to understand the interaction in Goose Lake between water column stability, nutrient availability, and primary productivity.

Materials and Methods:

In 2019 our research team deployed a buoy in Goose Lake that collected continuous data, including temperature and oxygen levels at multiple depths, as well as meteorological variables such as wind speed, from June through October. Additionally, scheduled samples of water were collected to measure the concentrations of phosphorus, nitrogen, and chlorophyll in Goose Lake. Orthophosphate and total and dissolved phosphorus were analyzed using the ascorbic acid method (spectrophotometric). Exploratory statistical analyses were performed on time series data to correlate indicators of water column stability with indicators of productivity, oxygen levels, and nutrient concentrations.

Results and Discussion:

This project will provide an analysis of the internal and external factors contributing to available nutrient levels and their effects on overall lake productivity in Goose Lake. A correlation between the stability of Goose Lake's water column, or stratification level of the lake, and levels of nutrients was discovered. It was demonstrated that as the lake became more stratified the lower layers began rapidly losing oxygen. When the lake mixed chlorophyll fluorescence increased as nutrients located at the bottom mixed up to the epilimnion layer allowing more nutrients to quickly circulate and primary production at the surface of the lake to increase. Results of this work aids in creating a realistic timeline for the recovery of Goose Lake. Further, it has implications for the management of eutrophication and algal blooms in shallow lakes.

Experimental characterization of photo-sensitive polymers to optimize UV curing parameters

Student Presenter: Joseph Van Linn, Mechanical Engineering
Faculty Advisor: Dr. Trisha Sain, Mechanical Engineering - Engineering Mechanics

Introduction:

This research describes the current experimental work and corresponding theory to characterize the light and heat absorption surface localization effects during stereolithographic curing processes. Stereolithographic curing is a common practice of additive manufacturing utilized to prototype and manufacture complex geometries in a short time frame and at low cost via the crosslinking of liquid monomers under the exposure of UV radiation. Radiative energy transfer is the primary energy source to initiate crosslinking. The propagating UV light reflects during the curing process which creates an uneven radiative energy transfer in the sample and in turn a variation of mechanical properties of the final cured product.

Materials and Methods:

The preliminary experiment utilizes ASTM-D638 tensile testing to identify the surface localization severity and its effects on mechanical behavior.

Results and Discussion:

This research is intended to be utilized by manufacturers to optimize their stereolithographic practices.

Optimizing the 3-D Printability of Glass Powder-filled Polypropylene

Student Presenter: Chris Wallenfang, Materials Science & Engineering
Faculty Advisor: Joshua Pearce. Materials Science & Engineering

Introduction:

Open-source 3-D printing is gaining economic popularity due to its widespread availability and cost-effectiveness. Polypropylene (PP) is a polymer with high chemical stability and a wide variety of applications. PP has been successfully 3-D printed at small scales, but larger parts fall victim to loss of shape and dimensional stability upon cooling. Recent studies have suggested that adding glass powder to PP as a filler material helps 3-D printed parts maintain dimensional stability.

Materials and Methods:

Open-source 3-D printing is gaining economic popularity due to its widespread availability and cost-effectiveness. Polypropylene (PP) is a polymer with high chemical stability and a wide variety of applications. PP has been successfully 3-D printed at small scales, but larger parts fall victim to loss of shape and dimensional stability upon cooling. Recent studies have suggested that adding glass powder to PP as a filler material helps 3-D printed parts maintain dimensional stability.

Results and Discussion:

A recyclebot extrusion temperature of 175°C produced the finest, most consistent filament across all compositions. For 3-D printing, a temperature of 210°C most consistently produced successful cube prints. Some warping was observed in these cube prints, with the greatest amount of warping occurring in the 0% and 10% glass cubes, with much less warping in the 40% glass cubes. Cubes printed with a skirt surrounding the bottom layer experienced less warping than those without. Filaments up to 30% glass could be printed with acceptable quality, while 40% glass cubes were under-extruded.

Uncovering a Community: Pioneers of African Descent in the Copper Country

Student Presenter: Lynette Webber, American History
Faculty Advisor: Sarah Fayen Scarlett, Social Sciences

Introduction:

The few known individuals of African American descent in the Copper Country before and during the U.S. Civil War have been overlooked as anomalies of local history. This project cross-references a broad selection of archival and geographic sources to reveal a complex, interconnected, and civically-engaged community of African descent in the nineteenth-century Keweenaw. Rediscovering this marginalized community and connecting it to regional and national stories of resistance and Civil Rights, this project highlights sources and methods from the field of spatial history. Stories and legacies of individuals already revealed through this research will be shared and future research directions discussed.

Materials and Methods:

What might constitute archival evidence of an African American population on national and regional levels was often deliberately concealed or avoided by community members or record takers. Many relevant records have been destroyed in the past. For a thorough geographical approach to this research, historical spatial analysis requires that numerous primary source types be examined and referenced against one another instead of relying upon a single record set for demographic data. Source types utilized in this study include federal and state census, land and tax records, cemeteries, mortgages, newspapers, court, prison, and probate records, records of losses on Great Lakes ships, vital records, photographs, church records, maps, charts, genealogies, memoirs and letters, contemporaneous publications and later histories, architecture, folklore, and genetic research. Thousands of records have been scoured for clues to aid in constructing an understanding of the Copper Country's Black community between 1840 and 1870, while many more remain to be examined. Perhaps most notably, this study includes sources and methods from the field of spatial history which examine waterways, distance, land features, and landmarks as additions to documentary clues.

Results and Discussion:

Early findings indicate that more research is justified in gaining a more comprehensive and accurate history of African Americans in the Copper Country and Upper Great Lakes region. Among the more significant events or trends uncovered in these records are:

- Freeborn African Americans Asa and Josiah Jeffrey voting in Ontonagon Township's 1849 founding election. Asa Jeffrey elected to office as Co-Director of the Poor.
- Self-emancipated freedom seeker John Brown related coming from Detroit with Cornish miners (1846) in his search for freedom. Freedom seeker Noel Johnson, who arrived the same year, discovered and claimed a copper mine.
- Transnationalism along a borderlands region, the former Pays d'en Haut. Regular movement between Canada and the U.S. without regard for borders.
- Community building activities in Ontonagon Village and at Renova, Houghton County. Subdivision of property.
- Chain migration of African-descended communities
- Numerous African Americans working aboard Lake Superior vessels

A nationally significant yet significantly forgotten community of African descent made the Copper Country their home before and during the U.S. Civil War. Research continues, with potential for new findings in state and national-level collections, on the landscape, and through archaeology.

Food-water-energy nexus

Student Presenter: Tia Willimas, Environmental Engineering
Faculty Advisor: Daisuke Minakata, Civil and Environmental Engineering, Department of Chemistry, Department of Physics

Introduction:

Food, water, and energy are limited resources. These resources play a major role in every day life functions. The U.S. electric system emits approximately

40% of all domestic greenhouse gases and contributes to greater than

40% of freshwater withdrawals.The significance of this research is to compare energy efficient technologies as opposed to non-efficient ones on a regional basis. These comparisons will show the impact of appliance use on a global scale. Eventually, this will aid in the determination of future food, water, and energy usage and standards.

Materials and Methods:

The processes used for this research include the information found in previous studies by Terrianna L. Bradley. The information given, include various research papers as well as an Excel file with quantitative information.

Results and Discussion:

The results are still to be calculated and determined. As of now, there is evidence that by using more energy efficient appliances, there will be a decrease in water use and carbon emissions.

Application of Q-transform to AGN Lightcurve Time-series

Student Presenter: Nicholas Zamora, Computer Engineering
Faculty Advisor: Petra Huentemeyer, Astrophysics Department

Introduction:

The Q-transform is a recent, locally developed signal processing method used to detect and extract signal buried in noisy time-series. The method is nonparametric, and consequentially makes no assumptions to underlying distributions in sample data, as well as rank-based, thus far less sensitive to outliers than other commonly used techniques. The goal of this research is to explore the prospects of using this method in the field of high-energy astrophysics to study lightcurves of transients and flaring objects such as active galactic nuclei. By using synthetic time-series, Q can be tested on a broad range of flaring patterns and its behavior better understood.

Materials and Methods:

This project is rooted in computational statistics and therefore data analysis programming languages were the central materials tools. As the source code for the Q-transform is written in the MATLAB language itself, for compatibility, the predominant language used was MATLAB, however all programs created can be made functionally equivalent in python using the Numpy and Pandas libraries. Pseudo-datasets were created with the intentions of being analogous to HAWC Gamma-ray Observatory AGN flux data (openly published), however with the freedom to form various flaring patterns in order to test the transform on any desired "AGN source." Noise in the simulated datasets was introduced through random gaussian variables, bearing close resemblance to HAWC data.

Results and Discussion:

The Q-transform performed remarkably well on the AGN-like datasets it was calculated upon. As a preliminary, the Q-transform was applied to a synthetic dataset of pure noise (little to no bias in sample data) resembling the magnitude and relative sample size of HAWC AGN data. The Q formalism did not detect any signal, as expected. Piece-wise flaring patterns of a single change point positioned half way through the time domain were then created and observed. The method showed the presence of signal in these sources, with Q accurately signifying positive or negative trends. Simulated datasets of varying flare duration and magnitude were created and Q behaved as expected on these datasets as well. Other time-series created included linear signal in noise, parabolic flares among pure noise, and several linear synthetic datasets generated in the python scikitlearn library. The Q-transform accurately signified the presence of signal (or suggested the absence thereof) in all AGN-like datasets it was computed upon, suggesting the method is possibly a viable option in AGN lightcurve analysis.