Michigan Technological University

2022

Undergraduate Research Symposium

Welcome to the 2022 Undergraduate Research Symposium!

The symposium features research conducted over the past year by undergraduate students at Michigan Tech who have worked, along with faculty, staff, and graduate students, to pursue their passions in exploration and discovery. These undergraduates have spent significant time in our University labs and facilities and out in the field, all the while under the mentorship of faculty who share their passions. The students have designed experiments, collected data, and analyzed results to test hypotheses, build new models, push innovations forward, and expand the understanding of our world. They have broadened their classroom experiences through real-world applications and developed professional skills that will help launch their careers.

Among the students presenting their work are those who have been supported by University programs such as Summer Undergraduate Research Fellowship (SURF), Undergraduate Research Internship Program (URIP), the Michigan Space Grant Consortium (MSGC), and Research Experience for Undergraduates (REU). Our thanks go out to the offices and agencies that provide support for these programs: Michigan Tech's Office of the Vice President for Research for funding SURF; the Portage Health Foundation and the DeVlieg Foundation for funding URIP; NASA for funding MSGC projects; and the National Science Foundation (NSF) for funding REUs.

Enjoy your time interacting with these exceptional students and perusing their research. I hope their passions will inspire your curiosity and edify your faith in our future.

Best regards,

Jean Kampe

Dean, Pavlis Honors College

SESSION A: 12:30-2 PM

	Presenter	Department	Title
1	Zachary Alesch	Biomedical Engineering	Conjugation of Serum Albumin with Horseradish Peroxidase Enables A Novel Protein Adsorption Imaging Technique on Biodegradable Metal Surfaces
2	Kenzie Baker	Computer Science	Finding the gold: Does game play or being a gamer improve creative thinking?
3	Sophia Bancker	Medical Laboratory Science	The Role of Orexin A in Salt Sensitive Hypertension
4	Thomas Basala	Human Biology	The Effects of Morning vs. Evening Mindfulness Meditation on Sleep, Anxiety, and Decentering
5	Caleigh Dunn	Biomedical Engineering	Improving North American Right Whale Satellite Tags Using a Degradable Tip
6	Ethan Gerds	Social Sciences with a concentration in Policy, Law, and Society	Adapting to a Changing Climate: Community and Policy Perspectives from El Salvador
7	Emilie Jacques	Psychology	The Immediate Effects of Mindfulness Techniques on Testing Anxiety
8	Chloe Loomin	Biological Sciences	Optogenetic Stimulation of the Internal Globus Pallidus for the Treatment of Depression
9	Hunter Malinowski	Computer Science, Psychology	Assessing the Effectiveness of the XAI Discovery Platform and Visual Explanations on User Understanding of AI Systems
10	Brian Reeves	Ecology and Evolutionary Biology	Mercury biomagnification in the plankton community of Keuka Lake, NY
11	Katherine Schnabel	Biomedical Engineering	Evaluating the Influence Age on Balance Recovery in Decreased Lighting Conditions
12	Tyler Sepanik	Economics	Understanding the Persistent Labor Shortage in the United States
13	Samantha Siefert	Biochemistry and Molecular Biology - Biology Focus	Evaluating Cell Cycle Quiescence in Ovarian Cancer

14	Morgan Smith	Biochemistry and Molecular Biology (Bio Focus)	The Effect of Prolonged Probiotic Supplementation Upon a Model of Chronic Obesity
15	Kamila Staniszewski	Mechanical Engineering	Harnessing the Offshore Winds of the Great Lakes to Supplement Electrical Needs
16	Chloe Strach	Environmental Engineering	Understanding and Predicting the Fate of 1,4-Dioxane in the Aqueous Phase UV/Chloramine Advanced Oxidation Process
17	Madalyn Tudor-Duncan	Applied Ecology and Environmental Science	Fine root respiration of Quercus rubra: Root system activity across a latitudinal gradient in the Midwest
18	Will Twardzik	Engineering Management	Under resourced College Students in the western upper peninsula
19	Libby Umlor	Chemical Engineering	Chemical Degradation of Polyethylene and Polyethylene Terephthalate Plastics
20	Sheridan Waldack	Chemical Engineering	Continuous Vaccine Purification Utilizing Tangential Flow Filtration and Aqueous Two-Phase Systems

1. Conjugation of Serum Albumin with Horseradish Peroxidase Enables a Novel Protein Adsorption Imaging Technique on Biodegradable Metal

Student Presenter: Zachary Alesch, Biomedical Engineering
Faculty Advisor: Roger Guillory, Biomedical Engineering

Introduction:
Biodegradable metal implants encounter a variety of proteins from the moment they enter the body. Albumin is among the most abundant and earliest blood proteins to interact with the surface and therefore has significant consequences for the wear, corrosion, and biocompatibility of candidate metals [1]. Many methods exist for assessing the adsorption of proteins onto metal surfaces [2], but the high costs and complexity of these techniques limit widespread use, especially with biodegradable metals. This project aims to address this need using conjugation of albumin and horseradish peroxidase (HRP), enabling chemiluminescent imaging of protein adsorption on metal sample surfaces.

Materials and Methods:
Conjugation of HRP to albumin was accomplished using the Lightning-Link kit (ab201807, Abcam plc., Cambridge UK), and the success of the conjugation was determined by western blot. Immersion experiments were conducted with 316L stainless steel and pure magnesium discs in DMEM. Imaging was performed by removing the discs from media and drying the discs in air, then adding enhanced chemiluminescence (ECL) substrate directly to the metal surface. By performing chemiluminescent imaging on the surface using Azure 600 (Azure Biosystems Inc., Dublin CA), the reaction of ECL and the adsorbed conjugate proteins can indicate the amount of protein adsorbed. The surface is subsequently washed to remove leftover substrate and returned to the immersion solution for continued study of the dynamic surface at multiple timepoints.

Results and Discussion:
Conjugation methods for bovine serum albumin (BSA) and HRP have been successfully developed and verified by this project. The conjugate maintains reactivity of the HRP domain with ECL substrate, while unconjugated BSA has no reaction with ECL. Preliminary testing with 316L stainless steel has confirmed that the conjugate maintains reactivity when adsorbed to the 316L surface after immersion for various durations. Using this chemiluminescent technique, the adsorption of BSA suspended in solutions of Hank's Balanced Salts and DMEM replicates the findings of a study that utilized fluorescently labeled albumin [3]. In this project, the chemiluminescent detection of BSA adsorption to degradable magnesium surfaces is developed for feasibility and efficacy as a novel cost-effective tool compared to alternative methods of surface analysis.

2. Finding the gold: Does game play or being a gamer improve creative thinking?

Student Presenter: Kenzie Baker, Computer Science
Faculty Advisor: Elizabeth Veinott, Human Computer Interaction

Introduction:
Many high schoolers play 10,000 or more hours of video games by the time they graduate; they are learning something. Does what they learn help STEM problem-solving skills? Does game play or being a gamer improve creativity thinking?

Materials and Methods:
Participants (159, with 70% gamers) were randomly assigned to one of three conditions for 30 minutes: control (watch a video), control game (Snood), or perspective-shift game (Roller Coaster Tycoon). Following this task, participants solved problems and completed a standard creativity measure (alt-use task such as "How many different ways can you use a shoe?"). Two coders independently coded the alt-use cases on four dimensions: elaboration, flexibility, originality, and fluency. Cohen's kappa for coding reliability was high for all four creativity categories (above 0.7).

Results and Discussion:
Using a between-subjects, 3 (game condition) x 2 (game), ANOVA to analyze the data, we found a statistically significant interaction between game condition and gamer status for the originality creativity measure, $F(2, 155) = 3.36$, $p = 0.038$, eta squared = 0.04). Gamers scored higher originality scores (M=6.48) than non-gamers (M=6.25) for the two game conditions, but non-gamers scored higher than gamers in the control condition. Overall, people playing the perspective-shifting game scored higher (M=8.19) than those in the control game (M=5.63) or video control (M=5.4). This suggests that both the 30 minutes of gameplay and being a gamer contributed to people's overall originality in creativity. Interestingly, there were no differences for the other creativity scores between the conditions or gamer status for the number of ideas (fluency), variety of ideas (flexibility), or elaboration on those ideas (word count).

While the perspective-shift-game condition was more original in the alternate-use cases generated, people did not produce more ideas, a wider variety of ideas, or more elaborate ideas compared to the control condition.

The results suggest that gamer experience supports creativity in this way, as does the 30-minute gameplay of a perspective-shifting game. These results suggest some promise of leveraging what students may bring to the table regarding 21st-century skills (McGonigal, 2011).

3. The Role of Orexin A in Salt Sensitive Hypertension

Student Presenter: Sophia Bancker, Medical Laboratory Science
Faculty Advisor: Dr. Jenny Shan, KIP

Introduction:

Hypertension (HTN) is a long-term condition in which the force of the blood against the artery wall is higher than normal pressure. It is a major risk factor for cardiovascular disease (CVD), and CVD is the number one killer in the United States and worldwide. Despite its prevalence among individuals, the pathophysiological mechanism of salt sensitive hypertension (SSHTN) is still not clear, given the fact that SSHTN is an extremely complex condition which involves multiple mechanisms. Many factors such as increased sympathetic outflow and dysfunctional renin-angiotensin-aldosterone system are implicated in the development of SSHTN. Most recently, studies suggest that hyperactivity of brain-orexin signaling may also be involved in the development of SSHTN.

Materials and Methods:

I will determine whether high-salt-diet intake increases orexin system activity including plasma OXA level, and OX1R and OX2R expression in adrenal glands and kidney. Ten, six-week-old male Dahl-salt sensitive (DSS) rats will be randomly divided into two groups and receive either normal diet (0.4% NaCl) or high salt (4%NaCl) for six consecutive weeks. Blood pressure of each rat will be measured once a week via tail-cuff method. At the end of the protocol, animals will be euthanized, their blood, adrenal glands, and kidneys will be collected. Plasma will be used to ELISA for OXA and corticosterone measurements. Adrenal glands and kidneys will be used to isolate RNA and proteins to measure OXA, OX1R, and OX2R expression. The results will be compared between the two groups.

Results and Discussion:

The BSA results include findings that the DSSM-HSD rats in the lung and spleen showed a decreased ACE, while the intestine showed that ACE increased. For ACE2, the DSSM rats showed decreased ACE2 in the heart and lung, but increased ACE2 in the intestine. Western Blot results are being collected this February.

4. The Effects of Morning vs. Evening Mindfulness Meditation on Sleep, Anxiety, and Decentering

Student Presenter: Thomas Basala, Human Biology
Faculty Advisor: Brigitte Morin, Biological Science and Dr. John Durocher, Clinical and Applied Human Physiology Laboratory

Introduction:

According to the CDC, most children and about one in three adults in the United States fail to reach their age-group-recommended quantity of sleep [1]. Recently, non-pharmacological sleep aids, such as meditation, have gained popularity. However, to our knowledge there is no research data that compares sleep metrics or psychological well-being between those who meditate in the morning versus in the evening. We hypothesized that those who meditate just before sleep would have improved sleep parameters and self-reported feelings of psychological well-being when compared to those who meditate in the morning.

Materials and Methods:

Sixteen college students participated in the study, eight who meditated in the morning (5M; 3F) after waking and eight who meditated in the evening (4M; 4F) just before going to sleep. Participants were asked to wear an Actiwatch Spectrum PRO to evaluate physical activity and sleep throughout the recording periods. The first phase of the protocol consisted of a four-day (Monday-Thursday) baseline recording period where total sleep time (TST) and sleep efficiency measures were recorded. Participants were instructed to not meditate during the baseline period. During the four-day intervention period which occurred the following week (Monday-Thursday), participants were randomized to a 24-minute pre-sleep or morning mindfulness meditation intervention from the app Insight Timer. At the conclusion of both baseline and intervention time periods (on Friday of each respective week), participants were instructed to complete a state-trait anxiety inventory (STAI), a Five Facts of Mindfulness Questionnaire, and a Decentering Questionnaire.

Results and Discussion:

Means were considered to be significantly different when $p<0.05$. The acute meditation protocols did not significantly change TST from baseline in the morning (6.7±0.2 vs. 6.8±0.2 hours) or evening (6.9±0.3 vs. 7.2±0.2 hours) meditators. Likewise, sleep efficiency was not significantly changed in either group. However, there was a significant decrease in both state and trait anxiety (baseline vs. treatment, $p<0.02$ for both), and a significant increase in the five facets of mindfulness and ability to decenter (baseline vs. treatment, $p<0.01$ for both). Our preliminary results suggest that acute meditation can help to improve several measures of psychological well-being whether it is done in the morning or evening. Further investigation within our own study and from others may help to better understand whether evening meditation can offer specific sleep benefits.

5. Improving North American Right Whale Satellite Tags Using a Degradable Tip

Student Presenter: Caleigh Dunn, Biomedical Engineering
Faculty Advisor: Dr. Bruce Lee & Dr. Rupak Rajachar, Biomedical Engineering

Introduction:

North American Right Whales (NARW) are considered one of the most endangered whale species with less than 400 right whales remaining in the oceans [1]. NOAA monitors the migration and movements of baleen whales using satellite telemetry tags. The currently used tags feature a sharp tip designed to cut through the blubber during deployment, which can lead to the development of persistent wounds due to the shear forces generated at the tissue-tag interface as the whale swims [2]. The development of a self-blunting tip for the current tag design can improve tag biocompatibility and reduce the development of persistent wounds.

Materials and Methods:

Through machining and hand-sharpening, a reproducible sharpened edge was created out of 316L stainless steel (thickness = 0.048 inches) to simulate the sharp edges of the consolidated tag tip. The sharpened coupons were then heat treated at 650℃ for six hours to create a sensitized surface [3]. Degradation experiments were run on the heat-treated 316L samples and non-heat-treated controls. Briefly, the sharpened sample edges were submerged in a simulated seawater solution (3.5 wt% NaCl in deionized water) for 48 hours under agitation at room temperature. Degradation was assessed through visual analysis of the edge using metallography and through a colorimetric iron assay (Sigma-Aldrich) to measure the concentration of iron ions present in solution post-degradation. The effect of case hardening on degradation is currently being investigated by heat treating sharpened 316L samples at 950℃ for 6, 8, and 12 hours with the sharp edge coated with graphite and cast-iron chips [4]. Degradation experiments will be conducted using simulated seawater and cell culture media. The cytotoxicity of serial dilutions of the degradation products will be assessed through live-dead assays and MTT proliferation assays with standard immortalized (L929) and primary humpback fibroblasts in culture.

Results and Discussion:

After 48 hours in simulated seawater, the concentration of iron ions was significantly greater for 6-hour heat treated samples versus controls (average iron ion concentration post-degradation at 3.66±0.1nM, and 0.87±0.2nM respectively). This indicates that the six-hour heat treatment at 650℃ accelerated corrosion of 316L stainless steel sharpened edges. This accelerated corrosion was likely due to the sensitization of the 316L stainless steel in which the chromium atoms present in the stainless steel form chromium carbide precipitates at the grain boundaries [5]. This diffusion results in a chromium-depleted region around the grain boundaries which leaves the material susceptible to intergranular corrosion. Visual analysis did not show any obvious changes to the radius of curvature of the sharpened edge. The expected outcomes of the degradation behavior of case-hardened 316L steel are that the increase in carbon diffused into the edge of the sample will result in localized accelerated corrosion at the sharp edge. It is expected that degradation will continue to be accelerated in oceanwater and in cell culture media due to the presence of chloride ions in both solutions. It is expected that the degradation products of the corroded 316L will likely not result in a significant change in cell viability.

6. Adapting to a Changing Climate: Community and Policy Perspectives from El Salvador

Student Presenter: Ethan Gerds, Social Sciences with a concentration in Policy, Law, and Society
Faculty Advisor: Dr. Kari Henquinet, Social Sciences

Introduction:

This research seeks to identify ways to strengthen sustainable community adaptation to climate change in El Salvador from a national policy and community perspective, using both policy documents and ethnographic data from a rural community in the Usulután Department as a case study. Working with the main in-country research partner Lutheran World Relief, this presentation focuses on what policies and strategies might contribute to sustainable community adaptation to climate change with temporary NGO support to develop capacity to continue efforts once the NGO leaves the community.

Materials and Methods:

This research analyzes primary sources from El Salvador. These sources include Salvadoran policy documents as well as field notes collected and interviews conducted by graduate students in the NSF-funded International Research Experiences for Students 2021 cohort. Data is analyzed using qualitative coding of the primary sources. The codes draw on best practices from other under-resourced communities in the research literature as well as the voices and perspectives from interviewees.

Results and Discussion:

This research contributes to the literature on strengthening sustainable community adaptation to climate change in under-resourced communities. Themes that emerged in our research site include agricultural adaptations, water quantity and quality challenges, disaster-mitigation planning, community strengths, and leadership-capacity building. In particular, women and youth are historically often excluded in community leadership structures. In California, the research site in El Salvador, municipal-level government units have partnered with several NGOs to address these challenges through rainwater-harvesting tanks, community gardens, community committees, and trainings. NGOs currently play a vital role in bringing these resources and opportunities for capacity building to rural El Salvador in the face of shifting national fiscal priorities and ongoing neoliberal policies.

7. The Immediate Effects of Mindfulness Techniques on Testing Anxiety

Student Presenter: Emilie Jacques, Psychology
Faculty Advisor: Susan Amato-Henderson, Cognitive and Learning Sciences

Introduction:

Students everywhere suffer from test anxiety and are often left without coping mechanisms for it right before, or during, a test. Previous research indicates that mindfulness can help reduce feelings of anxiety (Dundas et al., 2017). However, this is a skill that usually is practiced for several weeks, and changes often are not measured during the actual exam. This study can help us further understand the effects of mindfulness used during an exam, as well as provide our student participants with healthy coping mechanisms that they can carry through school and life.

Materials and Methods:

Our participants were sampled from the spring 2022 CH1150 course on a volunteer basis. The criterion to participate was a self-reported experience(s) of test anxiety. Volunteers were sent an electronic consent form and were asked to respond to the following questionnaires:
State-Trait Anxiety Inventory (Spielberger, 1989), which assesses anxiety about an event and anxiety as a characteristic.

Perceived Stress Scale (Cohen et al., 1983f), which is a measure of how stressful one perceives situations in their life.

Mindfulness Attention Awareness Scale (Brown & Ryan, 2003), which measures one's awareness of what is happening in the present moment and one's attention to it.

After completing the initial scales, participants learned about several different mindfulness techniques to use during testing. They were asked to practice and returned to an additional meeting for any questions or clarifications. Within 24 hours of beginning an exam, participants were to complete the online form provided, as well as record anxiety just prior to their exam, and fill out a post-examination form to report whether or not they utilized any techniques. Students in the control group were given content related to mindfulness they were instructed to read.

Results and Discussion:

We anticipate that using mindfulness techniques to reduce test anxiety will have an immediate effect on the participants' levels of test anxiety, as demonstrated through their self-reports and their exam performance (compared to a previous exam in the course). Though this may not yield as large of an effect due to lack of practice, it still has the potential to be useful for participants when they are taking tests. Many students feel nervous about taking tests, but it can be hard to cope with that stress in a room full of other students. These techniques provide a seated, still, and quiet way to cope with test anxiety that does not involve outing oneself to the rest of the class. By using some of these techniques, students may lower their own anxiety right before a test, or even during a test, and in turn produce a higher score and therefore improve their grades.

8. Optogenetic Stimulation of the Internal Globus Pallidus for the Treatment of Depression

Student Presenter: Chloe Looman, Biological Sciences
Faculty Advisor: Dr. Chunxiu (Traci) Yu, Biomedical Engineering

Introduction:

Deep brain stimulation via an electrode has been proven effective in treatment for Parkinson's disorder; however, such technology often diminishes in effectiveness over time. Optogenetic stimulation via a photosensitive vector and an implanted optic fiber is being studied as treatment for both Parkinson's and the frequently co-occurring depression. Two potential target regions include the excitatory subthalamic nucleus (STN) versus the inhibitory globus pallidus interna (GPI). This study investigates the effectiveness of deep brain optogenetic stimulation to the lesser-studied GPI region for treatment of depressive and motor symptoms in a Parkinson's rat model.

Materials and Methods:

Ten rats' dopaminergic brain regions were leisioned using 6-hydroxydopamine (6-OHDA) to induce Parkinson's disorder (PD). Six of these rats were assigned the PD group. The remaining four were assigned the PD-implant test group and were injected with the photosensitive (AAV5-CaMKII-GFP) and fitted with a fiber-optic implant reaching the GPI region. Two untreated rats were assigned to the control group. Following a week of recovery, behavioral tests were conducted. These tests included a novel-environment and sucrose splash test, designed to measure how long rats would explore and groom themselves when placed in a novel environment. A sucrose-consumption test measured the rats preference for sucrose water versus plain tap water. A Rotarod device quantified how long the rats could balance on a rotating cylinder, and the adjusting-steps test counted how many adjusting steps were made when dragged across a smooth surface. Behavioral tests were conducted every other week. After two rounds of behavioral tests, optogenetic DBS was conducted five days per week on the PD implant test rats at 130Hz, 10s on and 20s off, for 240 blocks for six weeks, with behavioral tests continuing every other week to track progress.

Results and Discussion:

The results of the behavioral tests were analyzed for trends pre- and post-DBS and between each of the three test groups. The novel-environment/splash test tracked changes in behavior regarding tendency to explore versus sit, and level of grooming in a fifteen-minute span. Following the start of DBS at week 5, the PD-implant group showed a marked increase in grooming behavior compared to the other test groups that continued upwards throughout the remaining weeks. The sucrose-consumption test analyzes preference for the favorable sucrose water over plain tap water as a measure of anhedonia and depression. While both the PD and PD-implant group trend closer to the control group over time, it is unclear if the PD-implant group varies significantly following treatment. The Rotarod and adjusting-steps tests show similarly unclear trends. A second round of testing is ongoing with two additional PD and two PD-implant test rats. We hope that the additional data will model the effectiveness of DBS treatment at lessening depressive and motor symptoms of Parkinson's disease, clarifying the efficacy of the GPI as a target region for treatment.

9. Assessing the Effectiveness of the XAI Discovery Platform and Visual Explanations on User Understanding of AI Systems

Student Presenter: Hunter Malinowski, Computer Science, Psychology
Faculty Advisor: Dr. Shane Mueller, Department of Cognitive and Learning Sciences, Mueller Lab

Introduction:

Artificial Intelligence (AI) and Machine Learning (ML) are playing an increasingly important role in our lives, including determining what we see on the internet, how the government interacts with us, and how companies assess risk regarding potential customers. Although AI has the potential to enhance our lives, there is a risk that it will also reinforce existing inequalities and prevent access to resources in unjust ways. Current AI systems are becoming increasingly complex, which has led to the development of eXplainable AI (XAI), aiming to explain AI systems to various stakeholders. In this study, we aim to find out if explanatory saliency maps, in conjunction with The Discovery System, will lead users to have a better understanding of AI systems.

Materials and Methods:

Thus far, the development of the visual explanations has been the main focus of interest and presented quite a challenge due to the inconsistencies between different programming languages and libraries. When we reach the user-testing phase, we will conduct an online study to test the effectiveness of the saliency maps on the Discovery Platform. Participants will be recruited from Michigan Technological University and receive no compensation. The study will include a training portion, followed by questions to determine understanding and retention, followed by an assessment of usability. It will be a between-subjects design, with the control group receiving the platform without the addition of the visual explanations.

Results and Discussion:

The study will have two main benefits. First, it will demonstrate whether enabling a user to explore patterns within an interactive browser can be an effective way of enhancing transparency and understanding. Second, it will demonstrate whether a commonly used visualization technique will lead to enhanced effectiveness over and above the interactivity. Although our study will use a commonly used imagery database, this can have important implications for other domains (credit ratings, loan recommendations, facial recognition) and for justice, equity, and fairness. Furthermore, it will provide practical approaches for enhancing overall usability and usefulness for developers and users of other AI systems.

10. Mercury biomagnification in the plankton community of Keuka Lake, NY

Student Presenter: Brian Reeves, Ecology and Evolutionary Biology
Faculty Advisor: Dr. Gordon Paterson, Biological Sciences

Introduction:

Mercury (Hg) bioaccumulation in aquatic food webs represents a human health hazard and contributes to over half of the sportfish consumption advisories issued throughout the Great Lakes basin. In this study, Hg concentrations and stable carbon and nitrogen isotope values were measured in dreissenid mussel, bulk zooplankton, and juvenile and adult freshwater shrimp (Mysis diluviana) specimens to assess Hg bioaccumulation and the trophic ecology among these aquatic invertebrates. This plankton community is structured very similarly to those present in the Great Lakes and can provide information regarding Hg bioaccumulation among the lower trophic levels of such aquatic food webs.

Materials and Methods:

Bulk zooplankton and freshwater shrimp samples were collected from Keuka Lake, NY during the summer and fall of 2016. Zooplankton samples were collected using a 0.5 x 1 m plankton net equipped with 64 µm mesh and hauled vertically from approximately 1 m above the lake bottom to the surface and over a distance of > 25 m. Freshwater shrimp samples were collected at night as animals completed vertical migration using a 0.5 x 1.0 m plankton net equipped with 500 µm mesh. Live shrimp were transferred into large (4 L) glass jars containing lake water, then pooled into juvenile (< 10 mm) and adult sizes under a dissection microscope, and then stored frozen in separate glass jars (Slife 2017). Dreissenid mussel samples were collected using a benthic grab sampler from water depths ranging between 10 – 25 m, with mussels sifted from bottom sediments, transferred into food grade plastic bags, and subsequently stored frozen. Samples were dried at 60°C prior to analysis. Stable isotope analyses were completed at the University of Windsor's Great Lakes Institute for Environmental Research using an isotope ratio mass spectrometer. Hg analyses were completed at Michigan Technological University using a Milestone Direct Mercury Analyzer.

Results and Discussion:

Analyses were completed on 18 zooplankton, 9 mussel, and 8 juvenile and 7 adult shrimp samples. Mercury concentrations (mean ± std dev) for Keuka Lake zooplankton ranged from 8.0 – 45.6 ng/g and averaged 27.5 ± 10.9 ng/g. For dreissenid mussels, Hg concentrations ranged from 30.2 – 39.3 ng/g with an average of 35.0 ng/g. Mercury concentrations in juvenile mysid shrimp averaged 54.0 ± 9.4 ng/g with the larger adults averaging 127.7 ± 17.7 ng/g. Carbon stable isotope (δ13C) values ranged from -27.1 to -30.2 ‰ with dreissenid mussels and zooplankton representing the extremes of this range. Nitrogen stable isotope (δ15N) values suggested that small mysids occupied the lowest trophic position among the samples (8.2 ‰) with larger mysids representing the highest trophic level (11.4 ‰) among the samples. Within this plankton community, Hg concentrations in large shrimp were 4.6-fold higher relative to preferred zooplankton prey with small shrimp demonstrating Hg bioaccumulation that was 2-times higher than zooplankton. The results of this study provide evidence for Hg biomagnification within the plankton community of a Great Lakes type food web, and emphasizes the importance of lower trophic predator-prey interactions on pollutant bioaccumulation and biomagnification (Oliver and Niimi 1988; Brown et al. 2022).

11. Evaluating the Influence of Age on Balance Recovery in Decreased Lighting Conditions

Student Presenter: Katherine Schnabel, Biomedical Engineering
Faculty Advisor: Carolyn Duncan, Kinesiology and Kevin Trewartha, Cognitive and Learning Sciences

Introduction:

Little research has been done to see how people recover their balance when beginning to fall. Vison plays a vital role in the detection of a loss of balance so that effective balance recovery mechanisms can be initiated. As adults get older, their vision acuity to light or dark decreases, making it more challenging to detect visual cues in conditions of decreased lighting (e.g., night time). The purpose of our study was to determine if decreased lighting conditions like those experienced in poorly lit environments affect older adults' ability to recover their balance in the beginning of a fall. This research is particularly helpful for the older adult population, which has more falls than other age groups. The information from this study can hopefully be used to improve environmental designs or prevent falls in areas like homes, long-term care facilities, and public buildings.

Materials and Methods:

We are currently collecting data from 12 healthy, community-dwelling older adults (ages: 65-80 years). All older adults are free of any musculoskeletal or neurological impairments that would affect balance. All participants performed a series of forward lean-and-release balance recovery trials in three lighting conditions (light, nightlight, dark). In each condition, participants started at a release angle of 10º. The release angle was increased incrementally between trials by 2º until the participant could not recover their balance with only one step. During all trials, kinematics were recorded with an 11-camera optical motion capture system (Qualisys, Sweden). Small reflective balls will be used for passive motion capture and placed on limbs and trunk of the participant to capture full body kinematics. COM kinematics (maximum velocity and acceleration), stepping temporal-spatial parameters (step length and velocity), and stepping onset latency were obtained between loaded and unloaded conditions at the greatest lean angle. This data will be compared to data previously collected from young and healthy adults (age: 18-40 years).

Results and Discussion:

Data collection is ongoing and will be completed by the symposium. Given the visual system's ability to detect changes in motion, I expect to see that the balance recovery is slower in older adults as well as in lower lighting conditions. This will also result in a smaller maximum lean angle that participants will be able to achieve without taking multiple steps or falling in the dark and nightlight conditions. Furthermore, given older adults greater reliance on visual cues to detect changes in motion, I expect the effect of the decreased ambient lighting conditions on maximum lean angle, response onset, and response characteristics (e.g., step length, center of mass velocity) will be greater for older adults when compared to young adults.

12. Understanding the Persistent Labor Shortage in the United States

Student Presenter: Tyler Sepanik, Economics
Faculty Advisor: Dr. Laura Connolly, Economics Department

Introduction:

Four-year colleges do not work well for many; 40% of students who start university drop out (Gordon, 2019). Further, the NCES (2000) states “one in ten students who dropout re-enroll elsewhere and graduate.” For the remaining 9 out of 10 students, vocational schools and community colleges can be a reasonable alternative. The problem is that there are not enough graduates from these sub-baccalaureate educational institutions to meet the demand in the labor market (Van Noy, 2012). This means that many middle-skill job vacancies will not be filled and could potentially be contributing to a labor shortage in the United States.

Materials and Methods:

For this project we use the Occupational Information Network (O*NET) and the Bureau of Labor Statistics (BLS) data sets to find high-growth occupations that match the definition of “middle skill.” For this research, we are using all occupations listed in O*NET’s job zone 3. This job zone requires “Medium Preparation” where most occupations require training in vocational schools, on-the-job experience, or an associate degree. The next task was to establish which job zone 3 occupations are considered high growth. O*NET has a classification built-in to its database of “bright outlook” occupations, which are those that are expected to grow rapidly in the next several years or will have a large number of job openings. The next step was to match the O*NET occupational names to the BLS occupations. The BLS data is a separate database that includes demographic data for each occupation. Approximately 16% of the O*NET occupations did not have a direct match to occupations in the BLS database. From the “bright outlook” occupations, we then linked the classifications to the individual occupations to provide a full set of occupations with education classification.

Results and Discussion:

Most notably from the dataset, an associate degree typically acquired from a community college is the most frequent form of required education. This could be due to the increased reliance on technology in occupations. Skills like basic coding are generally required for these occupations, and that type of education is often taught in community colleges as opposed to hands-on training. This is also evident in the types of occupations that are classified as “bright outlook.” Occupations like “Computer User Support Specialists,” “Solar Energy Installation Managers,” and “Web Developers" are occupations that are relatively new to the labor market. Occupations that require a knowledge of machinery or mechanics tended to follow their historical education paths. These occupations are ones that do require hands-on learning experience and vocational schools offer resources to aid students in that. One of the most interesting findings from this research is the number of “bright outlook” occupations in the health and science industry. Job availability for technologists and technicians in almost every field of healthcare is expected to grow rapidly. Future work that could be done is to link education data, including demographics, to the “bright outlook” occupations in order to evaluate the viability of these sub-baccalaureate programs.

13. Evaluating Cell-Cycle Quiescence in Ovarian Cancer

Student Presenter: Samantha Siefert, Biochemistry and Molecular Biology - Biology Focus
Faculty Advisor: Dr. Paul Goetsch, Biological Science

Introduction:

The Goetsch lab is studying how the DREAM complex and pRb function in ovarian cancer cells. Ovarian cancer is the eighth most common cancer in women, and the fifth largest cause of cancer deaths among women. To study why cancer cells continue to grow in adverse conditions, we will be treating cells with a mixture of palbociclib, abemaciclib, and ribociclib to lock cells into G0, and with nocodazole to lock them in G2.

Materials and Methods:

Quiescence—a reversible state in which the cell cycle is temporarily arrested—commonly helps cancer cells maintain irregularities from normal cells. That is, their ability to mutate, initiate metastasis, survive in low-nutrient environments, and even to resist cancer therapy treatments. Both pRb and the DREAM complex repress cell-cycle genes, preventing the cell from entering the cell cycle [1]. When cells receive the signal to divide, pRb and the pocket proteins p130 and p107 (part of the DREAM complex) are phosphorylated by cyclin dependent kinases CDK4/6-cyclin D, releasing transcriptional repression of the cell-cycle genes [2]. Because of their importance in maintaining cell-cycle quiescence, loss of both DREAM and pRb causes mammalian cells to be unable to exit the cell cycle.

We will use Western blots to test whether pRb or p130/p107 are in various states of phosphorylation at five time points: proliferating, G0, G1, S-phase, and G2. Western blots use gel electrophoresis to separate proteins by molecular weight. The results are transferred to a membrane that is incubated with antibodies that are specific to the protein of interest. In the end, bands indicate the presence or absence of the proteins being investigated.

Results and Discussion:

"We will establish Human Foreskin Fibroblast cells (HFF) as controls for normal pRb and DREAM activity for the experiments described above [3]. Thicker bands indicate that more of the protein is present while thinner bands show the opposite, and phosphorylated pRb and p130 proteins are expected to migrate at a detectably higher molecular weight. We expect pRb or p130 proteins to be phosphorylated in the dividing cells and not phosphorylated in quiescent cells.

While pRb is known to be commonly inactivated in cancer cells, the status of DREAM function in cancer cells is generally understudied. This means that any results we arrive at may provide important information for future study of the DREAM complex in mammalian cells. In this way, we can identify whether or not the pRb or p130 proteins are present in SKOV3 cells and are phosphorylated in the dividing cells and not phosphorylated in quiescent cells."

14. The Effect of Prolonged Probiotic Supplementation upon a Model of Chronic Obesity

Student Presenter: Morgan Smith, Biochemistry and Molecular Biology (Bio Focus)
Faculty Advisor: Thomas Werner, Biological Sciences

Introduction:

According to a 2015 Global Burden of Disease Study, an estimated third of the world population is overweight or obese, and the prevalence of obesity is still climbing worldwide. Obesity is a multifactorial, chronic disease that leads to many health complications, including a higher risk of mortality. Manipulating the gut microbiome (the symbiotic microorganisms of the intestines) shows great potential as a treatment for obesity, and may help to lower the risk of mortality. Thus, this study was designed to elucidate the effect of probiotic supplementation on length of life (longevity) using a drosophila model of obesity.

Materials and Methods:

In this study, adult drosophila melanogaster flies were fed a diet containing 10% vegetable shortening by volume to induce an obesity phenotype. Within the experimental group, this diet was supplemented with 1.0 x 10^8 CFU per mL of lactobacillus plantarum. Flies were maintained on their respective diets for the remainder of their life and their longevity was recorded.

Results and Discussion:

Obesity causes dysbiosis within the gut microbiome, and probiotic supplementation helps to stabilize this dysbiosis. Previous experiments have shown dietary supplementation with 1.0 x 10^8 CFU per mL of lactobacillus plantarum to have significant benefits upon the longevity of drosophila melanogaster. As such, it is expected that probiotic supplementation will extend the longevity of obese flies. This research is ongoing. Results from this study will encourage and guide future research into the effect that the gut microbiome has on human health. Furthermore, as this study spans the entire lifetime of a chronically obese model, it will provide data on the effect of supplementing the gut microbiome throughout the entirety of adult life.

15. Harnessing the Offshore Winds of the Great Lakes to Supplement Electrical Needs

Student Presenter: Kamila Staniszewski, Mechanical Engineering
Faculty Advisor: Dr. Ana Dyreson, Mechanical Engineering Wind Energy

Introduction:

Offshore wind as a source of energy has become more evident in the U.S. especially after the construction of the first offshore wind farm in the U.S. in Block Island, Rhode Island. After seeing the success that the wind farm has had, more organizations have been striving for more potential offshore wind farms in the U.S., but most work has been focused on the East and West Coasts. The Great Lakes were the main focus of this research project to determine if the offshore wind would be enough to meet consumer demand.

Materials and Methods:

First, an in-depth literature review was conducted to better understand how the offshore wind turbines functioned, how they were structured, and what types of conditions were necessary to ensure the utmost performance. In addition, previous studies on offshore wind from 2016 were taken into account to see what data was found. Similar to the New England study, wind validation was performed to ensure that the model data wind speeds were matching the observed data. To complete this, 18 buoys at 200-meter hub heights were selected in total within the five Great Lakes. However, buoy locations were selected based on studies that focused on the environment around the Great Lakes. Based on the sizes of these lakes, more buoys were selected for Lake Michigan than for Lake Ontario. Data from the National Renewable Energy Laboratory (NREL) Wind Toolkit was used as our model data to compare to the observed data. We compared the model data to observed data from buoys from the National Data Buoy Center (NDBC) at a 200-meter hub height. The total necessary data points were 8,760 for each hour throughout the year. Once all the power calculations were completed, it was necessary to compare the energy consumed in states surrounding those lakes.

Results and Discussion:

Once all the buoys ran through the wind validation code, a series of figures was provided by the validation code that showed whether or not the model and observational data was validated. The rest of the buoys from each of the Great Lakes had the same results where the modeled wind speed was vastly larger than the buoy data. In addition, the relative frequency of the winds was calculated compared to the wind speed. Similarly, the relative frequency was lower in the model data than the observed data since wind speeds were more spread out. During the summer months, the biases were lower; therefore, the results were more consistent and accurate. However, the results in the winter months were of higher values. This could be due to the sudden gusts of wind, freezing temperatures, or ice in the Great Lakes, which don't affect the wind speed in the summer months. In addition, there was higher bias in the afternoons compared to the mornings, which could be a result of wind direction changing from one time of day to the next. Ultimately, the wind validation was unsuccessful where the model could not be used to accurately provide model offshore wind farms. Since it was not validated, the buoy data was used in the SAM software to calculate the power of the offshore wind farm.

16. Understanding and Predicting the Fate of 1,4-Dioxane in the Aqueous-Phase UV/Chloramine Advanced Oxidation Process

Student Presenter: Chloe Strach, Environmental Engineering
Faculty Advisor: Dr. Daisuke Minakata, Department of Civil, Environmental, and Geospatial Engineering

Introduction:

The presence of anthropogenic organic contaminants in water presents challenges for ecological and water-energy infrastructure systems and human health. Ultraviolet light combined with free chlorine in the presence of ammonium, that is UV/free chloramine advanced oxidation process, is an attractive alternative to conventional UV/H2O2 process. Yet, the detailed mechanisms are not well understood.

Materials and Methods:

Extensive literature reviews were conducted to compile the chloramine-involving reaction rate constants from the National Institute of Standards and Technology (NIST) solution kinetic data base. We further conducted critical data analysis by evaluation of the experimental solution pH, temperature, and ionic strength used in the literature. We then wrote the ordinary differential equations (ODEs) of all elementary reactions involved in the UV/chloramine processes. The numerical solution of stiff ODEs was performed using a backward Newton method, called gear-method, and we systematically evaluated the errors resulting from systems, roundoff, and truncation. Finally, we obtained the time-dependent concentration profiles of 1,4-dioxane and the formation of reaction products under various experimental conditions such as pH and the presence of other water constituents, and validated the results with experimental observations in the literature.

Results and Discussion:

We found that UV/chloramine process was highly effective in degrading 1,4-dioxane. UV/chloramine is advantageous over conventional UV/H2O2 because chloramine can generate greater amounts of chlorine-derived reactive radicals in addition to oxygenated radicals. The use of UV/chloramine has advantages such as chloramine residue as secondary disinfectant, omitting the need for additional secondary disinfectant inputs.

17. Fine root respiration of Quercus rubra: Root system activity across a latitudinal gradient in the Midwest

Student Presenter: Madalyn Tudor-Duncan, Applied Ecology and Environmental Science
Faculty Advisor: Molly Cavaleri, College of Forest Resources and Environmental Science

Introduction:

Northern red oak (Quercus rubra) is an important hardwood species and plays a key role in carbon sequestration. From north to south in the Midwest, mean annual temperature (MAT), growing season, and precipitation vary widely. As a result, a species growing across latitudinal gradients may exhibit differential growth and physiology. Across the Midwest, I investigated how latitude affects root respiration, root nitrogen concentration, and root biomass of Quercus rubra. Root respiration is an important component of carbon cycling, and our research aims to learn more about this process in Quercus rubra and implications from a changing climate.

Materials and Methods:

Six sites were established in public forests from upper Michigan to southern Illinois and Indiana, and were ranked by their MAT as cold (4.1 - 4.9 º C), intermediate (5.4 - 9.8 º C), and warm (11.3 - 14.2 ºC). Each site was visited twice during the 2021 growing season, in late June and late July. During each visit, a set of four soil cores (5 cm diameter x 10 cm deep) was taken from the bases of six different Quercus rubra trees found in the forest. From each of the six sets of cores, tree fine roots were sorted from other herbaceous roots and cleaned of soil, then placed into the chamber of an infrared gas analyzer to measure root respiration. Respiration measurements were taken at two temperatures: ambient soil temperature at 5 cm, derived from a thermometer placed in several locations within the forest soil, and a reference temperature of 20º C. Each root sample was frozen until it could be cleaned, dried, weighed, and ground for nitrogen and carbon analysis. Respiration data was then compared to biomass, root nitrogen concentrations, and other variables using regression analysis in Excel.

Results and Discussion:

"Results from the June 2021 sampling show trends among several variables. First, higher root biomass is significantly correlated to lower specific root respiration (per unit root mass). Second, increased root nitrogen concentration is significantly correlated with higher specific root respiration. These results also seem associated with MAT, with higher root biomass being found at colder sites, along with lower root nitrogen concentration. The warm sites typically had lower root biomass and higher root nitrogen concentration.

Colder sites typically have shorter growing seasons, therefore requiring more roots to do the same amount of work as in warmer climates, which could explain the increase in root biomass. This would fall in line with the findings that with higher root biomass there is a decreased rate of specific root respiration (per unit root mass). This trade-off between biomass and respiration rate results in fairly similar allocation of carbon to fine-root respiration at the ecosystem level (i.e., per unit ground area) across the sites. These findings could provide insight into how Quercus rubra may respond to warming temperatures and changing climates."

18. Under-Resourced College Students in the Western Upper Peninsula

Student Presenter: Will Twardzik, Engineering Management
Faculty Advisor: Jon Leinonen, College of Business

Introduction:

This project focuses on better supporting under-resourced college students within the western Upper Peninsula. This project started with the Portage Health Foundation in 2020. The goal of this project is to identify specific opportunities to better understand the conditions from which under-resourced students enroll at Michigan Tech and how faculty and administrators can engage and support retention of under-resourced students, and to help to infuse information and social capital with under-resourced students by supporting their graduation and career goals, and long-term benefits to the regional economy. This project is being driven from a student perspective, students helping students, to best identify and develop methodologies that support long-term outcomes.

Materials and Methods:

The process for completing this project involves identifying best practices, contacting members of different communities to gather suggestions from professionals working with under-resourced populations, and compiling data for the Upper Peninsula region. Our goal is not only to provide ideas to work with inside Michigan Tech but also to improve awareness and connectedness among service providers in the western Upper Peninsula for what under-resourced college students need most.

Results and Discussion:

The research is ongoing, so we do not have all of the results yet. We are investigating under-resourced college students in the western Upper Peninsula. We are also investigating why this area has a low rate of high school graduates receiving secondary education. The findings will hopefully explain why this happens, along with ways to help under-resourced students in the area. The results will be shared with the Portage Health Foundation to help them decide how to allocate resources.

19. Chemical Degradation of Polyethylene and Polyethylene Terephthalate Plastics

Student Presenter: Libby Umlor, Chemical Engineering
Faculty Advisor: Dr. Rebecca Ong, Chemical Engineering

Introduction:

The current approach to plastic recycling is non-sustainable and energy-intensive; looking toward chemical degradation would allow for the recycling of plastic to be far more feasible. The objective of this research is to determine the feasibility of recovering and recycling the polymer components of Meals Ready to Eat (MRE) bags used by the military. These mylar bags consist of three layers of material: polyethylene (PE), polyethylene terephthalate (PET), and aluminum. This project is being conducted in tandem with other plastic degradation projects with the overarching goal of creating an integrated system to deconstruct plastics for use as a microbial carbon source.

Materials and Methods:

The MRE bags were passed through a paper shredder to cut the bags into small, uniform pieces. The polyethylene layer was recovered by mixing and heating the MRE bag with a solvent in a 1:2 ratio. The PET layer was recycled by mixing the MRE bag with an ammonia hydroxide solution in a horizontal reactor and processing it under high temperatures. The final solid product was separated from the liquid using vacuum filtration. The samples are then to be evaluated using Fourier transform infrared spectroscopy (FTIR) technique to determine the effectiveness of the solubilization process, and processed in a muffle furnace to determine the amount of residual plastics remaining on the samples post-processing.

Results and Discussion:

This research project is ongoing, and the largest hurdle is determining the ideal solvent for separating the polyethylene layer. It was expected that both the aluminum layer and polyethylene terephthalate would fully dissolve and be removed with the use of the ammonia hydroxide solution. However, from initial experiments, the aluminum remains intact following processing. Through this research, the ideal concentration of ammonium hydroxide and solids loading will be determined. The waste generated in military operations poses logistical problems that can limit the course of the operations; this process has the potential to sustainably recycle the MRE bags (14,000 tons waste per year) currently being used by the United States military.

20. Continuous Vaccine Purification Utilizing Tangential Flow Filtration and Aqueous Two-Phase Systems

Student Presenter: Sheridan Waldack, Chemical Engineering
Faculty Advisor: Dr. Caryn Heldt, Heldt Bioseparations Laboratory

Introduction:

Recent COVID-19 vaccination efforts have highlighted the importance of cost-effective vaccines and efficient manufacturing. This has led to a desired shift from batch to continuous manufacturing in the pharmaceutical industry. A large benefit of continuous manufacturing is minimized downtime between unit operations. Vaccine production involves upstream processing, which deals with growing the product, and downstream processing, which focuses on purification and formulation. Around 70% of vaccine production cost results from purification, so this study focuses on downstream processing. Utilizing tangential flow filtration and aqueous two-phase extraction, the feasibility of transitioning to continuous manufacturing is demonstrated.

Materials and Methods:

This experiment demonstrates the continuous purification of porcine parvovirus (PPV). First, PPV is concentrated using tangential flow filtration (TFF). We varied the flow rate and degree of concentration to find the best conditions. Citrate salt and PEG polymer stocks are then mixed in line with the concentrated virus, which initiates the first stage of aqueous two-phase extraction. A critical part of this process is mixing to allow the virus and impurities to contact the PEG and citrate and partition to the phase that aligns with the hydrophobicity and charge of the molecule. To ensure proper mixing, either a helical mixer or stir bar mixing is utilized before the phases separate in a settling container. The virus partitions to the PEG phase in the first stage and the cell debris partitions to the citrate phase. The PEG phase is harvested from the top phase and mixed with citrate stock and nanopure water to back extract the virus into the citrate phase, which is needed for future processing. The same mixing process is repeated. Once this solution reaches the second settling container, the citrate phase contains the purified and concentrated virus.

Results and Discussion:

Data has been collected from batch processing for PPV ATPS back extraction, but it has not been operated continuously or with a connected TFF concentration step. The single unit operation of concentrating PPV showed an 89% recovery of PPV utilizing the TFF system. Batch method two-stage ATPS showed up to 84% PPV recovery. While the conditions of this process still need to be optimized, this small-scale demonstration shows the feasibility of creating a large-scale continuously operated process. Previous experiments in the lab with a single-stage continuous ATPS system had recoveries over 90% when mixing was optimized, so adding a second phase and concentrating the virus beforehand shows a lot of promise for this three-unit-operation continuous system. Additional experiments will be performed this semester to determine PPV recovery on the full, continuous downstream processing system. The potential implications of these findings may show that converting systems to continuous processing can prove that much higher recoveries make the transition worth the initial capital costs of buying new equipment.

SESSION B: 2:30-4 PM

	Presenter	Department	Title
1	Ayodotun Aluko	Biomedical Engineering	Characterization of the Focused Ultrasound Effect on Active Agent Release Behavior from Fibrin Composite Hydrogels for Tendon Repair
2	Katherine Dvorak	Social Sciences; Law, Policy, and Society	Understanding the Importance of Mutual Aid in a Food Apartheid
3	Madeline English	Biomedical Engineering	Evaluation of Protein Expression in Skin Cells due to Direct Soil-Arsenic Exposure Using In-Cell Western
4	Connor Hall	Biochemistry and Molecular Biology - Chemistry Focus	Investigating the Effect of pH on Lysozyme Aggregation
5	Kathleen Heusser	Biomedical Engineering	Effect of Extracellular Matrix Density on Traction Force Transmission by Fusion Protein Positive vs Negative Rhabdomyosarcoma
6	Nick Kampfschulte	Environmental Engineering	Anthropogenic Reactive Nitrogen Deposition to Remote Lakes in the Upper Great Lakes Region
7	David Kromholz	Forestry	Spatial Patterning and Growth of Naturally Regenerated Eastern White Pine in a Northern Hardwood Silviculture Experiment
8	Nick Niemi	Biomedical Engineering	Design and Testing of a Novel Transcatheter Mitral Valve
9	Theresa Passe	Environmental Engineering	Characterizing the Fate of SARS-CoV-2 During Wastewater Treatment
10	Abigail Pettit	Sustainability Sciences and Society	Community Solar Policy Review
11	Drew Pienta	Mechanical Engineering	Automatic Extraction of Coronary Arteries using Deep Learning in Invasive Coronary Angiograms
12	Henry Roell	Chemistry	Purification and Characterization of a New Bioactive Compound from Plant

13	Drew Rosales	Applied Math + Computer Engineering (Double Major)	Incremental Geometric Multi-Resolution Analysis
14	Elizabeth Schumann	Chemical Engineering	Depolymerization of Polyester, Nylon, and Spandex in Batch Reactor System with Ammonium Hydroxide
15	Ellie Sempek	Biochemistry and Molecular Biology	Understanding the Impact of Different Virus Purification Techniques on Virus Physicochemical Properties
16	Lilly Van Loon	Medical Laboratory Science	The Role of Orexin A in Salt Sensitive Hypertension
17	Brianna Wieferich	Applied Ecology and Environmental Science with a Plant Genetics focus	Seed Germination Patterns in an Experimental Grassland and Plant Genome Size
18	Andrew Zampaloni	Chemistry	Quantum-Chemical Explorations into the Nucleation Mechanism of the 2:1 HMX/CL-20 Co-Crystal through the Analysis of Small Structural Oligomers
19	Claudia Zinser	Wildlife Ecology and Management	Cryptic Equatoguinean Birds: DNA Barcoding and New Identification Techniques

1. Characterization of the Focused Ultrasound Effect on Active Agent Release Behavior from Fibrin Composite Hydrogels for Tendon Repair

Student Presenter: Ayodotun Aluko, Biomedical Engineering
Faculty Advisor: Dr. Smitha Rao and Dr. Rupak Rajachar, Biomedical Engineering

Introduction:

Tendon injuries are a problem due to their prevalence, and there are no effective treatments that resolve the injury without a resultant deficit in function or long-term effects on tissue stability that lead to reinjury. One advancement is the development of hydrogels to treat tendinopathy; hydrogels have the unique ability to stabilize the structural environment of a tendon while also being capable of delivering therapeutics. This aids in restoring normal tissue function and properties as well as speeding up the natural healing process. Therapeutic release needs to be controlled and this can be done with thermal/mechanical loading via focused ultrasound.

Materials and Methods:

Fibrin particles were synthesized via emulsion polymerization of a fibrinogen solution and a thrombin/$CaCl_2$ solution. The emulsion is cooled, and particles are recovered by vacuum filtering and an acetone rinse to separate particles. To make SNAP-Fibrin particles, PBS is added to SNAP and then NaOH until SNAP dissolves. HCl is then added until the desired pH is reached. A small portion of this solution is mixed with a base fibrinogen solution, and emulsion steps are repeated as previously described. Polyethylene-glycol (PEG)-fibrin microparticle hydrogels were synthesized using an established protocol.

To determine nitric oxide release behavior, each sample (particle or hydrogel) is placed in a cell trap and their release behavior was assessed using an NO analyzer with or without the application of thermal/mechanical loading via a custom focused ultrasound (FUS) system. Release was recorded for two hours for all sample preparations. Samples were treated with continuous-wave FUS with an amplitude of 150 mVpp using the 3.5 MHz transducer.

Results and Discussion:

Fibrin-only particles showed zero NO release before and after FUS stimulus was applied. This result was expected because the sample has no SNAP. NO release from SNAP-fibrin particles without FUS stimulation showed rapid NO increase until it reached a peak of 1.0 moles/(min*cm^2) and then rapidly decreased till NO levels plateaued at 0.1 moles/(min*cm^2). NO release from FUS-stimulated SNAP-fibrin particles showed a similar behavior except its peak was higher. NO release of non-stimulated PEG-fibrin hydrogels showed a more controlled release profile. The NO release of FUS-stimulated PEG-fibrin hydrogels was similar except in the duration when FUS stimulus was applied and spikes in NO release occurred. These results indicate that FUS stimulation with PEG-fibrin hydrogels shows tight temporal control of NO release.

2. Understanding the Importance of Mutual Aid in a Food Apartheid

Student Presenter: Katherine Dvorak, Social Sciences; Law, Policy, and Society
Faculty Advisor: Dr. Angie Carter, Department of Social Sciences

Introduction:

Houghton County Michigan and the surrounding areas have long experienced a food apartheid ("food apartheid": an all-encompassing term which describes the lack of access to fresh and healthy foods due to systemic, socioeconomic issues within our food system);[9] despite the historic abundance of these lands' and waters' foods for people since time immemorial, people now struggle with food insecurity at rates higher than state or federal levels.[8] Recently, a grassroots community group, Growing from the Heart, has sprung up to help combat the issues within our current food system. Growing from the Heart is a pilot food-sharing program inviting community members to grow and share extra food that is facilitated through the Western U.P. Food Systems Collaborative (WUPFSC).

Materials and Methods:

This study engages a multifaceted qualitative and quantitative research plan utilizing different social science methods. I have attended the Growing from the Heart group meetings since summer 2020 and did some initial analysis of their pilot season, summer 2020, in my fall 2020 Communities and Research class project with Dr. Carter. I originally planned on interviewing Growing from the Heart participants over the duration of the summer and participating in the program myself, attending meetings and engaging in participant observation. Unfortunately, due to the Delta Variant and conflicting work schedules, I was not able to complete the in-person interviews. I was able to engage in participant observation through zoom as well as some in-person observation at various different events during the summer of 2021 and spring of 2021. From the data I collected during my participant observations, I used a constructivist approach of grounded theory to then code and better understand the observations. The reason for using a constructivist approach versus the positivist approach is because of the nature of mutual aid.

Results and Discussion:

The Keweenaw region has an abundance of creative and local food projects underway even as it struggles with food apartheid. The reasons for food apartheid in our region are systemic and go deep into the roots of capitalism, which is why mutual-aid groups such as Growing from the Heart are so important to our local food systems. Many of those involved with mutual aid are not aware that the time that they have given is even considered as aid. For example, one of the events I observed this summer was a garden build at Horizon's alternative school in Mohawk. The students had designed their own garden and volunteers from Growing from the Heart showed up to help build the garden. This detail is one of my personal favorites: as in most garden builds, the volunteers help design the garden, but the students had not only designed it but did all the math to map out the blocks needed as well as dirt and gravel, and that made the day that more exciting. Another local group had also made an appearance, the Women's Roller Derby team from Calumet, Michigan. The community involvement throughout this project was extensive as it brought so many different people together.

3. Evaluation of Protein Expression in Skin Cells due to Direct Soil-Arsenic Exposure Using In-Cell Western

Student Presenter: Madeline English, Biomedical Engineering
Faculty Advisor: Dr. Smitha Rao, Biomedical Engineering

Introduction:

Arsenic (As) is a carcinogenic metalloid. Various short-term effects of exposure include gastrointestinal and neurological issues [1]. Long-term As exposure causes various types of cancers and other health complications [2]. Currently, the WHO and EPA have set exposure limits for air and drinking water, but there are no guidelines for exposure via contact. Arsenic leaches from the soil into groundwater. Areas with As-containing pesticides and processes like mining pose a greater risk. The baselines established in this research can serve as a springboard for safety protocols and establish guidelines for exposure via skin contact and provide insight into cell-As interaction.

Materials and Methods:

Extraction of As from the soil is a key component. Conventionally, arsenic salts are used, which does not represent environmental exposure. Hence, As was obtained from soil samples and processed using sequential extraction. Healthy human immortalized keratinocytes (HaCaT), and healthy adult human dermal fibroblasts (HDFa) cells under standard conditions (5% CO_2, 95% relative humidity, 37°C) in their respective culture media were used. Arsenic leachate was added to cell media in four different concentrations (45, 225, 450, and 900 ppm of As) chosen based on As accumulation in soil over a period of 10 years due to use of arsenical pesticides [3]. Samples were fixed after 24 hours. Quantitative expression of CD44, ZEB1, and actin proteins post-treatment with As was assessed using In-Cell Western using standard protocols.

Results and Discussion:

Changes in protein expression of actin after exposure to different concentrations of As were quantified. There was an increase in actin with the concentration of soil-As, suggesting that cells begin to lose their epithelial-like nature and gain mesenchymal properties. CD44 is a glycoprotein that has a role in cellular adhesion and proliferation and is overexpressed in cancer cells. Data indicates lack of CD44 in the control cells, but sharply increases when cells are exposed to 45 ppm As and levels off after 225 ppm As, indicating the toxic effect of soil-As beginning at 225 ppm. The measurement of expression levels of ZEB1 was chosen because this transcriptional suppressor of both epithelial and neural cadherin promotes drug resistance, proliferation, and metastasis of cancers. There was no expression of this protein in the control cells or at 45 ppm As, but continually increased with the higher concentrations of As up to 900 ppm. This is the first study to report ICW on in-vitro effect of soil-As and can serve as a protocol to assess effects of As. Future studies will involve understanding As uptake and localization within the cell to elucidate mechanisms affecting cell proliferation, migration, and growth.

4. Investigating the Effect of pH on Lysozyme Aggregation

Student Presenter: Connor Hall, Biochemistry and Molecular Biology - Chemistry Focus
Faculty Advisor: Dr. Ashutosh Tiwari, Chemistry

Introduction:

Protein aggregation is central to toxicity in many neurodegenerative diseases such as Alzheimer's disease, Parkinson's disease, and amyotrophic lateral sclerosis. These different protein aggregation diseases share some aggregate morphology as well as physicochemical properties. Changes in pH, temperature, and disulfide reducing agents can affect protein aggregation properties and its kinetics. A good understanding of how these changes in environmental influence impact aggregate structure and aggregation kinetics can lead to insight on the disease process and hence provide targets for therapeutic interventions. In this study, we investigated how pH influences aggregation morphology and kinetics using a model protein, lysozyme.

Materials and Methods:

Lysozyme samples were prepared in a 20 mM GCH buffer (a mix of glycine, citrate, and HEPES buffers) at pHs 4.5 and 7.2. Lysozyme samples were incubated in triplicate at a concentration of 40 µM in the presence and absence of 5 mM TCEP (a disulfide reducing agent) for varying time points. Proteins were incubated at 37°C for 1 hour, 4 hours, 1 day, and 7 days. Post-incubation, samples were diluted and analyzed by intrinsic fluorescence and also in the presence of dyes such as ThT, Bis-ANS, or ANS for extrinsic fluorescence measurements. In addition, the protein samples at various time points were also visualized by FESEM to characterize their aggregate morphology.

Results and Discussion:

We wanted to understand how changes in pH as reflected in different cellular compartments such as cytoplasm (pH 7.2), lysosomes (~pH 4.5), and mitochondria (pH 8.0) impact protein aggregation properties. While experiments are in progress at pH 8.0, herein we report our results for work done at pH 7.2 and pH 4.5. Both intrinsic and extrinsic fluorescence spectra for lysozyme at pH 7.2 show a rapid unfolding and increase in hydrophobicity that is sustained over a longer period of time (observed high fluorescence at 1 hour time point stays high even after 7 days of incubation). Interestingly, there is a blue shift (peak value of fluorescence shifting to lower wavelength) for ANS bound to misfolded lysozyme as a function of time, indicating well-formed hydrophobic pockets appearing upon longer time incubation. These fluorescence peaks and wavelength shifts were less pronounced at pH 4.5. FESEM images for aggregated proteins showed that protein aggregates are amorphous for disulfide reduced lysozyme that stay amorphous even after longer incubation time. We will also carry out lysozyme aggregation studies at pH 8.0 to see if changing the pH from acidic to neutral to alkaline impacts its aggregation properties or not.

5. Effect of Extracellular Matrix Density on Traction Force Transmission by Fusion Protein Positive versus Negative Rhabdomyosarcoma

Student Presenter: Kathleen Heusser, Biomedical Engineering
Faculty Advisor: Dr. Sangyoon J. Han, Biomedical Engineering

Introduction:
Rhabdomyosarcoma (RMS) is the most common childhood soft tissue cancer, with 4.5 cases per million adolescents per year. Research has shown a 75% cure rate for localized RMS, but metastatic RMS patients' survival rate is 30%. A major factor determining metastatic malignancy is the fusion protein PAX-FOXO1: the two histological subtypes, alveolar and embryonal rhabdomyosarcoma, are fusion-protein-positive and fusion-protein-negative, respectively. In brief, FPRMS cells produce much less of the extracellular matrix (ECM) proteins than FNRMS cells. This study will investigate cellular mechanical response to the induced difference in ECM protein density.

Materials and Methods:
Bovine Collagen II of thick (5ug/mL) and sparse (0.1ug/mL) density, coated on top of 0.7 kPa or 12.5 kPa Qgel 920 silicone gel from Quantum Silicones, creates the 2D "ECM" for experiments. This will be coated with 40nm fluorospheres, then cells will be placed on the substrate and imaged live under a total internal reflection microscope (TIRF) with 60x oil-immersion objective lens. Images of beads will be processed with TFM software in MATLAB to reconstruct traction, whereas the images of cells will be analyzed for membrane protrusion and adhesions. RH41 cells are the first RMS cells to be used in live-cell imaging experiments, as they grow most quickly due to PAX-FOXO1 expression; also RH30 (FPRMS), RH18 (FNRMS), and SMS-CTR (FNRMS) cells will be used.

Results and Discussion:
"Two independent parameters, i.e., gel stiffness and ECM density, will be tested for traction and migration. Two different gel stiffness, i.e., soft (0.7 kPa) and stiff (12 kPa), and two different collagen II densities, i.e., sparse (0.1 ug/mL) and dense (50 ug/mL) will be used. The aim of the project is to determine the cellular response, in terms of cell spread area, traction force exerted, and migratory pattern, to different stiffnesses of gel and different thicknesses of collagen layer, particularly as the presence of the fusion protein influences ECM protein secretion. As I started the project in January, the current stage is the culture of Rh41 cells and training of TFM substrate fabrication.

The outcome of this study will shed light on the relationship of fusion-protein presence to the tumor microenvironment (TME), and in turn, the TME's mechanical impact on the cells. Knowledge of this relationship will help us to target RMS therapies more specifically depending on the type of cancer present."

6. Anthropogenic Reactive Nitrogen Deposition to Remote Lakes in the Upper Great Lakes Region

Student Presenter: Nick Kampfschulte, Environmental Engineering
Faculty Advisor: Cory McDonald, CEGE

Introduction:
Human industrialization has increased the amount of reactive nitrogen in the atmosphere and on the earth's surface. Nitrogen (N) plays a significant role in the productivity of aquatic ecosystems; however, the extent to which increased N depositions have affected lakes is unknown due to disturbances in aquatic ecosystems, which have led to increased N loading, making it difficult to isolate the impact of atmospherically deposited N.

Materials and Methods:
Sediment cores were taken from three relatively pristine headwater lakes in the upper Great Lakes region; minimally or completely free from watershed disturbance, they allow us to isolate the impact of atmospherically deposited N. Cores were sectioned and analyzed for radioisotopes using the Ra-226 decay series, measuring the gamma activities of Pb-210 and Cs-137 to establish a ~150-year chronology. C and N, as well as stable C and N isotopes, are being measured using an IRMS elemental analyzer to determine anthropogenic N sources and lake productivity.

Results and Discussion:
Research is ongoing. Having an improved understanding of the anthropogenic contributions to the nitrogen cycle on aquatic ecosystems will improve our current scientific basis for establishing regulatory criteria for nitrogen in lakes.

7. Spatial Patterning and Growth of Naturally Regenerated Eastern White Pine in a Northern Hardwood Silviculture Experiment

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

Introduction:
The abundance of eastern white pine in the upper Midwest has been reduced due to historic overlogging. Maintaining and enhancing tree-species diversity are important for maintaining resilient forest ecosystems in the face of a changing climate. This project aims to understand the spatial patterning and growth of eastern white pine across varying canopy and soil treatment within a northern hardwood forest. This knowledge can aid efforts to enhance diversity in managed northern hardwood forests and enhance species and habitat diversity.

Materials and Methods:
The study took place in Alberta, Michigan, in the College of Forest Resources and Environmental Science's NHSEED project from November 2021 to current time. Parallel transects were walked to search the entirety of the 100-acre NHSEED project area for white pine saplings. Mapping of saplings was conducted using a Garmin GPS unit, compass, and a DME sonic rangefinder. Heights, diameter at breast height, number of whorls, and height from the fifth whorl from the top of the tree were collected. The treatment units surveyed included low and high residual shelter woods and clearcuts. Single tree selections will be surveyed after the snow melts. Additionally, data were collected for all potential seed trees within 200 meters of the project's boundaries. The resulting GPS data were used to construct a map of the eastern white pine locations in ArcGIS Pro. Spatial analysis of spatial patterning was also conducted within the ArcGIS Pro software.

Results and Discussion:
Research is still ongoing. We hypothesize that treatment units with highest levels of canopy opening and scarification will produce greater eastern white pine regeneration than areas with minimal canopy opening and scarification assuming seed trees are nearby. Areas without intentional scarification are hypothesized to have an increased spatial aggregation of eastern white pine since incidental scarification is likely highly localized around machine trails. On the other hand, areas with scarification should exhibit increased spatial regularity as suitable microsites for regeneration become more common across a treatment unit. Our findings should clarify the potential to increase white pine in hardwood stands when only scattered seed trees are present.

8. Design and Testing of a Novel Transcatheter Mitral Valve

Student Presenter: Nick Niemi, Biomedical Engineering
Faculty Advisor: Dr. Hoda Hatoum, Department of Biomedical Engineering - Biofluids Laboratory

Introduction:

The mitral valve (MV) is located on the left side of the heart between the left atrium and ventricle and is bi-leaflet. The most prevalent MV disease causes them to not fully close leading to leakage, referred to as mitral regurgitation [1]. Transcatheter Mitral Valve (TMV) Replacement (TMVR) is an alternative method to replace damaged mitral valves in patients too high risk to undergo surgery; however, current TMVs are tri-leaflet, which leads to non-physiological flows in the ventricle, and they are prone to obstruct the left ventricular outflow tract (LVOT). We aim to design a TMV that addresses these drawbacks.

Materials and Methods:

Using CAD software, we designed two valves: a D-shaped conical valve and an asymmetric valve, both mimicking native annulus shape (non-circular) to ensure the right fit in the native geometry.

To fully understand the mitral valve geometry, we used a commercial valve (Edwards SAPIEN 3 26 mm) Transcatheter Heart Valve to run simulations in the native geometry. To deploy this valve in the native geometry of the heart we had to 1) segment native geometry obtained from CT scans from Mayo Clinic under an IRB approved study, 2) check for the closing forces and the stress distribution on the leaflets, 3) crimp the valve using finite element analysis (FEA), and 4) expand the valve in native geometry using FEA.

Using the data we obtained from crimping and expanding the SAPIEN 3 in the native environment, we were able to gain a better understanding of how our valve would be deployed. The crimping device and balloon design for our device was a much more demanding process due to the complexity of our D-shaped valve cross-section compared to the SAPIEN's circular cross-section. Using a D-shaped crimping device and balloon, we were able to simulate the crimping and expansion of our D-shaped valve design.

Results and Discussion:

Our results from the deployment of the SAPIEN 3 heart valve in native mitral geometry showed that the valve itself did not sit very well in the annulus of the mitral valve. The mitral valve has a saddle-D-shaped design, which does not match well with the cylindrical design of the SAPIEN 3, leaving a lot of room for movement and leakage. The distribution of the stresses showed that there is barely any contact between the native geometry and the SAPIEN valve, necessitating a more appropriate valve size.

Because of the small size of the SAPIEN 3 valve compared to the native annulus size, no potential neo-LVOT obstruction showed, as the anterior leaflet was not pushed completely toward the aortic valve.

Our results from our D-shaped conical valve showed that upon crimping with a circular cylinder there was extreme deformation of the valve, which pushed us toward designing a D-shaped crimping device to maintain the overall shape of the valve to ensure it can expand back to its D-shaped cross-section. We are still currently working on the D-shaped crimping device design along with a D-shaped balloon for expansion of our D-shaped stent-frame designs.

9. Characterizing the Fate of SARS-CoV-2 during Wastewater Treatment

Student Presenter: Theresa Passe, Environmental Engineering
Faculty Advisor: Dr. Jennifer Becker, CEGE

Introduction:

Responsible for the Covid-19 pandemic, SARS-CoV-2 virus is shed in feces by infected individuals and enters municipal wastewater streams. The main objective of the project is to track the levels of SARS-CoV-2 in wastewater as it undergoes treatment at municipal water resource recovery facilities (WRRFs) in the Upper Peninsula, Michigan. Quantification of viral levels throughout the wastewater treatment process will identify the optimal sampling location and the cause of the unexpected virus levels in the WRRF, as found in preliminary tests. Wastewater surveillance programs must obtain representative samples to help environmental regulators and health officials guide us through the pandemic.

Materials and Methods:

Wastewater and solid samples were collected at Portage Lake Water and Sewer Authority (PLWSA) and the Marquette Area Wastewater Treatment Facility (MAWTF, Marquette, MI) starting in May 2020, but the focus for the project are the weeks of November 2020 through January 2021. Wastewater and solids samples were collected from several locations throughout the WRRFs. Wastewater samples were thawed, concentrated, and extracted following the 4S method, as previously described [6]. Solid samples were extracted using the Qiagen Total RNA/Power Soil kit according to the manufacturer's instructions as previously modified [2]. A Nanodrop (ThermoFisher) spectrophotometer was used according to the manufacturer's instructions to quantify the abundance of RNA and characterize sample purity (measured as the ratio of sample absorbance at 260 nm to that at 280 nm or A260/A280) in undiluted and some diluted samples [2]. A StepOne Plus Real-Time (RT) PCR system (Applied Biosystems) was used to perform PCR (polymerase chain reaction) to detect and quantify the virus levels. Quality control methods included spiking the samples with target RNA and then analyzing three dilutions to determine if the dilutions resulted in the expected increase in the cycle threshold (Ct) values [6] (detect inhibition).

Results and Discussion:

A total of 5 and 11 wastewater samples from PLWSA and MAWTF, respectively, were extracted. There are 41 total PLWSA wastewater sample extracts since March 2020. A total of 9 and 11 solids samples from PLWSA and MAWTF, respectively, were extracted.

Comparison of the wastewater standard’s efficiency and R2 were within, or near, the ranges as previously described [3]. Little to no inhibition occurred in any of the wastewater samples for SARS-COV-2 standards, neither from MAWTF or PLWSA. Initial tests performed on the solid samples are more equivocal. High levels of RNA are present in the PLWSA solids, with lower levels present in the MAWTF samples. To gain a complete understanding of why the differences in the total RNA values occur between the treatment facilities, the composition of the solids from MAWTF versus PLWSA will be compared. Concentration and extraction of the wastewater and solid samples from MAWTF and PLWSA will continue through the chosen timeframe. Continued RT-qPCR with the appropriate dilution factor can commence once inhibition testing of the solids is complete. Then the quantification of the SARS-CoV-2 can then be determined, and ultimately, the mass balance for the treatment plants will be calculated.

10. Community Solar Policy Review

Student Presenter: Abigail Pettit, Sustainability Sciences and Society
Faculty Advisor: Dr. Richelle Winkler, Social Sciences

Introduction:
The research that I am conducting with Dr. Winkler relates to reviewing and evaluating community solar policies existing throughout the United States. In conjunction with research on existing policies, I am also looking into recent community solar house bills introduced to the Michigan House Energy Committee. This research is important because it helps to bring awareness to a topic that focuses on assisting low income communities. Community solar projects allow communities to band together to support renewable energy sustainability and can allow for better energy access.

Materials and Methods:
For my research, I am reading grey literature, college studies, and analysis papers of existing community solar projects and the policies that assisted in their start up. I am mainly focusing on evaluation and analysis papers to gain information on the outcomes of certain projects, as not all community solar policies work out for the best. By understanding the outcomes of other programs, I will be able to spread correct information about the policies being pushed in Michigan's legislature. While community solar projects can be started without state policies, I have been focusing on projects that have been formed because of said policies.

Results and Discussion:
I have just begun my research so it is not finished as of yet. There is an end goal, however, which is to complete a literature review of existing community solar policies. I am hoping, with the information provided within the literature review, I will be able to assist others and share information about the house bills brought to light by the Michigan House Energy Committee. Maybe even by the end of my research, I will be able to see the house bills passed.

11. Automatic Extraction of Coronary Arteries using Deep Learning in Invasive Coronary Angiograms

Student Presenter: Drew Pienta, Mechanical Engineering
Faculty Advisor: Dr. Weihua Zhou, College of Computing

Introduction:
Current deep-learning methods for locating the coronary arteries from images obtained via invasive coronary angiogram (ICA) can struggle to identify the varying feature sizes present in coronary arteries. Improving the feature receptivity of deep-learning models will allow for improved detection of both large and small coronary arteries, thus allowing for more accurate algorithmic detection of coronary artery disease (CAD).

Materials and Methods:
In this work, the application of a selective kernel (SK) module [1] is explored in conjunction with long short term memory (LSTM) module. The SK module is designed to achieve a learned receptive field as opposed to a standard convolution wherein the kernel size is fixed. By employing multiple concurrent kernel sizes and a learned selector, the SK module is capable of learning to detect features of different sizes in an efficient manner. A convolutional LSTM is proposed as a method to process the sequentially generated feature maps that are output by the SK/convolution modules at each level of the encoder. The outputs of the convolutional LSTM can then be used to replace the skip connections that are typical in semantic segmentation models. Additionally, deep supervision is explored as a method to improve model generalization and learning capability; especially important given the increased parameters that accompany the SK and LSTM modules.

Model training is performed using Keras with a TensorFlow backend with a realtime data augmentation system adding variation to the training process. The dataset used consists of 192 manually annotated ICA images [2].

Results and Discussion:
This research is ongoing; however, preliminary results show promise. Using the Sørensen–Dice coefficient as comparison metric, the current best score is 0.8899 [2]. The best Dice score achieved to date in this study is 0.8805 with a simple U-Net with SK modules replacing the standard convolutions. A standard U-Net model, by comparison, achieves a Dice score of 0.8654 [2]. It is anticipated that a Dice score >0.9000 will be attainable once the sum of each proposed improvement is implemented.

Further opportunities for improvement include the addition of a feature pyramid as proposed by Chen et al. [2], and the implementation of transfer learning for either individual parts or the entire model.

12. Purification and Characterization of a New Bioactive Compound from Plant

Student Presenter: Henry Roell, Chemistry
Faculty Advisor: Tarun K. Dam, Department of Chemistry / Health Research Institute

Introduction:
Plants species have provided researchers with bioactive compounds that have helped fend off and cure human diseases. However, as plants produce a variety of biomolecules along with the compound of interest, one must perform many steps of purification to isolate those that are desirable. The goal of this project was to understand the properties of a potentially pharmacologically relevant plant-based biomolecule, named Hemolysin X (HelyX). HelyX is proficient in its ability to destruct (lyse) red blood cells, cancer cells, and fungal cells. This property makes HelyX a potential lead compound for drug development.

Materials and Methods:
To investigate the binding property of HelyX, plate-based assays were performed by using HelyX and different ligands. The inhibitors used were TGB, ASF, beta-lactose, blood plasma, and lysed rabbit red blood cells. Plate assays were conducted with 96 - well round bottom plates. Rabbit erythrocytes were used to assay the lytic ability of HelyX. HelyX was extracted through both aqueous and organic solvent-based methods. After extraction, HelyX was purified by size-exclusion chromatography (Agilent 1260 Infinity II) and high performance liquid chromatography (MALDI-TOF Bruker Microflex LRF).

Results and Discussion:
HelyX proved extractable through both aqueous and organic solvent systems. HelyX still retained its lytic ability regardless of the solvent system used to extract the biomolecule. It was found that HelyX was also inhibited via blood plasma, and slightly inhibited by ASF, beta-lactose, and lysed red blood cells. TGB displayed no inhibition activity at all.

It was found that active HelyX samples typically resolved peaks around 1000 m/z -1200 m/z and 1800 m/z - 2200 m/z. This information will be useful in determining the structure of HelyX going forward. HelyX is a promising bioactive compound that can potentially be used as an anti-cancer agent.

13. Incremental Geometric Multi-Resolution Analysis

Student Presenter: Drew Rosales, Applied Math & Computer Engineering
Faculty Advisor: Ben Ong, Mathematics

Introduction:
Networks of sensors help to inform autonomous vehicles in the form of multi-dimensional data. Lots of data points are generated that are not easily interpreted, but low dimensional approximations can be found through a variety of methods. Approximation can allow businesses to make decisions and create automated predictive algorithms; e.g., for the advancement of protein folding, machine learning, and simulation of real-time physics. The poster will examine the adaptation of a method for constructing a low dimensional model of high dimensional data, geometric multi-resolution analysis (GMRA). The adaptation is to accommodate data added to the data set through streaming applications. The goal is to reduce the computational cost for finding the model for a dataset without the need for re-computation and reduction in sparsity.

Materials and Methods:
The research is conducted using sample data sets placed through a cover tree, a data structure that helps to organize high dimensional data based on nearest neighbor. GMRA requires the data set to be manifested into a tree composition with subsets that can have an affine approximation on each. GMRA utilizes this tree-like structure along with wavelets to construct the approximation. Our construction of these wavelets is through the singular value decomposition (SVD). The left and right singular vectors are used for the basis vectors of the approximation. The analysis of GMRA and the cover tree is modified and tested using Python and the corresponding NumPy library. First, verification of the current original GMRA paper using a cover tree is conducted along with slight changes to previously created MATLAB code. These changes are to allow for modification to the cover tree and GMRA structure for streaming applications.

Results and Discussion:
Research is currently ongoing, but the hope is to verify our research on the self-constructed data sets. A software pipeline that simulates data getting updated to the data set would also be a necessary step for verification. The approximation should also resemble our knowledge of common PDEs such as Laplace, wave equation, heat equation, and more using several regions.

14. Depolymerization of Polyester, Nylon, and Spandex in Batch Reactor System with Ammonium Hydroxide

Student Presenter: Elizabeth Schumann, Chemical Engineering
Faculty Advisor: Rebecca Ong, Chemical Engineering

Introduction:

In the textile industry, there is increasing usage of synthetic fabrics that pose recycling challenges. Developing chemical recycling strategies for these products is necessary to alleviate dependence on fossil fuels and contribute to a circular economy, where deconstructed waste plastics and textiles re-enter production streams at the raw material level [1]. Previously, the depolymerization of PET in ammonium hydroxide to produce terephthalamide, terephthalic acid, and ethylene glycol was optimized in a batch reactor system. The goal of this experimentation is to assess whether this process has broader applicability in the deconstruction of synthetic fabrics such as polyester, nylon, and spandex.

Materials and Methods:

The fabric sample types tested in the depolymerization experiments are as follows: 100% polyester, 100% nylon, 92% nylon - 8% spandex (polyurethane), 85% polyester - 5% spandex, and 90% polyester - 10% spandex. Deconstruction of the plastic was conducted using ammonium hydroxide in a small horizontal batch reactor, which was heated and held at the desired reactor conditions with heating tape and a temperature controller. The reaction was conducted at 240℃ for 60 minutes with 10% NH_4OH and 0.25 g fabric/mL NH_4OH. The processed samples were vacuum filtered and oven dried to determine the final mass of the solids remaining after deconstruction, from which the solubilization yield can be calculated.

Results and Discussion:

This research is ongoing. Thus far, experimentation has determined that polyester fabric can be successfully depolymerized in the same batch reactor conditions used to optimize deconstruction of PET pellets and waste plastic bottles, and the testing of the remaining fabric types will be executed. The expected results include a comparison of yields from the depolymerization of five different fabric types. Work will be done to assess optimum reaction conditions for these samples, and the products of the deconstruction reactions will be analyzed if methodology is available.

15. Understanding the Impact of Different Virus Purification Techniques on Virus Physicochemical Properties

Student Presenter: Ellie Sempek, Biochemistry and Molecular Biology
Faculty Advisor: Dr. Caryn Heldt, Department of Chemical Engineering

Introduction:

Current virus purification methods used in the vaccine industry are developed empirically. Little is known about the physicochemical properties of viruses; this knowledge is needed to develop more scientifically driven purification processes. Therefore, to improve on this process, the physicochemical properties that affect viral recovery and purity must be determined. We have developed a single-particle method to measure these properties and we want to use it to understand how different purification methods change the surface properties of a virus.

Materials and Methods:

Four different methods of purification were performed in triplicates. The methods used were dialysis, which employs a cellulose acetate semi permeable membrane; anion-exchange (AEX) chromatography, which uses a positively charged filter to attract negatively charged molecules; polyethylene glycol (PEG) precipitation, which precipitates the virus out of its impure solution; and ultracentrifugation, which separates the virus through a density gradient at high speeds. After purification, MTT assay was performed on the purified viruses and compared with the impure viruses and physicochemical properties. This gives the viral recovery after purification.

To determine the purity of the virus after purification, a Bradford assay and sodium dodecyl sulfate–polyacrylamide gel electrophoresis (SDS-PAGE) were performed. In a Bradford assay, purified samples are serially diluted and placed into a 96-well plate for colorimetric assessment of protein content. SDS-PAGE offers a visualization of the purified protein by staining a gel run with the purified samples. These analyses allow the extent of purification to be determined and therefore gives key information in the comparison of techniques.

Results and Discussion:

The MTT assay that gives the titer of the virus samples is not complete for BVDV yet. For PPV, dialysis and PEG precipitation have similar recovery percentages of 80.8% and 71.3%, respectively. AEX filtration data is not completed, yet the ultracentrifugation percentage is 43.5%. These results indicate that dialysis and PEG precipitation may have produced high-titer viruses with less contaminants, the goal of purification processes. However, each method must be examined for purity as these results paired with titer data will provide a full understanding of the methods.

The percentage of protein left in the purified samples was determined for each method using the Bradford assay data. Initial BVDV results and PPV results indicate that ultracentrifugation purified the virus to the greatest extent, having less than one percent protein left. This means that ultracentrifugation is the best method in terms of the extent of purification. Initial SDS-PAGE gels have been successful in the visualization of the purification.

Further research must be performed to determine how each purification method affects the surface properties of the virus. This information will aid in indicating the most favorable purification method in combination with the recovery and purity data.

16. The Role of Orexin A in Salt-Sensitive Hypertension

Student Presenter: Lilly Van Loon, Medical Laboratory Science
Faculty Advisor: Zhiying Shan, Kinesiology and Integrative Physiology

Introduction:
Orexin A (OXA) is a neuropeptide, produced in a small group of lateral hypothalamic (LH) neurons, with numerous physiological functions including blood pressure regulation. Orexin A exerts its function by binding to orexin 1 receptors (OX1R) and 2 receptors (OX2R). Hyperactivity of orexin system has been found in several form of HTN including SSHTN, and blockage of orexin A receptors in the brain attenuated HTN, demonstrating the potential role of brain orexin system on BP regulation. However, the role of orexin system in periphery on the development and maintenance of SSHTN has not been determined.

Aim1. Determine if a high-salt diet increases activity of peripheral orexin system in DSS rats.

Aim 2. Determine if high-salt diet induced increase in peripheral orexin system has a sex difference.

Materials and Methods:
We will be using Dahl-Salt Sensitive (DSS) rats and measuring OXR protein levels in the adrenal glands, heart, and kidneys using Western Blot. Half the DSS rats were fed with a normal diet and half with a high salt diet. Blood pressure was recorded for the female rats using CODA system.

Results and Discussion:
We observed that DSS female rats on the high salt diet had an increasingly higher blood pressure than the DSS female rats on the normal diet. We have isolated the proteins from the tissues of the DSS female and male rats. This research is ongoing and Western Blot data will be collected and analyzed in February and March to complete this project.

17. Seed Germination Patterns in an Experimental Grassland and Plant Genome Size

Student Presenter: Brianna Wieferich, Applied Ecology and Environmental Science with a Plant Genetics focus
Faculty Advisor: Erika Hersch-Green, Biology Department

Introduction:

Anthropogenic eutrophication and landscape modifications/disturbances can have major impacts on species composition, productivity, and biodiversity patterns. We established a field site in collaboration with Nutrient Network, a global, collaborative research network that investigates the role of soil nutrients and ecological disturbances on plant productivity-diversity relationships. In addition to the goals of this network, we are also investigating whether plant genome size interacts with the nutrient and disturbance treatments. This may influence the structuring and change of multi-species communities. Here, we are investigating the effect of plant genome size (GS) on seed bank germination dynamics.

Materials and Methods:

In summer 2021 at our experimental field site, we set up four blocks, each containing eight plots which were assigned one of the eight treatments of varying nutrients and disturbance. We collected sixteen total 10x10x5 cm deep soil-seed-bank samples in mid-May, which was before treatments were administered. Each soil-seed-bank sample was air dried for 48 hours and then sieved to remove plant material, rocks, and insects. Each cleaned soil sample was divided into the top layer of two germination trays lined with gardening fabric and a 5-cm layer of a vermiculite–perlite soil media mix. Seed-bank trays were watered and monitored regularly. Upon the germination of a seedling, the date of germination was recorded, and each seedling was marked with a date indicator (e.g., toothpick of various colors and patterns). Species were identified by repotting randomly selected seedlings and growing them to maturity in individual pots. Once identified, the first germination date, last germination date, and total number of seedlings germinated were recorded for each species. Using an Accuri 6C+ flow cytometer, the genome size (2C DNA content) of each species was calculated.

Results and Discussion:

This data is representative of the “pre-treatment” year of this experiment, where seed-soil-bank surveys were taken prior to the addition of nutrient and/or disturbance treatments. This data is especially important for this multi-year study because it will serve as a comparative control for future years’ data. We used ANCOVA models to determine the effect of plant genome size (2C DNA content) and treatment plot on the number of seedlings emerging (log transformed) and germination length (square-root transformed). We found that on average more seedlings emerged of plants with larger genomes ($F_{1\ 1,164}=17.9$, $P<0.001$). The interaction between plant genome size and plot identity had no effect on the length of germination which is a good indicator for data representing “pre-treatment.” In this study, the observation of smaller-genome-sized plants germinating first could be due to these plants being able to more readily allocate resources and energy toward growth rather than the maintenance and support of a large genome. In observation of this research long term, nutrient and disturbance treatments may influence germination patterns discussed. This may provide a better understanding of how communities recover from nutrient runoff and disturbance.

18. Quantum-Chemical Explorations into the Nucleation Mechanism of the 2:1 HMX/CL-20 Co-Crystal through the Analysis of Small Structural Oligomers

Student Presenter: Andrew Zampaloni, Chemistry
Faculty Advisor: Dr. Loredana Valenzano-Slough, Department of Chemistry

Introduction:

In this project, several density-functional-theory (DFT) approximations were used to investigate the interactions between molecules in the 2:1 co-crystal of CL-20 ((CH)6N6(NO2)6) and HMX ((CH2)4N4(NO2)4) explosives. The co-crystal, first synthesized in 2012 at the University of Michigan by Matzger's group, showed to be unique in its capability of retaining both the shock stability of HMX and the energetic power of CL-20. The stability of the material is particularly interesting and is at the origin of this project, which aims at the analysis of the complexation mechanism of the molecules forming the nucleation seed of the co-crystal.

Materials and Methods:

The Gaussian 16 quantum chemical computational program was adopted to model the electronic environment of the molecules in the co-crystalline structure. The B3LYP-D3 Hamiltonian was heavily used to conduct the presented calculations in conjunction with numerous basis sets (6-311G, 6-311G(d,p), aug-cc-pVDZ).
The intermolecular interactions between the various oligomers were described by scanning the linear distance between the centers of mass of the molecules. The various potential energy surfaces (PESs) so obtained, were then further examined to rank the relative stability of the oligomeric molecular moieties and determine the equilibrium geometries and equilibrium energies via numerical fitting with respect to third-order polynomials. Specifically, the following dimeric molecular moieties were analyzed: three different CL-20-CL-20 dimers, three HMX-HMX dimers, and three CL20-HMX mixed dimers. Results were corrected to account for the effect of the basis set superposition error (BSSE) and were obtained under vacuum.

Results and Discussion:

Equilibrium energy values float around -14 kJ/mol, with distances between structures falling at about 9 Å. Considering the BSSE and non-BSSE results, there is an appreciable energy difference between the two scenarios, specifically at the equilibrium geometry and at shorter distances, as expected. For the CL-20 dimers, initial calculations reveal a difference of ~6 kJ/mol between the BSSE corrected and non-corrected results.
Calculations performed so far on the HMX dimers reveal significantly more variation between the several complexes, up to ~ 10 kJ/mol; future calculations are expected to reveal more quantitative information about these structures. Overall, the HMX dimers appear to be more stable than CL-20 dimers, the former showing equilibrium energies ranging from -21 kJ/mol to -24 kJ/mol. This hints at HMX's importance in the nucleation and stability of the co-crystal.
Mixed dimers of HMX/CL-20 were also examined. Initial explorations revealed a variety of results, from the most stable interaction of any of the dimers—equilibrium energy > -30 kJ/mol—to one of the weaker, -9 kJ/mol. Further calculations are expected to not only refine these trends but also to allow for an analysis of other mixed dimers within the co-crystal structure and more complex oligomers such as trimers.

19. Cryptic Equatoguinean Birds: DNA Barcoding and New Identification Techniques

Student Presenter: Claudia Zinser, Wildlife Ecology and Management
Faculty Advisor: Kristin Brzeski, Brzeski Conservation Genetics Lab

Introduction:
Several bird species from Equatorial Guinea are cryptic and difficult to confidently identify down to species, including the genera Phyllastrephus, Illadopsis, and Criniger. Working with Equatoguinean bird samples provided to Drs. Brzeski and Wolfe's program, the Biodiversity Initiative, I will identify birds of the aforementioned genera down to species, as well as analyze the data collected on the physical measurements of the birds to find any traits the different species possess to make identification "in the hand" easier.

Materials and Methods:
DNA from 36 avian blood samples from genera Phyllastrephus, Illadopsis, and Criniger collected from Equatorial Guinea were extracted. Samples were then identified down to species using DNA barcoding by amplifying a portion of the ND2 and cyt-b genes using PCR. Primers used are based on those used by Roy (1997). After PCR, DNA was sequenced and analyzed for species identification. Using this identification, we will be able to go back and compare the different physical characteristics (wing chord, weight, etc.) of the different sampled birds to see if there is any significant difference of these traits between difficult to differentiate species, so identification in the hand is easier and more accurate.

Results and Discussion:
Identifying these samples down to species will help to create a more robust database for the Biodiversity Initiative, which will assist in gathering more data on these understudied birds. Additionally, by developing new identification techniques for these birds, data collected both by the Biodiversity Initiative and by other researchers working in the Afrotropics will be more accurate and less resource intense, as researchers will not have to use genetics for identification as often.