AGRICULTURAL SCIENCE

Milorganite fertilizer expected to facilitiate copmarable grwoth of arugala, kale, and spinach to organic fertilizers

Aaron Cook, Plant Sciences & Plant Pathology; Kaitlyn Weber, Plant Sciences and Plant Pathology; Braden Denler, Plant Sciences and Plant Pathology

Mentor(s): Clair Luby, Plant Sciences & Plant Pathology

Milorganite is a biosolid fertilizer made up of kiln dried pelleted microbes that have consumed treated sewage sludge. They are rich in nitrogen and safe for consumer use, however they are not used as widely as other commercial fertilizers. The process of creating milorganite could potentially be implemented into any sewage plant and creates an opportunity for local, environmentally friendly fertilizer; cutting down on travel emissions, synthetic fertilizer, and waste. Milorganite is used in turf management and home gardens but little research has been done on its effectiveness on common greenhouse crops. As part of our spring 2025 senior horticulture capstone we are testing the efficiency of milorganite fertilizer against other commercial fertilizers. It is expected that the leafy green varieties that have been given milorganite will have a comparable rate of growth and amount of growth, (height and width), to the greens using commercial organic fertilizer. We are testing three different fertilizers with equivalent nitrogen application rates on three varieties of leafy greens; arugula, spinach, and kale. These species are being grown because they respond well to fertilizer and are fast growing, which produce easily observable results. If milorganite produces plants with similar growth rates to the other fertilizers, this could indicate wider future usage of the fertilizer; reducing transport emissions and fertilizer costs for growers.

Bean to bar to bin - connecting the life stories of cocoa with farmers' market consumers to promote cocoa shell upcycling

Chidimma Ifeh, Health & Human Development; Bruce Barnhart, Art; Helen Agu, Food Science and Technology

Mentor(s): Wan-Yuan Kuo, Health & Human Development

Up to 30% of cocoa beans are removed as cocoa shells in chocolate making. With a global 5 million tons of cocoa produced annually, up to 1.5 million tons of cocoa shells are generated each year despite the richness of cocoa shells in antioxidants, which have equal amounts as compared to dark chocolate—the shells are underutilized in the food industry. Major chocolate manufacturers have made strides in creating non-food products like the

"Bean Board" product display by utilizing cocoa shells. The project involved documenting valuable bean-to-bar practices from our partnering chocolatiers and consumer feedback in Montana. While our Nigerian partnering chocolatiers fully utilized the cocoa shells in making non-food products such as shoe polish and pig feed, the Montana chocolatiers lacked awareness regarding cocoa shell utilization beyond composting or fertilizer. The findings inspired us to believe that proper upcycling education for chocolatiers and consumers in the USA can be a practical approach to addressing cocoa shell waste. Two cocoa shell food products, a chocolate cookie and a spice mix demonstrating cocoa shell upcycling potentials, were developed. Visual designs in product packaging and educational posters to promote cocoa shell upcycling among farmers' market consumers and food science students were created. Consumers that tasted the products gave high overall liking scores to the chocolate cookies, while individuals that liked spicy food preferred the spic mix applied to popcorn. Our project spans diverse audiences and mediums to inspire cocoa shell up-cycling and bean-to-bar practices to promote a holistic chocolate value chain.

Acknowledgements: College of Education Health and Human Development

Effects of Common Household Solutions on Bloom Duration of Narcissus spp.

Haley Kaplan, Plant Sciences & Plant Pathology and Sierra Kurth, Plant Sciences and Plant Pathology

Mentor(s): Claire Luby, Plant Sciences & Plant Pathology

Understanding how to promote longer bloom times is of interest to both producers and consumers in the floral industry. While many studies support the use of germicides, plant hormones, and sucrose solutions to extend bloom longevity in cut flowers, less is known about whether similar treatments can influence flowering duration in intact aqueous grown bulbs. This senior capstone study investigates the effects of common household solutions on the bloom duration of intact Narcissus spp. bulbs. Five treatments were selected based on past research and consumer accessibility: ethanol, liquid indole-3-butyric acid (IBA), bleach, vinegar, and a control of tap water. This study was conducted in a greenhouse at Montana State University in spring 2025. Key measurements included plant height, leaf count, and the number of days until 50% floral senescence. Data is analyzed using ANOVA to assess statistical significance between treatments. Results will offer practical insights into whether household solutions can effectively prolong bloom time in Narcissus spp., with potential implications for home gardeners and the floral industry. If successful, this

study could highlight cost-efficient alternatives to commercial products aimed at enhancing floral longevity.

Barley Stripe Mosaic Virus-Mediated Assays for functional genomics in Wild Oats (Avena fatua)

Breonna Lucas, Chemistry & Biochemistry

Mentor(s): Li Huang, Plant Sciences & Plant Pathology

Herbicide-resistant weeds, particularly wild oat (Avena fatua), pose significant challenges to global agriculture by reducing crop yields and increasing production costs, with non-target site resistance (NTSR) enabling weeds to evade herbicide action without direct target-site mutations; however, the molecular mechanisms driving this resistance remain poorly understood. This study aims to establish a Virus-Induced Gene Silencing (VIGS) system using Barley Stripe Mosaic Virus (BSMV) in Avena species, including Avena fatua and Avena sativa, where VIGS—a widely used functional genomics tool for transient gene knockdown—has not yet been successfully applied. The research will evaluate the feasibility of BSMV-mediated VIGS by silencing phytoene desaturase (PDS), a reporter gene whose suppression produces a visible photobleaching phenotype, while employing quantitative RT-PCR for gene expression analysis to assess knockdown effectiveness and testing optimal target fragment sizes to improve silencing efficiency. Additionally, the study will investigate whether BSMV-based expression systems can serve as a platform for future overexpression studies of stress-related genes linked to herbicide resistance. By developing a reliable BSMV-VIGS protocol for wild oats, this work will provide a valuable tool for exploring genes involved in herbicide resistance and other agronomically important traits, potentially yielding novel insights into the molecular basis of NTSR and supporting broader efforts in weed management and plant biotechnology.

Acknowledgements: USP - Undergraduate Scholars Program

How can California winegrape growers manage their vineyards for a changing climate?

Madeleine Martinelli, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

Grapevines are a rich part of California’s heritage and have significant contributions to the state’s economy. But with warmer temperatures caused by greenhouse gas emissions, California’s wine-growing regions are threatened with extinction. This rise in temperature is changing the chemistry of grape varieties and their distinct characteristics that produce

premium, sought-after wines. Climate policies that promote sustainable agricultural practices will benefit growers in reducing further warming while policies that encourage fossil fuel consumption are likely to worsen the challenges that winegrape growers face. For this study, the objectives were to construct a synthesis on how California vineyards are responding to climate change and provide solutions for growers on how to mitigate these impacts. Based on the results found in this study, growers will have to alter their cultivation practices to continue producing winegrapes in California. Enhancing soil health, improving water use efficiency, specific row orientation, and implementing IPM approaches are the first modes of action but switching to more climate-suitable grape varieties or genome editing may be necessary for the future of California's winegrape heritage.

Acknowledgements: PSCI448

Rapid Generation Advance in Winter Wheat

Duncan Pantos, Plant Sciences & Plant Pathology

Mentor(s): Suchismita Mondal, Plant Sciences & Plant Pathology

Winter Wheat has a very long generation time relative to other cereal crops because of the long vernalization time associated with it to initiate flowering. This project is twofold, the first part focuses on developing a screening process to test for stem solidness under specific controlled lighting conditions. By developing a screening process, it is possible to determine which lines are most suitable for different environments around the state of Montana, factoring in Wheat Stem Sawfly infestation rates. The other aspect to this project deals with shortening the vernalization time that Winter Wheat requires in order to increase the number of generations grown each year and advance new varieties faster than has been previously possible. Growing lines in the Plant Growth Center under speed vernalization treatments allows for the F1-F5 breeding process to occur faster, which then allows for the overall breeding pipeline process to be shortened by 2-3 years, allowing for faster varietal release.

Evaluating Cyber Threats and Mitigation Techniques for Smart Farming Technologies

Jessica Stevens, Animal & Range Sciences

Mentor(s): Clemente Izurieta and Yvette Hastings, Computer Science

Smart farming technologies, such as automated irrigation systems, GPS-guided equipment, and livestock monitoring technologies, have revolutionized agriculture,

improving the efficiency, sustainability, and productivity of farming practices. However, these technologies have introduced significant cybersecurity vulnerabilities, resulting in ransomware attacks and data breaches. Cyberattacks on these systems have substantial financial losses, with major agricultural companies experiencing millions of dollars in damages due to operational shutdowns and data theft. Additionally, these attacks have disrupted food production and supply chains, leaving the world population at risk of contaminated food sources and increased food insecurity. Due to a lack of cybersecurity awareness among farmers and limited industry-specific protective measures, the risks of cyberattacks have increased. Through a comprehensive literature review, this study presents a detailed analysis of cyber threats in agriculture, visualizing attack frequency, industry impact, and at-risk technologies. This study also presents mitigation strategies, such as enhanced cybersecurity training, multi-factor authentication, and government-supported security initiatives, which have proven effective in reducing threats. The results of this study emphasize the urgent need for cybersecurity integration within the sector to safeguard food security and economic stability.

Acknowledgements: VICEROY Northwest Institute for Cybersecurity Education and Research (CySER), Air Force Research Laboratory, and the Griffiss Institute

Camelina sativa Mutant Identification and Growth Rate Analysis

Brody Sturgis, Plant Sciences & Plant Pathology

Mentor(s): Jennifer Lachowiec, Plant Sciences & Plant Pathology

Camelina sativa (Camelina) is an oilseed crop desired primarily for the production of biodiesels. Camelina currently does not have high yields compared to other similar oilseed crops like canola, but camelina oil has more potential for modification by breeding and genetic engineering due to it not having undergone as much domestication by breeders throughout the 19th and 20th century. Two main factors currently hinder camelina's development into a more prominent crop: 1) its uneven growth rate across individual plants, making management and harvest difficult for producers, 2) its small seed size and associated low yields. My project focuses on both of these aspects. First to characterize growth rates, I am analyzing daily images of 100 varieties of camelina during their first week of growth to measure the growth rates to inform future breeding efforts for more consistent growth rates. The second part of my research is involving a gene attributed to trehalose biosynthesis the controls the production of trehalose-phosphate. Trehalose-6-phosphatase was found in a mapping study to be a candidate gene that may be involved in the control for seed size, which would increase the yield and the ease of harvest

simultaneously. To determine if this candidate gene indeed affects seed size, CRISPR-Cas9 knock outs were created, and their seed sizes will be analyzed. This project focuses on performing PCR and Sanger sequencing and their associated analyses, to determine if they knock outs are homozygous or heterozygous.

Acknowledgements: Undergraduate Scholars Program (USP), U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research, Genomic Science Program Award No. DE-SC0021369

ARTS AND MUSIC

Portraits of a Planet in Crisis

Amelia DiGiano, Film & Photography

Mentor(s): Ian van Coller, Film & Photography

The climate crisis makes my future, and the future of humanity, feel alarmingly precarious. I started to develop this series as a way of documenting this sensation, the chronic fear associated with climate change. But as I began approaching people to include in the project, it became clear that we do not all conceptualize climate change in the same way. To some it feels existential, but to others it feels fabricated and to many, it feels entirely beyond human control. Portraits of a Planet in Crisis explores and documents this broad spectrum of human stories that transpire within stories of environmental devastation.

Acknowledgements: USP - Undergraduate Scholars Program, Opportunity Grant - College of Arts and Architecture

Stumbling into greatness: what we can learn about community design from an unlikely ballroom in Detroit

Timothy Dubler, Architecture and Jordan Zignego, Architecture

Mentor(s): Jordan Zignego, Architecture

With today's ever-digitizing reality, architects must assume the responsibility of creating designs that improve the communities that inhabit them. Through a cultural-architectural lens, this paper will analyze the success of a surprisingly prime example of community design, the Grande Ballroom (pronounced Gran-dee) in Detroit, Michigan. Through a series of chance circumstances mixed with charismatic people and the cataclysmic events of the 1960s, the Grande Ballroom grew to hold legendary status in the world of rock music.

Oftentimes, the Grande Ballroom receives praise for hosting young rock stars like the Who and Led Zeppelin, but it was the ballroom's circulation, acoustic design, and site context that allowed for community interaction, supporting the musicians in their rise into fame. The building's current conditions are beyond repair, but the cultural impacts of the Grande Ballroom still reverberate through the community of Detroit and quietly offer important insights into community design for the modern architect.

Acknowledgements: Montana State University College of Arts and Architecture, Architecture Department (Independent Study)

Securing Image Metadata: Cyber Security Risk Mitigation in Digital Photography

Abby Jones

Mentor(s): Evette Hastings, Computer Science

With the growing use of digital photography and image-sharing platforms, metadata, such as geolocation, timestamps, device information, and editing history, is vital in enhancing the user experience. However, this information can be misused by cybercriminals for malicious activities like location tracking, identity theft, and unauthorized data mining. Photographers and other digital device users need to be aware of these malicious activities so that they can employ risk mitigation strategies to protect sensitive information. For this study, I utilize a mixed-methods approach to investigate the vast information obtained from metadata and how it is used to track individuals or extract personal information for malicious intent. This research also explores how specific mitigation strategies can help secure image metadata. These strategies include data encryption, image hashing, and improved platform security practices. With this knowledge, photographers and other digital device users can prevent practical metadata-related cybersecurity risks in an increasingly interconnected digital world.

Women Who Design

Sasha Maguire, Art

Mentor(s): William Culpepper, Art

Women Who Design is a research project dedicated to amplifying the stories, challenges, and achievements of women designers in Bozeman. Through interviews, visual storytelling,

and curated work samples, this project highlights their creative processes and showcases the unique contributions of local designers, shedding light on their impact within both the industry and the broader community. The primary deliverables for this project include a series of five individual zines—small, independently published magazines—each focused on a featured designer. These zines serve as an intimate and visually engaging medium to present their narratives, work, and design philosophies. Additionally, a website will offer an archive of these stories digitally, broadening the reach of this project beyond Bozeman and allowing for future expansion. The branding and structure of Women Who Design are intentionally designed for scalability, with plans to replicate this research in Maine and other locations where women designers' stories remain underrepresented. By documenting and sharing these stories, Women Who Design seeks to foster greater recognition and appreciation for women in the design field while creating a lasting resource for aspiring designers. This project celebrates the individuals featured and contributes to a broader conversation about equity, representation, and inclusivity in design.

Acknowledgements: USP - Undergraduate Scholars Program

Emphasizing Human Design in an Increasingly A.I. Reliant Society

Jason Rigg, Art

Mentor(s): William Culpepper, Art and Jordan Zignego, Architecture

Design shapes how we communicate, connect, and understand the world. In a society becoming increasingly reliant on artificial intelligence (AI), designers are in jeopardy of losing work to technology that lacks the empathy it takes to create impactful visual communication. This research, led by senior graphic design student, Jason Rigg, focuses on elevating design aesthetics through education, training, and hands-on work. This project is centered on connecting senior architecture students in the Montana Community Design Center with a graphic designer to develop a deeper understanding of the importance of typography principles, effective layout, and visual hierarchy—essential components of professional design practice. These architecture students were exposed to methods that balance creativity and clarity by integrating historical and contemporary design practices to emphasize the human characteristics of their work. A prominent outcome of the research is the creation of a flexible book design and publication template for current and future students in the Community Design Center. This template was created through the implementation of hands-on design sessions, educational presentations, and professional production techniques to further the students' understanding of design principles. Although AI tools offer new ways to generate visual

content, this research emphasizes that creativity, critical thinking, and cultural understanding remain essential to great design.By focusing on collaborative, human-centered processes, this project highlights the ever lasting value of thoughtful design in creating work that is both effective and empathetic.

BIOCHEMISTRY

Utilizing Mass Spectrometry to Elucidate Acetone Carboxylase Dynamics

Ethan Hasenoehrl, Chemistry & Biochemistry

Mentor(s): Brian Bothner, Chemistry & Biochemistry

Acetone is the most widely used organic solvent both domestically and industrially. Since the development of the Hock process in the 1940s, acetone has increasingly shown to be a cheap and effective solvent. However, with the rise of acetone use, its ecological pollution of acetone has been a progressively difficult challenge to overcome. Acetone is an organic molecule meaning that disposal requires either incineration or burying the solvent in landfills. The enzyme acetone carboxylase isolated from xanthobacter autotrophicus (AC) catalyzes the conversion of acetone and bicarbonate into product acetoacetate thereby allowing the bacteria to incorporate acetone into its biomass. This reaction is achieved by first converting acetone and bicarbonate into the highly reactive intermediates phosphoenolacetone and carboxyphosphate at phosphorylation site. These two molecules then travel 40 Å to a Mn (II) redox center, allowing for the completion of catalysis and the release of acetoacetate product. Previous studies from our research team have shown that the beta subunit of AC undergoes conformational change. During this change, a channel opens between the Mn (II) redox center and the ATP binding sites to facilitate movement of the reaction intermediates. Our research group has utilized both hydrogen-deuterium exchange mass spectrometry and native mass spectrometry to better understand the dynamics of AC. These probes have furthered the understanding that we have of this protein and how it may be used in acetone bioremediation.

Acknowledgements: INBRE - IDeA Network for Biomedical Research Excellence, USP - Undergraduate Scholars Program

Evaluating Succinate Supplementation for Potential Metabolic Benefits for Familial Dysautonomia Mouse Model

Danielle Horan, Chemistry & Biochemistry

Mentor(s): Valérie Copié, Chemistry & Biochemistry

Neurodegenerative diseases are widespread globally and are characterized by the loss of neuronal function and degradation of neurons in the central or peripheral nervous system. Familial dysautonomia (FD) is a rare disease that encompasses both neurodevelopmental and neurodegenerative components. Individuals with FD present a range of symptoms, including gastrointestinal dysfunction, progressive vision loss, and pain and temperature deficits. FD is associated with significant energy (ATP) deficits, with reduced retinal succinate levels observed in some FD mouse models. As a key tricarboxylic acid (TCA) cycle intermediate, succinate supports (ATP) production through the coupled processes of electron transfer from Complex 2 (succinate dehydrogenase) to Complex 3 of the electron transport chain (ETC). While ETC Complex 1 and Complex 4 show dysfunction in FD patient muscle, Complex 2 and Complex 3 remain fully functional. Thus, we hypothesize that succinate supplementation could enhance ATP synthesis by driving electron transport through Complexes 2 and 3 of the ETC, thereby improving ETC-mediated ATP production. This research investigated the potential metabolic benefits of succinate supplementation to improve FD hallmarks using an Elp1 LoxP/LoxP mouse line (FD mice) that recapitulates hallmarks of the disease. One-dimensional (1D) proton (1H) Nuclear Magnetic Resonance (NMR) spectroscopy was employed to quantify changes in polar metabolites from liver samples of succinate-treated FD mice and control mice. The resulting metabolite concentrations were analyzed using both univariate and multivariate statistical approaches using MetaboAnalyst. The findings indicated subtle differences in metabolite concentrations between FD and control groups.

Acknowledgements: USP - Undergraduate Scholars Program, INBRE - IDeA Network for Biomedical Research Excellence

Unraveling Oxidative Stress Pathways in Psychrobacter cryohalolentis: Insights from Silica Induced Metabolic Changes

Nicole Krysiak, Chemistry & Biochemistry; Markus Dieser, Chemical & Biological Engineering; Heidi Smith, Microbiology & Immunology

Mentor(s): Christine Foreman, Center for Biofilm Engineering and Brian Bothner, Chemistry & Biochemistry

A guiding principle of Astrobiology is the search for life on other worlds. To achieve this goal, research on Earth's moon, Mars, and icy moons (such as Europa and Enceladus) has begun and much has been learned. NASA has created a "Roadmap" describing the characteristics believed necessary for extraterrestrial-life to be possible. The icy moons of

the outer solar system are leading candidates for this Astrobiology exploration. NASA's Cassini satellite collected a wealth of information about Enceladus, by measuring water vapor, ice grains, salt, and organic compounds shot through plumes on the surface of the icy moon. With this information scientists have made predictions about the environmental conditions present on Enceladus. Cassini found evidence of silica, which may indicate the possibility of hydrothermal vents in the subsurface ocean below the icy crust. In this research, I investigate the ability of Psychrobacter cryohalolentis, isolated from Earth's polar regions, to grow under simulated Enceladus-like chemical conditions. These microorganisms are exposed to different concentrations of silica that may be found on Enceladus to determine under which set of conditions life could be possible. Bacterial activity is determined through the incorporation of isotopic labels, specifically heavy water (D2O), using Raman Spectroscopy. Metabolic adaptations are measured through comparative metabolic analyses using Liquid Chromatography Mass Spectrometry (LCMS). This research aims to provide supporting evidence that life is possible under the geochemical conditions present on Enceladus.

Acknowledgements: MSGC - Montana Space Grant Consortium

Metabolomic Analysis of Water-Soluble Metabolites Extracted from Mouse Liver Tissue Following Treatments in Wilson Disease: Identifying Diagnostic Markers of Treatment Efficacy and Impacted Metabolic Pathways

Linnea Lake, Chemistry & Biochemistry

Mentor(s): Valérie Copié, Chemistry & Biochemistry

Wilson disease is a recessive disorder caused by mutations in the ATP7B gene, which codes for a copper transporter protein. ATP7B mutations lead to abnormal copper transport and deleterious copper accumulation in various organs. Without treatment, individuals with Wilson disease typically have a life expectancy of only 40 years. Two potential treatments include tetrathiomolybdate (TTM) and zinc acetate. TTM binds free copper in the bloodstream, facilitating copper excretion through the urine, while zinc acetate works by inhibiting copper absorption in the gut by binding to copper uptake receptors. My research investigates the metabolite alterations experienced by ATP7B knockout (Wilson disease) mice compared to healthy littermates, treated with either TTM, zinc, or neither as a control. The goal is to assess how treatment affects the mice's metabolism and identify metabolic pathways that are impacted by treatment. Knowledge gained from these studies could provide potential diagnostic markers of Wilson disease,

which, in the long term, could potentially be used to guide the development of new or more effective therapies.

Acknowledgements: USP - Undergraduate Scholars Program, INBRE - IDeA Network for Biomedical Research Excellence

C2-Selective Amination of 2,4-Dihalopyrimidines

Daniel Lanske, Microbiology & Cell Biology and Connor Uter, Biochemistry

Mentor(s): Oliver Jackson, Chemistry & Biochemistry and Sharon Neufeldt, Chemistry & Biochemistry

Cross-coupling reactions connect two organic fragments using a transition metal catalyst. They are widely used in medicinal chemistry and drug discovery, allowing for late-stage functionalization of complex molecules. One class of interest is pyrimidines, a common scaffold in a broad range of pharmaceutical drugs and natural products. Their structural versatility and ability to interact with biological targets make them essential in drug design, contributing to a wide range of therapeutic applications, including cardiovascular, infectious diseases, and hematological treatments. Despite their widespread use, 2,4-dihalopyrimidines preferentially react at the C4 position over the C2 in both cross-coupling and nucleophilic aromatic substitution (SNAr) reactions. Development of a robust cross-coupling method for selective functionalization at the C2 site would enable access to new drug candidates and improved production of current drug molecules. Herein, we report that a palladium catalyst supported by a bulky ligand uniquely affects C2-selective cross-coupling of 2,4-dichloropyrimidines with amines. This reaction represents the first instance of selective C—N cross-coupling at the C2-position of an unsubstituted 2,4-dihalopyrimidine. Selectivity is high with most aniline derivatives, and the reaction is also effective with substituted dichloropyrimidines, demonstrating wide applications for this reaction sequence. Future work will consist of the synthesis of biorelevant molecules using our C2-selective aminated product, demonstrating the possible impacts of this new methodology.

Structure-Fuction Studies of a Ferritin-like Fusion Encapsulin from Saccharolobus Solfataricus

Jesse Petersen, Chemistry & Biochemistry; Alexander Charbonneau, Chemistry and Biochemistry; J Gentry, Chemistry and Biochemistry; Colin Gauvin; Chemistry and Biochemistry, Brian Bothner, Chemistry & Biochemistry

Mentor(s): Martin Lawrence, Chemistry & Biochemistry

During proteomic studies on the viral infection of Saccharolobus Solfataricus, a Crenarchaeote native to Yellowstone, a virus-like particle (vlp) was characterized as an archaeal provirus. This was due in part to sequence homology of its major capsid protein with a vlp-forming protein from Pyrococcus Furiosus that exhibits the HK-97 major capsid fold used by many archaeal and bacterial viruses. Recently the function and identity of this provirus was reconsidered due to the discovery of encapsulins, HK-97-based organelles found in many bacteria and archaea that assist with redox homeostasis via various classes of cargo protein loaded into their interior. To more thoroughly understand the nature of this putative encapsulin, a high-resolution electron density map was obtained using cryo-EM. An atomic model of the icosahedral asymmetric unit was built into the map while symmetry operators were applied to build the rest of the icosahedral structure. Further, it was found that within this encapsulin from S. Solfataricus, a second interior shell appears at lower contour levels where there would be encapsulin-associated cargo proteins if they were expressed simultaneously. The presence of this second shell along with N-terminal sequence homology with an encapsulated ferritin from P. furiosus suggests the fusion of a ferritin-like domain with the N-terminal arm of the HK-97 encapsulin subunit, a feature scarcely described in present studies. Further structural research would likely lead to insights regarding the function of this interior shell regarding iron homeostasis and oxidative stress in S. Solfataricus as well as hint at the relationship between the origins of this function in archaeal organisms and the viruses that infect them.

Acknowledgements: USP - Undergraduate Scholars Program

Exploring Midkine's Oncogenic Role through Bioinformatics and Structural Analysis

Audrina Williams, Microbiology & Cell Biology

Mentor(s): Joshua Heinemann, Electrical & Computer Engineering

The study investigates the structural features and interaction networks of Midkine (MDK), a key protein implicated in cancer progression. We aim to identify conserved amino acids within MDK's domains across different species to understand its role in cancer susceptibility and resistance, addressing a significant gap in the current understanding of MDK's function in oncology. Utilizing bioinformatics tools, we analyzed MDK's structure through data from the Protein Data Bank (PDB), molecular visualization with Chimera, and sequence alignments with Jalview. These methods allowed for a detailed examination of the conserved amino acids within MDK's electrostatic, hydrophobic, and cysteine-rich domains. Our analysis revealed high conservation of specific amino acids such as lysine

and arginine, crucial for MDK's heparin-binding functionality. Additionally, superimposing human MDK domains onto zebrafish models based on these conserved residues provided insights into MDK's stability and binding efficiency, highlighting potential therapeutic targets within its structure. The findings confirm that MDK's structural integrity, governed by these conserved amino acids, plays a critical role in its oncogenic activities. These insights open pathways for developing targeted therapies aimed at inhibiting MDK's interactions within the tumor microenvironment. Future research should focus on translating these structural insights into clinical strategies, potentially offering new avenues for cancer treatment.

Acknowledgements: 490R Credit

BIOMEDICAL SCIENCE

Small-Molecule Aptamer Selection via a Restriction Enzyme-based SELEX (RE-SELEX)

Addison Bahr, Chemical & Biological Engineering

Mentor(s): Stephanie McCalla, Chemical & Biological Engineering; Camden Long, Chemical & Biological Engineering

Aptamers are unique sequences of DNA or RNA that bind selectively to a variety of targets, such as proteins, pharmaceuticals, and whole cells. They are highly specific and effective at identifying a wide range of targets, with industrial applications in medicine and environmental safety (1). The standard method for finding aptamers is a process called Systematic Evolution of Ligands by Exponential Enrichment (SELEX) that has been used to identify over 2000 aptamers (2). However, it has been shown that traditional SELEX is not as effective for small target molecules with less unique structures (3). For example, overdose of Acetaminophen, or Tylenol, is the leading cause of liver failure in the USA and abroad (4). However, there has yet to be an aptamer developed for rapid quantification of acetaminophen in blood for use during acute overdoses. To combat this challenge, improved versions of the SELEX method like RE-SELEX have been developed. RE-SELEX utilizes restriction enzymes to select for structure-switching aptamers for small molecules with limited unique functional groups such as kanamycin (3,5). As such, the RE-SELEX method provides an opportunity for the selection of other small molecules, like acetaminophen. However, like all SELEX methods, maintaining high yields between each step is imperative to preserving the quantity and diversity within the aptamer library. Before integrating this method into the lab, the individual selection steps need to be optimized. Therefore, we aim to reform the RE-SELEX workflow to maintain high yields of aptamer candidates between steps, with the goal of selecting an aptamer for acetaminophen.

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Acknowledgements: USP - Undergraduate Scholars Program, EcoStart

Comparing Strain and Osteocyte Activity in Male and Female Rat Femurs

Grace Baker, Center for Biofilm Engineering

Mentor(s): Chelsea Heveran, Center for Biofilm Engineering

Osteocytes, which make up about 90% of bone cells, are mechanosensitive and play a crucial role in bone turnover — a process essential for maintaining bone health. Understanding the differences in strain distribution and osteocyte activity between sexes is key to uncovering sex-specific variations in bone mechanics. To investigate these differences, micro-CT imaging was used to create 3D models of 9-month-old Wistar rat femurs. Finite Element Analysis (FEA) was then performed on these models to map strain distribution under controlled loading conditions. In the next phase of the study, the osteocyte activity data procured from fluorescent labeling and counting will be compared with the strain maps to identify patterns in strain-induced cellular responses. This research addresses a critical gap in understanding how sex-based differences in bone structure and cellular activity contribute to varying fracture risks. The insights gained could pave the way for more personalized treatments for bone fragility and inform prosthetic design by incorporating sex-specific bone mechanics. This project aligns with broader efforts to advance bone health strategies and improve patient outcomes in the future.

Acknowledgements: USP - Undergraduate Scholars Program

Influence of Shared Ancestry on the Expression of Traits in Tissues

Liam Feigin, Chemical & Biological Engineering and Gia Matsko

Mentor(s): Chris Organ, Earth Sciences

Like all living things, cells and tissues have an evolutionary pathway that has led to their genetic and physical makeup. The concept of evolutionary history has been used commonly in ecological frameworks when studying species and organisms but is frequently missing from medical research. This has led medical research to treat diseases like cancer as individual occurrences or populations, rather than having relatedness through their shared ancestry. In this research, we extensively reviewed the literature to create an accurate phylogenetic tree portraying the developmental pathways of human tissues from the point of fertilization to the point of viability. With this phylogeny, we analyze the shared ancestry of tissues and their relationship to traits, such as genes, material properties, cancer risk, and stem cell divisions, to determine whether their expression is phylogenetically patterned. We use BayesTraits, a phylogenetic analysis program, to calculate the phylogenetic signal, Lambda, to determine the importance of shared ancestry on how the trait is expressed across our phylogeny. Then, we compare trials at set phylogenetic signals, among other tests, to determine the best-fit model, recommending that trait for future research. Through this project, we highlight the non-independence of tissues and emphasize the importance of evolutionary lineages in studying medical topics. Additionally, we hope to highlight traits that important to cell phylogeny for future research, in our lab or elsewhere, to help find cures for diseases like cancer.

Acknowledgements: USP - Undergraduate Scholars Program

Investigating Gesture-Word Mismatch in Children with ASD and DLD

Mackenzie Hughes, Education

Mentor(s): Nadezhda Modyanova, Education

Children with Autism Spectrum Disorder (ASD) and Developmental Language Disorder (DLD) often exhibit challenges in language comprehension and social communication. Gesture-based interventions have shown promise in supporting these populations, yet little is known about how children process gestures that match or mismatch accompanying spoken words.

This study, conducted as part of the INBRE-funded RAISE project (Rural Autistic Individuals – Supporting Expression), examines how children with ASD and DLD interpret and respond to gesture-word mismatches in a structured task. We designed a Match/Mismatch

paradigm in which participants viewed spoken words paired with either congruent or incongruent gestures. Non-invasive EEG (electroencephalography) recordings captured event-related potentials (ERPs) to assess neural sensitivity to gesture-word mismatches. Key components of interest include the N400, associated with semantic processing, and the P600, linked to reanalysis and integration.

Preliminary data suggest that children with ASD and DLD exhibit attenuated N400 amplitudes and delayed P600 effects in response to mismatched stimuli, indicating difficulties in real-time multimodal integration. Differences in ERP responses between groups may provide insight into the underlying mechanisms of language processing challenges in these populations.

This research contributes to a deeper understanding of how children with ASD and DLD process multimodal information at the neural level. By refining EEG-based assessments and integrating findings into intervention strategies, we aim to enhance communication support for neurodivergent children.

Acknowledgements: USP - Undergraduate Scholars Program, INBRE - IDeA Network for Biomedical Research Excellence

Electrochemical Impedance Spectroscopy (EIS) Analysis of Midkine (MDK) and B7-H3 Interactions in Metastatic Melanoma Using IDE Fabricated Sensors

Kestley Lutey, Chemical & Biological Engineering and Richard Warner

Mentor(s): Joshua Heinemann, Electrical & Computer Engineering

Over 97,000 people are diagnosed with melanoma annually and it becomes harder to treat as it metastasizes. Is there another pathway for melanoma treatment that can be targeted with new therapeutics? Specifically, the interaction between B7-H3 and Midkine (MDK) can provide insight for melanoma treatments and detection. Both B7-H3, a transmembrane protein, and MDK, a growth factor that mediates cancer growth, are highly expressed in melanoma cells. Interaction analysis between B7-H3 and MDK utilized Microfabrication, Electrochemical Impedance Spectroscopy (EIS), and Mass Spectrometry (MS). These studies were conducted at the Montana Microfabrication Facility (MMF) and Mass Spectrometry Facility at MSU. EIS was performed with a Palm Sens 4 impedance analyzer and 8x multiplexor. Stoichiometric ratios of MDK, B7-H3, and Antibodies mixed with heparin were analyzed by sensors for data collection. Protein interactions were measured through changes in impedance and verified using matrix assisted laser desorption/ionization mass spectrometry (MALDI-MS). We identified binding between the

B7-H3 receptor and MDK, however found no effect when heparin was added. When comparing this data to an antibody specific for MDK, interaction between MDK and its antibody was affected. Cancer has the ability to avoid the host immune system, and these results suggest MDK can operate normally in signaling while remaining cloaked as a means of evasion. This motivates further research to understand how cancer survives and what new therapeutic targets can be developed. Bioengineers could use provided data to develop new treatment targets, along with other fields such as microfluidics, microfabrication, electrical engineering and pharmaceuticals.

Acknowledgements: USP - Undergraduate Scholars Program, INBRE - IDeA Network for Biomedical Research Excellence

Comparison of Classic Ski Striding on Snow and Roller Skis

Olivia Matsoff, Health & Human Development; Sage Eaton, College of Health and Human Development; Isaac Burgess, College of Health and Human Development

Mentor(s): John Seifert, Health & Human Development

Classic ski striding is the most commonly practiced technique for climbing a hill in competitive Nordic ski racing, and roller skiing is the closest activity to replicating the technique of Nordic skiing when snow is unavailable. Athletes need to train proper technique in the off-season so as not to create habits that could be detrimental to the efficiency of on-snow competitive skiing. The purpose of this study is to compare classic striding techniques on snow versus on roller skis by examining the estimated load in a skier's feet through the push-off phase of the stride. Due to the ratchets on roller ski wheels stopping the ski from rolling backwards, as opposed to the dependency on ski pressure to hold the ski to the snow long enough for the skier to transfer their weight, it is possible that classic striding technique is not accurately practiced on roller skis. To determine these pressure values, Xsesnor pressure insoles were placed atop the participant's boot insoles. To track muscle activation, an EMG was placed on the medial head of the gastrocnemius. The participant skied the same stretch of Crosscut Loop four times for approximately six minutes of skiing total, and the same conditions were replicated on roller skis on the ski treadmill. Results showed that the peak estimated load was higher on snow (1075.6 ± 47.4 N) than it was on roller skis (849.7 ± 22.5 N). These results suggest that classic striding technique differs between on-snow skiing and roller skiing.

Acknowledgements: MSU KIN 492

Untargeted Metabolomic Analyses of Loaded MLO-Y4 Cells

Tyler McMillan, Chemical & Biological Engineering

Mentor(s): Chelsea Heveran, Mechanical & Industrial Engineering; Stephen Martin, Chemistry & Biochemistry

Bone diseases are detrimental to overall health, with the most prevalent complication being fractures. Along with osteoblasts and osteoclasts, osteocytes remodel bone to maintain its structural and material robustness. Osteocytes can modify bone indirectly—by chemically signaling osteoblasts and osteoclasts—and directly, by remodeling the surrounding bone matrix. To perform these functions, osteocytes must utilize energy. There is a significant gap in knowledge of the type, and in what situations, osteocytes employ various central energy metabolism pathways. Osteocytes are mechanosensors, detecting and remodeling bone in response to the movement of ions in loading-induced fluid flow. For this reason, fluid flow shear stresses were utilized to induce anabolism in osteocyte-like MLO-Y4 cells. The degree to which an anabolic response was successfully generated in these cells was first quantified based on the relative gene expression of key markers: Cox-2, RANKL, and OPG. Although these trials are still in progress, preliminary results align with existing literature, demonstrating increased Cox-2 expression and decreased RANKL expression, in groups of varying levels of fluid loading. These results stem from a dose-response experiment, which compared relative gene expression with various amplitudes of shear stress, against a control group. The cells will then be subjected to an untargeted metabolomic analysis using mass spectrometry, following further fluid loading at the optimal shear stress. A mass spectrometry analysis will ideally illuminate prominent energy pathways these cells employ during an anabolic state. This will highlight therapeutic targets to restimulate bone formation. However, initial untargeted metabolomic analysis did not produce significant results.

Acknowledgements: USP - Undergraduate Scholars Program, INBRE - IDeA Network for Biomedical Research Excellence

Osteochondral Fluid Transport in a Human Osteoarthritic model

Ara Mercer, Chemistry & Biochemistry; Aurora Gallagher, Biology

Mentor(s): Ron June, Mechanical & Industrial Engineering

Objective: Previous studies investigating bone-to-cartilage fluid transport in a bovine model revealed an influence of mechanical loading. The objective of this study was to use a human osteoarthritic model to (1) quantify diffusion of 3kDa molecular tracers and (2)

characterize fluid transport in different loading conditions. Design: Osteochondral cores extracted from end-stage OA patients' femoral heads (n=16, 8 female, 8 male) were subjected to either no-load (i.e., pure diffusion), pre-load, or cyclic compression (1.5 ± 2% or 3 ± 2%) conditions in a two-chamber bioreactor. Cartilage (top) was sealed from the bone portion and 3kDa dextran tracer (bottom compartment). Tracer concentrations in the upper compartment were measured every 5 min for 60 min to measure the bone-to-cartilage movement of dextran.

Acknowledgements: USP - Undergraduate Scholars Program

Defining Sex Differences in Osteocyte Turnover of the Bone Matrix

Colette Niglio, Center for Biofilm Engineering; Kenna Brown, Biomedical Engineering

Mentor(s): Chelsea Heveran, Center for Biofilm Engineering

Women are at an elevated risk of fracture compared to men. Bone has been shown to differ between the sexes in multiple aspects, including microarchitecture, density, and quality. Previous research regarding the sexual dimorphism of bone focuses primarily on the differences in the signaling of osteoblasts and osteoclasts, which are the bone cells that build and break bone. It was recently discovered that osteocytes, the most abundant bone cell, also directly remodel the matrix of bone through a process called peri lacunar-canalicular system (LCS) bone turnover. Since osteocytes have access to a higher surface area of bone compared to osteoblasts and osteoclasts combined, they can significantly alter the structure and fragility of bone. However, whether the process of LCS bone turnover differs between the sexes has not yet been researched. My project examines how LCS bone turnover compares between males and females using confocal laser scanning microscopy (CLSM) and alizarin and calcein fluorochrome labeling. Fluorochrome labels bind to calcium and fluoresce during CLSM imaging, allowing the number of osteocytes participating in bone turnover to be counted. Images of the samples obtained via CLSM will be analyzed using Imaris and MATLAB, and the number of osteocytes participating in LCS turnover will be compared between the sexes. Understanding if LCS turnover is sexually dimorphic will provide more knowledge of the mechanisms behind the disparities in bone fragility between males and females.

Acknowledgements: USP - Undergraduate Scholars Program

Using hydrogel micro embossed neuronal patterning to study neuronal networks in vitro

Mckennah Thompson, Chemical & Biological Engineering

Mentor(s): Anja Kunze, Electrical & Computer Engineering

This project aims to shape neuronal network growth into finite graph-theory-based network structures using a hydrogel agarose micro embossing method. Neurons wired together in networks form the foundation for how the brain processes and computes information. A key part of this processing is the excitation of specific groups of neurons that are linked to behavior. Outside the brain, dissociated neuronal cultures on dishes, are often used for drug testing and studying neuron behavior. However, these cultures tend to form random connections, lacking the structured networks seen in the brain. This makes them less useful for studying real neuronal circuits as seen in the brain. To address this issue, we developed a specialized hydrogel-based "brain-on-a-dish" system. This system uses structured microwells to guide neuron growth, promoting both small and large-scale connections. We improved this system and used calcium imaging to observe spontaneous neuron activity. This technology improves neural network studies leading to future multi-scale connectivity within the brain.

Acknowledgements: USP - Undergraduate Scholars Program

Functional Implications of Dual-Neurotransmitter Neurons in the Drosophila male reproductive system.

John Toney, Microbiology & Cell Biology; Jace Tolleson-Knee, Microbiology and Cell Biology

Mentor(s): Steve Stowers, Microbiology & Immunology; Marta Chaverra, Microbiology & Immunology

The existence of two classical neurotransmitters in the same neuron has long been acknowledged in some neural circuits. However, the mechanisms by which co-transmission occurs in these neurons is only beginning to be appreciated. For years, the Stowers lab has been studying these dual-neurotransmitter neurons in Drosophila, also known as the common fruit fly. In 2023, we discovered that the neurons that innervate the male Drosophila reproductive system are entirely dual-neurotransmitter neurons. Since then, we have been working to understand how these neurons affect reproductive function, the mechanism of synaptic co-transmission, and how these distinct neurotransmitters affect neuronal activity. We have successfully described the distribution of each neurotransmitter within the Drosophila male reproductive system and found that there are two distinct types of neurons. One is a subset of octopamine/glutamate dual neurotransmitter neurons, the other is a subset of serotonin/glutamate dual

neurotransmitter neurons. These two types of neurons have unique, functionally significant distributions within the different organs of the male reproductive tract. Additionally, we have investigated the distribution of several neurotransmitter receptors, which also bear a unique functional distribution. This novel description of the dual-neurotransmitter neurons that innervate the male Drosophila reproductive system will further our understanding of male reproductive evolutionary development, but also dual-neurotransmission in the brain, which is crucial to the treatment of neuropsychiatric disorders whose etiologies remain somewhat mysterious.

Acknowledgements: USP - Undergraduate Scholars Program

NMR investigations of the serum metabolome of advanced liver disease patients aimed at deciphering how copper deficiency increases patients' mortality risks

Logan Webster, Chemistry & Biochemistry

Mentor(s): Valerie Copie, Chemistry & Biochemistry

Advanced liver disease has been widely regarded as one of the major causes of mortality in humans and has increased in incidence over the past few decades, due to several factors ranging from alcoholism (alcoholic liver disease) to obesity (non-alcoholic fatty liver disease). Several elements can influence the risk of liver disease development, prognosis, and severity. A particularly interesting feature is the observation that copper deficiency exacerbates liver disease and increases patients' mortality risks, although the underlying biochemical mechanisms that contribute to this phenomenon are not understood. NMR (nuclear magnetic resonance) spectroscopy is increasingly being used as an analytical metabolomics technique to identify and quantify small molecule metabolites in complex systems. NMR offers a unique approach to assess changes in metabolite levels and to characterize alterations in metabolic pathways resulting from copper deficiency. In addition, the current standard for liver disease diagnosis is liver biopsy, which is highly invasive. In contrast, NMR can provide small molecule markers of disease using less invasive methods of sample collection. NMR metabolomics can be leveraged to help identify liver disease patients with copper deficiency who are at increased mortality risk. This project was done in Dr. Copié's lab using MSU's 600 MHz (14.1 Tesla) NMR instrument. 1H NMR spectra were collected and analyzed to identify diagnostic metabolites and characterize metabolite patterns that differentiate liver disease patients with adequate copper from those with inadequate copper. The project's long-term goal is to use this knowledge to improve care and to generate insights into underlying cellular mechanisms.

Acknowledgements: USP - Undergraduate Scholars Program, INBRE - IDeA Network for Biomedical Research Excellence

BUSINESS AND MARKETING

Understanding Student Perceptions and Behaviors of Adobe Express for Strategic Marketing Recommendations

Rebecca Jolley, JJCBE Center for Entrepreneurship; Monica Macpherson, JJCBE Center for Entrepreneurship

Mentor(s): Eric Van Steenburg, JJCBE Center for Entrepreneurship

As part of a broader marketing plan developed in BMKT 485, this study explores student perceptions and behaviors toward creative software, focusing on Adobe Express. Through four focus groups, two nationwide surveys, and three interviews with Adobe Student Ambassadors, data was collected from students aged 18-27 to assess their attitudes, brand awareness, and willingness to subscribe toward creative software. Findings indicate that students value a user-friendly interface, accessibility, and features such as storage and design templates. However, low awareness of Adobe Express in this target market hinders adoption, despite a generally positive perception of the Adobe brand. Comparative analysis reveals that students use Canva more frequently than Adobe Express, associating Adobe products with a steeper learning curve. Awareness of Adobe Express was significantly lower than competitors, with only 39% of survey respondents familiar with it. Key factors influencing adoption include brand recognition, professional development opportunities, and an intuitive interface. However, concerns about Adobe products' complexity deter students. When testing which word best represented Adobe Express's services, "create" was strongly associated. Given the low awareness of Adobe Express, rebranding to Adobe Create could enhance recognition and adoption. An educational campaign emphasizing Adobe Express's ease of use, generative AI credits, templates, and storage will further enhance brand awareness. Simplifying the interface and leveraging short-form tutorials can address learning curve concerns and improve adoption. Additionally, positioning Adobe Express more favorably against competitors through comparative marketing strategies and clear value communication could enhance student engagement and increase subscription rates.

Acknowledgements: USP - Undergraduate Scholars Program

Is Nuclear Energy Right for Montana?

Grant Kahle, JJCBE Center for Entrepreneurship; Ryan Beatty, Business; Duane Catlett

Mentor(s): Paul Gannon, Chemical & Biological Engineering

50+ years of safe, secure, and reliable operations of clean electrical power generation has proven that nuclear energy must be a part of our nation's future clean energy portfolio. In the past, public opinion has inhibited the growth of this electricity source; today, the pressure of climate change is forcing the world to make a radical change in the way our society generates electricity. Almost 20% of our electricity generation currently comes from nuclear power and meeting our future energy needs will require a much larger role for nuclear in the future. Our first research objective was to gain a better understanding of public opinion and knowledge of nuclear energy in Montana; and importantly, the foundation and reasoning for their views. We designed a survey that asks whether the respondent is favorable or unfavorable and why they hold that opinion, then whether they feel knowledgeable or unknowledgeable about nuclear energy to produce electricity. We identified several stakeholder/cohort groups to research and our survey was distributed to these groups, including legislators and government administrators, utility companies, prospective nuclear site community members, nuclear energy experts, environmentalists, economists, and MSU students and faculty. Our second research objective was to gain an understanding of why nuclear reactor construction costs so much. We researched the costs through summaries of techno-economic analyses of the construction and operation of previous nuclear power plants. To achieve this goal, we held extensive interviews with representatives of stakeholder groups. We have found that the upfront costs of licensing, engineering and construction of reactors are the most important barriers nuclear energy has to overcome. Nuclear energy can decrease costs by: legislative reform, new reactor volume and series construction, and supply chain availability. Once in operation the costs are low, stable and lay the groundwork for an abundant clean energy future.

Acknowledgements: USP - Undergraduate Scholars Program

Investigating the Circular Economy and Sustainable Consumer Behavior in Online and Offline Settings

Monica MacPherson, JJCBE Center for Entrepreneurship

Mentor(s): Eric Van Steenburg, JJCBE Center for Entrepreneurship

Sustainable consumption behavior (SCB), introduced at the 1994 Oslo Symposium, addresses environmental concerns like climate change and resource depletion by emphasizing mindful practices such as buying durable goods, avoiding overconsumption,

and promoting resource reuse and recycling. In the fashion industry, SCB is reflected in trends like vintage shopping and DIY fashion. Second-hand clothing stores, such as thrift stores and flea markets, play a critical role in this system, enabling consumers to reduce consumption and increase recycling while positioning themselves as supporting sustainable fashion options that mitigate environmental harm. Despite research on offline and online consumer behaviors related to second-hand clothing, little attention has been paid to how purchase intentions differ across platforms, nor how one's SCB affects behavior. This study explores sustainable consumption in fast-fashion and second-hand clothing across online and offline environments using experimental design across four scenarios. The scenarios given differed between online and offline stores with vintage or fast-fashion clothing.

Findings reveal that SCB moderates the relationship between subjective norms and purchase intentions more strongly than attitudes or perceived behavioral control, though all TPB components significantly predict vintage clothing purchase intentions. These insights underscore the importance for nonprofit organizations operating thrift stores to establish an online presences with e-commerce capabilities to boost income, while also highlighting the growing need to understand consumer behavior across diverse retail environments to support sustainable fashion and advance the circular economy.

Acknowledgements: USP - Undergraduate Scholars Program

COMPUTER AND INFORMATION SCIENCE

Buried in Complexity: Assessing Differences in Risk Messaging of Avalanche Centers

Nicholas Clausen, Computer Science; Aidan Keefe, Computer Science; Henry Jacobson, Computer Science

Mentor(s): Ann Marie Reinhold, Computer Science

Daily avalanche reports from the United States Forest Service Avalanche Centers contain messages that aim to save lives. The reports outline current risks, snow travel suggestions, and expert risk assessments of the snowpack. However, these daily reports vary in terminology and the gravitas given to risk levels depending on the Avalanche Center that writes and publishes them. More specifically, messages differed in sentiment, common words used, and length of messages. These inconsistencies in messaging create confusion among those who read them. These insights will demonstrate to Avalanche Centers that standardizing their current messaging systems will dig people out of their confusion and ultimately save lives.

Teaching in the Age of GenAI: Social Media Insights on Opportunities and Challenges

Alexander Ellingsen, Computer Science

Mentor(s): Neda Nazemi, Computer Science

Generative Artificial Intelligence (GenAI) is evolving rapidly, with sophisticated models being increasingly utilized by students. This swift adoption poses both opportunities and challenges for educators, necessitating a deep understanding of their responses to adapt effectively. Traditional methods like interviews and surveys are often too slow to capture the rapidly shifting landscape of GenAI, risking obsolescence before studies conclude. This study addresses the need for timely insights by analyzing unstructured data from social media platforms such as X (formerly Twitter) and BlueSky, focusing on posts by educators discussing GenAI. The analysis aims to uncover real-time reactions to GenAI's role in education, track sentiment evolution since the use of GenAI became widespread, and identify categories of barriers to classroom adoption and adaptation to challenges. To achieve this, we collected and preprocessed over 1,000,000 posts across platforms that related to the field of GenAI. This data was filtered to only include posts from educators and students to provide firsthand accounts of GenAI use in education. Advanced text-mining techniques such as topic modeling and sentiment analysis were applied to extract patterns, sentiments, and recurring themes in the discourse. Our findings reveal key insights into educators' perceptions, including the benefits, risks, and challenges associated with integrating GenAI into educational practices. These results offer valuable guidance to both the educational community and GenAI developers, enabling the design of tools and strategies that better align with educators' needs and address the complexities of GenAI in learning environments.

Acknowledgements: USP - Undergraduate Scholars Program, INBRE - IDeA Network for Biomedical Research Excellence

WindNinja Graphical User Interface Redesign

Henry Jacobson, Computer Science; Cody Matz, Computer Science; Austen Harrell, Computer Science; Jack Hayward, Computer Science

Mentor(s): Clem Izurieta, Computer Science

WindNinja is a wind analysis tool created by the USDA Forest Service Missoula Fire Sciences Laboratory for managing wildfires. WindNinja predicts wind patterns through

various geographic features such as mountains, ridges, and valleys. These features alter the surface elevation wind vectors against their higher elevation atmospheric vectors. Amalgamated together, this software is an improvement over NOAA's operational weather prediction models that are run over vast areas and are unable to resolve local terrain features. This data is pertinent because wildfires are highly sensitive to wind conditions. WindnNinja offers information for predicting fire behavior and enhancing firefighter safety. While the WindNinja application has several interfaces, the graphical user interface was developed in a now deprecated C++ framework over fifteen years ago. In addition, data results from running WindNinja cannot be viewed natively; users have to view results in external third-party applications such as ArcGIS or Google Earth. This project addressed these issues by updating the graphical user interface using a modern framework and allowing users to view georeferenced wind data on a map-based layer natively. The updated application is fully cross-platform between Windows, MacOS, and Linux operating systems. Lastly, WindNinja remains free and open source, in accordance with Title 17 Section 105 of the United States Code for software written by a government agency.

Embrace: A One-Stop Resource for Immigrant and Limited English-Speaking Communities in the US

Elizabeth Pauley, Computer Science

Mentor(s): Clemente Izurieta, Computer Science

Millions of individuals born in foreign countries reside in the U.S. today, with immigrants making up more than 14% of the population. People can face many obstacles adjusting to life in a new country. Even those born in the U.S. can face unique challenges if they grow up as either a second-generation immigrant, a member of a multilingual household, or both. This community's key needs include access to healthcare, childcare, English education, interpreters, legal and financial aid, housing, and more. Navigating these areas can feel even more daunting if one feels alone in their struggles. While many resources seeking to address these problems exist, finding a resource based on one’s specific needs can be challenging, given that in-person offerings vary based on location and the plethora of online resources can be overwhelming to sort through. To take the first step toward addressing this issue, I developed the prototype Embrace, a web app intended to support immigrant and limited English-speaking families and individuals in the U.S. This app features a database of resources that users can filter and search to find resources that are most relevant and beneficial given their needs, a free document translation service for registered users, and a simple discussion board that allows individuals within a community to engage

with each other, ask questions, and relate over shared experiences. Embrace centralizes all the information and tools one needs to find support and connection within one's community and navigate everyday life in the U.S.

Acknowledgements: USP - Undergraduate Scholars Program

Bringing Space Weather Down to Earth: A Risk Communication Analysis

Sarah Pawlowski, Physics and Elizabeth Pauley, Computer Science

Mentor(s): Ann Marie Reinhold, Computer Science

Space weather can significantly impact critical infrastructure both in space and on Earth, disrupting satellite communications, power grids, and other essential systems. Public awareness of these risks is crucial, especially during disruptive events. Government agencies, satellite operators, and power companies must be able to communicate space weather risks effectively. The Space Weather Prediction Center (SWPC), a branch of the National Oceanic and Atmospheric Administration (NOAA), is the primary authority on space weather in the United States. They provide forecasting and hazard warnings but these alerts are highly technical, lack emotional appeal, and require prior knowledge of the subject matter to understand. This lack of accessibility creates a disconnect between those issuing the alerts and the general public who may ultimately be affected by space weather events. To address this issue, we created a dashboard that compiles real-time space weather data from the SWPC and distills it to the most relevant information for critical infrastructure. We introduced a streamlined warning system that incorporates a single numerical risk scale alongside textual descriptions to make hazard data easy to interpret. To enhance accessibility, we used Natural Language Processing to analyze and refine the messages displayed on our dashboard. This approach ensures the language is clearer, less technical, and more engaging for non-experts than existing sources. This dashboard is a valuable resource for the public and a model for communicating complicated, low-frequency, and high-impact hazards like space weather. By simplifying technical information and making the language more accessible, we bring the topic of space weather back down to earth and empower people to make informed decisions when a disruptive event occurs.

Acknowledgements: This project is part of the Data Science capstone requirement

Enhancing Data Accessibility in Applied Statistics at Montana State University: Data curation methods to support intermediate and upper level statistics at MSU

Amelia Pomazal, Mathematical Sciences

Mentor(s): Mark Greenwood, Mathematical Sciences

Access to new and interesting data sets is the lifeblood of applied statistics courses. Modern journal articles often include data and sometimes the code used to analyze the provided data. Usually, there is a gap between the data posted and the actual analysis and results in the paper, making student access difficult. Thus, this data curation project worked to bridge that gap for students by adding to the R package catstats2 to add additional data sets to those already provided. This project explored methods for documenting and archiving data sets in R packages. It determined what methods for data cleaning are necessary to make a dataset informative but still ready for use by introductory and intermediate statistics students. This project also increased ease of access for datasets used by other MSU statistics program instructors and created concise help files to summarize important information about the curated datasets.

Liberty's Handbook: A New Way to Support US Immigrants

Gunnar Rasmussen, Computer Science; Caber Caldwell, Computer Science

Mentor(s): Clement Izurieta, Computer Science

Ever since the foundation of the United States of America, it has been a country where many migrants and settlers have left their home in order to start their lives in a new land with new opportunities they have never seen before. However, despite how many people continue to immigrate to the United States, many of these people struggle to find their footing in their new home. The language barrier remains a struggle, as even though there are many people of many backgrounds, English is the language that is the most prevalent language by far, with most states declaring it to be the official language. This is the source of many of the issues newcomers to the country face. Finding a job or a place to live is a struggle when one can't properly fill out the official documents in a language they don't fully understand. In addition, it's a struggle to find local resources that can help immigrants in a more hands-on way, especially in a more rural area where that kind of help is much less common. For a solution to these issues, we have begun developing Liberty's Handbook, a web app which aims to address these issues with two main features. To address the issue of many important resources not being written in the primary language of the user, the first of these will be a document translation feature, where the user can upload a document such as a job or apartment application, and have the document translated into their target language while keeping the formatting of the document, allowing the user to understand the content of the document much easier. To address the lack of an

accessible way of finding resources, the second feature is a database of resources curated by an admin of the web app, which will recommend local resources based on location and relevance to the user. These will be the main features of Liberty's Handbook, and will prove to be a useful resource to new immigrants to the United States. We aim to create a useful tool for new immigrants to the United States, and are excited to not only present a functional prototype, but to continue development into the future and release a tool that we know can make a positive impact on the lives of migrants in their new home.

Acknowledgements: USP - Undergraduate Scholars Program

Dashboard of Cyber Attacks and their Historic Timeline

Gideon Survoy, Political Science; Keeler Sparks, History Department

Mentor(s): Clemente Izurieta, Computer Science; Yvette Hastings, Computer Science

Cyberattacks have become a growing threat to life as we know it, causing significant disruptions across civilian and government sectors, including power outages, interrupted food supply chains, and compromised personal information. These attacks result from malicious hackers infiltrating or disrupting computer systems. With the growing frequency of cyber threats, it is imperative to visualize and analyze historical and real-time attack patterns using dashboards to aid mitigation planning. However, no centralized dashboard currently exists to track past and ongoing cyberattacks. In this study, we developed a real-time dashboard to visualize global cyberattacks, incorporating both historical and current attack trends. Our dashboard highlights attack frequency, locations, perpetrators, and impacts, enabling cybersecurity professionals to identify recurring patterns and trends that inform cybersecurity strategies. Additionally, we highlight four major historical cyberattacks and their global consequences. By highlighting historical and real-time cyberattack information, cybersecurity professionals are provided with valuable insights into past vulnerabilities, can more effectively identify trends, monitor frequently targeted areas, and enhance future cyber mitigation strategies, leading to improved cyber defense responsiveness.

Acknowledgements: VICEROY Northwest Institute for Cybersecurity Education and Research (CySER), Air Force Research Laboratory, and the Griffiss Institute

Stop Stealing from Grandma:

Wyatt Vopel, Computer Science; Alex Roylance, Computer Science

Mentor(s): Ann Marie Reinhold, Computer Science

Scammers are constantly developing new techniques to exploit the vulnerable, particularly the elderly. As technology advances, so do the methods used to deceive these people through phishing schemes and misleading messages. Although risk communication messages exist to warn against these dangers, they often fall short in effectiveness. Many of these messages are overly complex, relying on negative phrasing or technical jargon that can confuse or overwhelm older audiences. To address this, we conducted a comprehensive evaluation of currently available warning messages using Term Frequency-Inverse Document Frequency (TF-IDF) and sentiment analysis. These methods allowed us to pinpoint which linguistic elements are most effective in communicating warnings clearly and positively. Our findings show that straightforward, easy-to-understand, and positively framed language significantly improves message reception and retention. By focusing on these characteristics, we can craft more impactful warnings that resonate with elderly individuals. We also emphasize the importance of educating caregivers with these strategies, so they can better train and support the elderly in recognizing and avoiding scams. With the right approach, stealing from grandma will be harder than ever.

Portfolio Automation Software System

Mason Watamura, Gallatin College; Shane Costello, Gallatin College; Gabriel Martens, Gallatin College

Mentor(s): Clem Izurieta, Computer Science

Participating in a stock exchange is a well-known method of increasing personal wealth. Nearly all American adults are familiar with the concept, yet only 62% are invested in stocks. Breaking that figure down by income, we see that 84% of Americans earning $100,000+ annually own stocks. This is true for only 29% of those earning less than $40,000 annually. A similar positive correlation exists with the highest level of education completed. These statistics make apparent the reason why Americans are not invested in the stock market. It is due to a lack of exposure and relevant education. When engaging with the stock market, people face a plethora of industry jargon that only someone with knowledge of the field would understand. The process of purchasing and trading a stock for the first time is subsequently confusing. With money on the line, people are nervous about making uninformed decisions and opt to not participate at all. It is the mission of our software solution, the Portfolio Automation Software System (PASS), to lower the barrier of entry for Americans investing in the stock market. It is our goal to simplify the process and get more Americans invested in the stock market. To do this, we have developed a unique stock

selection algorithm. The user inputs how long they'd like to be invested and how much they'd like to invest, and our algorithm does the rest. Pulling real-time stock data from the NASDAQ index (via a news API), our algorithm considers many factors, including sentiment analysis, to develop a diverse, high-yielding portfolio. Users are presented with information regarding their generated portfolio, including relevant news stories and pertinent financial metrics, enabling them to become more informed. Coupled with an intuitive user interface, PASS is the answer for Americans looking to make their first investments.

Acknowledgements: USP - Undergraduate Scholars Program

EARTH AND ENVIRONMENTAL SCIENCE

Weather and Atmospheric Particulate Survey in the Gallatin Valley

Milo Anderson, Physics; Riley Logan, Engineering

Mentor(s): Joseph Shaw, Electrical & Computer Engineering

Research published by Montana State links the increase of wildfires seen in western Montana to a growth in the risk of PM 2.5 exposure across the state. Other forms of pollution also tend to become trapped in deep valleys, like the Gallatin, due to weather patterns known as winter inversions. Pollution, specifically PM 2.5 particles defined by their size of 2.5 micrometers or smaller, poses a risk when inhaled. These microscopic particles can penetrate deep into a person's lungs, potentially crossing into the bloodstream, causing significant problems for the human body. To examine these particles, air quality is surveyed with laser-based technology to determine the total makeup of the atmosphere. I have utilized a Nephelometer to measure the scattering coefficient and an Aerodynamic Particle Sizer (APS) to measure the size of particles, so I can characterize the makeup of the air people breathe in Gallatin County. I hypothesize that the dominant public health threat of air pollution in the Gallatin Valley comes from wildfire smoke more than from wintertime temperature inversions. I also believe that there will be an increase in pollutant levels compared to a previous study by the Optical Remote Sensing Laboratory (ORSL) in 2011. A year-long study will be conducted using these optical instruments and the results will be compared to previous data. Collected data will be published on an existing website maintained by the ORSL, informing the public about air quality and trends. The knowledge gained in this study will contribute to a further understanding of air quality, this links to my future work focusing on an analysis of the polarization characteristics of wildfire smoke plumes.

Acknowledgements: MSGC - Montana Space Grant Consortium

Exhumation of the Bridger Range, Montana through application of low temperature thermochronology

Liam Arnold, Earth Sciences

Mentor(s): Rebekah Kennedy, Earth Sciences; Devon Orme, Earth Sciences

The Bridger Range in southwest Montana is one of the many high elevation ranges in the Northern Rockies that developed when the western edge of North America became a convergent margin with oblique subduction of the Farallon plate during the Late Jurassic (~150 Ma). This resulted in Sevier and Laramide style crustal thickening and the formation of mountains in western North America. Subsequent crustal extension began ~25 Ma with associated normal faulting from the Basin and Range Province, further uplifting these mountain ranges, including the Bridger Range. The exact timing of normal faulting and exhumation in southwest Montana remains unclear. Using apatite (U-Th)/He thermochronology, we aim to better determine the most recent timing of exhumation of the Archean metamorphic basement exposed on the west side of the Bridgers. Apatite (U-Th)/He thermochronology is sensitive to low temperatures (~40-80 ℃) that correspond to crustal depths of ~1-3 km. The ages obtained by this method record the timing at which a sample cooled through these temperatures as it was exhumed toward the surface. Analysis of 5 apatites from 3 basement samples are ongoing. Based on geomorphological evidence for recent normal faulting, namely steep topography and triangular facets that define the west side of the range, we hypothesize our apatite (U-Th)/He dates will be less than 10 Ma. In turn, we will construct a series of thermal history models using this data to reconstruct the time-temperature history of the Bridger Range testing the sensitivity of our data in recording recent exhumation of the range.

Acknowledgements: USP - Undergraduate Scholars Program

How Has Climate Change Impacted Montana's Outdoor Recreation?

Ella Balan, Political Science

Mentor(s): Paul Lachapelle, Political Science

Climate change is negatively affecting Montana's outdoor recreation, particularly winter sports. Warmer temperatures and reduced snowfall are making it increasingly difficult for Montanans to participate in activities like skiing, snowboarding, and snowmobiling. In The

Impact of Climate Change on Montana's Outdoor Economy by Dr. Thomas Michael Power and Donovan S. Power, prepared for the Montana Wildlife Federation, the authors highlight the threat to winter recreation, stating that "skiers, snowmobilers, and winter recreationists of all sorts will have to recreate in a winter that is significantly shorter, significantly warmer, and has significantly less snowpack as more precipitation comes in the form of rain as opposed to snow" (Power & Power, 2015, pg. iii). As a result, ski areas may be forced to increase artificial snow production—if temperatures allow—or move to higher elevations in search of cooler conditions. Additionally, Tom Dickson's Feeling the Heat discusses how rising temperatures are altering Montana's ecosystems, further impacting outdoor activities dependent on cold weather. With winter sports seasons becoming shorter and snowfall becoming less reliable, climate change is reshaping a defining aspect of Montana's winters. My research question is as follows: How has climate change impacted Montana's outdoor recreation?

"How have warming ocean temperatures affected the abundance and distribution of Alaska's key commercial fish stocks?"

Bria Bjork, Political Science

Mentor(s): Paul Lachapelle, Political Science

Climate change is impacting Alaska's marine ecosystem at profound rates, triggering a reduction in the abundance and distribution patterns of critical commercial fish stocks throughout Alaska. Increasing ocean temperatures have contributed to the substantial altering of fish populations, causing disturbances within small fishing communities, harming the livelihoods of small indigenous fishing villages. The research presented is a synthesis of existing literature, focusing on the examination of how increasing ocean temperatures are impacting fisheries management, marine ecosystems and the long-term sustainability of fish stock. Key findings demonstrate how species such as Gadus macrocephalus and Oncorhynchus are progressing north in hopes of reaching cooler waters. This migration then triggers economic hardships projected upon small fishing communities who rely on these fish species for food security. Additionally, it has been documented that recent marine heatwaves can be directly correlated with the decline of reproductive capabilities in large marine mammals, such as humpback whales. Emphasizing the cascading effects of climate change and how the consequences are large enough to impact even the largest marine mammals. With these challenges being presented, this study provides insight to sustainable fisheries management practices that can be employed, along with integrating adaptation and response-based strategies, aiming to preserve fisheries within Alaska, all while equally working to address the long-term impacts of climate change on marine ecosystems.

Best Practices for Reducing Wildfire Frequency and Severity While Strengthening Resilience and Protecting At-Risk Ecosystems and Communities

Cole Bullock, Political Science

Mentor(s): Paul Lachapelle, Political Science

California's wildfire has reached unprecedented levels, with the 2020 season burning over 4 million acres, resulting in billions in damages (California Fire, 2020 incident archive). As of 2025, the issue continues to be significant because of climate change, urban expansion in fire-prone areas, and prolonged droughts. The study explores the approaches to determining the best practices for reducing wildfire frequency and severity while strengthening resilience and protecting at-risk ecosystems and communities. Some of the key solutions and findings that will have major outcomes such as AI and machine learning systems like ALERTCalifornia, continue to enhance early fire detection and prediction. Indigenous cultural burning traditions and programs such as Firewise USA have proven effective in reducing fire risk and fostering community resilience. Along with this, policies that include SB 901 and SB 182 focus on improving forest management and regulating development in high-risk areas through enforcement and funding. While each strategy has merit, the effectiveness is maximized when applied and integrated effectively, as community programs increase preparedness, technology innovations provide early detection, and legislation provides structural support. California has to adopt a varied strategy that integrates technology, legislative reform, and community participation to mitigate wildfires effectively. Through fostering collaboration among stakeholders and addressing structural challenges, California can protect its ecosystems and residents from wildfire threats. Moving forward, future research should work towards understanding and reducing the effects of climate change through enhancing early detection and quick response, and creating more efficient and sustainable fuel management techniques, such as mechanical thinning and prescribed fire.

Public Water Supply Vs. Private Well Water

Eric Castro, Earth Sciences; John Doyle

Mentor(s): Margret Eggers, Earth Sciences

Public Water Supply Vs. Private Well Water Supply Water users on the Crow Reservation in South Central Montana rely on a combination of public water supplies (PWS) and private wells. The PWS are regulated under the US safe Drinking Water Act (SWDA), with testing

and treatment conducted by municipalities and overseen by the US EPA, but there are still health risk concerns related to both inorganic contaminants and waterborne disease. Private wells are not covered under the SWDA, so well owners must test and address quality concerts for their own water. The aim of this project is to explore health concerns related to drinking water from public water supplies and private wells throughout the Crow Reservation, and to share those results with Crow Tribal members and communities. In the summers of and, through a collaboration of the Crow Environmental Health Steering Committee (CEHSC), Little Big Horn College, the Biawaachaache (Good women) Collective, Montana State University Extension and Land Resources Environmental Science Department, USGS, and myself were trained to collect water samples and data from both water systems and private wells. 2022 results from the major PWS on the Reservation revealed that they were all in compliance with SDWA standards, but on off reservation PWS exceeded disinfection byproduct standards. Each private well owner received a summary and interpretation of their results from a member of the collective, and an invitation to attend a local community meeting where we shared and discussed community-wide results. Water coolers have been offered free of charge to many individuals whose private wells were tested. Our next steps are to summarize the results based on cumulative human health risk and to continue to share these results with the broader Crow Community. Authors: Eric Castro, John Doyle, Dr. Adam Sigler, Joree LaFrance, Dr. Mari Eggers.

USING PLANT SPECTROSCOPY TO IDENTIFY PLANT SPECIES

Aidan Chapman, Land Resources & Environmental Sciences

Mentor(s): Anna Schweiger, Land Resources & Environmental Sciences

This research aims to develop a predictive model for plant species identification using leaf-level spectroscopy of herbarium specimens. The study will organize samples phylogenetically and measure their spectral reflectance using a high-resolution spectometer across visible (400–700 nm), near-infrared (700–1100 nm), and short-wave infrared (1100–2500 nm) wavelengths (Schweiger et al., 2018). Spectroscopy has demonstrated potential for identifying plant characteristics, with evidence that closely related species share similar spectral signatures (Meireles et al., 2020). A partial-least-squares discriminant analysis (PLSDA) model will test the extent to which species can be differentiated based on their spectral reflectance (Brereton & Lloyd, 2014). Spectral loading values will identify the most important wavelength regions for species discrimination, linking them to known absorption features in plant foliage (Cavender-Bares et al., 2017).

Herbarium specimens will be sourced from the Yellowstone National Park (YNP) herbarium. Spectral dissimilarity among species has been shown to correspond with functional and evolutionary divergence (Schweiger et al., 2018; Meireles et al., 2020). Insights from this work will improve remote sensing technology for assessing plant diversity at larger scales. NASA and the European Space Agency (ESA) are set to launch the first free-flying spectrometers by the decade's end, making spectral libraries like ECOSIS essential for interpreting satellite data (Schimel & Poulter, 2022). Findings from this project will contribute to the Schweiger lab's spectral model library and advance remote sensing methods for monitoring plant diversity.

Acknowledgements: USP - Undergraduate Scholars Program

How will climate change affect wine-producing regions in the future?

Ryan Conway, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

Climate change is having large effects on agriculture around the world. This research synthesis was performed in order to understand how these regions will be affected in the future. Studies on climate change and the current state of these regions were compared in order to understand this issue. Temperature shifts, extreme climate events, and changing precipitation patterns will result in geographic shifts of the vineyards and will require winemakers to adapt to these changes. These workers will have issues when considering current and past practices. The result will be new regions and different techniques, meaning the wine in your glass will change drastically in taste and price.

Evaluation of Trap Type and Sampling Period on Bee Species Composition

Mia DeGarmo, Land Resources & Environmental Sciences

Mentor(s): Michael Ivie, Plant Sciences & Plant Pathology; Casey Delphia, Plant Sciences & Plant Pathology

The Wild Bees of Montana Project (WBMP) is a 15-year study initiated in 2017 that aims to document bee species and their distribution throughout the state. However, methods for efficiently inventorying such a diverse and important group of insects over such a large area are not well established. The objective of this study is to examine trap type and sampling period for evaluating how to maximize bee diversity measures with minimal collecting effort. To assess this, I will compare bee morphospecies composition (relative species

abundance and richness) among biweekly samples from 30 May through 15 September 2023 collected at one site using two trap types: blue vanes and bee bowls. These data collected through this study indicate that using both trap types is necessary when attempting to inventory as many bee species as possible in this particular site. The results suggest that repeated collecting over the entire field season would be necessary to document the greatest number of bee species. The results also suggest that there is not a single sample that is representative of the total pool of species present in all samples. This project's parent study, the WBMP, can use these results to inform their collecting efforts, I recommend the WBMP continues sampling throughout the field season using both trap types.

Acknowledgements: USP - Undergraduate Scholars Program

Climate Change and It's Implications on Great Lakes Region Wastewater Management

Morgan Fiereck, Microbiology & Cell Biology

Mentor(s): Paul Lachapelle, Political Science

Climate change has had various impacts on weather patterns worldwide; one example is the impact on weather patterns in the Great Lakes Region. Climate change has led to increased dry events, followed by extreme precipitation events, leading to an increased risk of waterborne diseases. This is primarily a concern in cities with combined sewer systems, and improving infrastructure is becoming increasingly imperative. Recent studies have shown a significant association between hydrological changes and gastrointestinal illnesses. Current findings indicate that extreme precipitation significantly increases contamination risk. Policy interventions, including changes to the Clean Water Act and the Canada Water Act, are needed to address climate change. Other improvements are needed, such as improved infrastructure, which poses significant political and economic barriers. Other adaptation, mitigation, and resilience actions are needed to help reduce risk without improved systems. The freshwater resources of the Great Lakes region should be protected, and the people relying on the lakes should not be at significant risk for waterborne disease.

Exploring Student Perspectives on Climate Change: Assessing Support For Dedicated Courses in the MSU CORE Curriculum by Analyzing Sociodemographic and Statistical Data

Zoë Goodwin, Plant Sciences & Plant Pathology; Ella Villeneuve, PSPP; Holt Burge, PSPP

Mentor(s): Claire Luby, Plant Sciences & Plant Pathology

Education surrounding climate change has struggled to reach broader application across the Montana State University (MSU) course curriculum. Implementing climate change education (CCE) into higher education institutions is fundamental in preparing the future workforce for dealing with the repercussions of the changing environment. Courses directly addressing climate change at Montana State University are limited and largely inaccessible to the majority of the student body due to prerequisite requirements. Introducing CCE into the CORE curriculum at MSU will provide a general overview of key concepts affecting current issues in science. For this Horticulture Capstone Project, a survey will be conducted to gauge student interest in implementing a climate course into the CORE curriculum. The survey consists of 7 multiple choice questions, as well as 2-3 demographic questions aimed to understand and accurately represent the population at MSU. The diversity of student interests in these courses will provide various responses and will yield the necessary data to test the hypothesis that students at MSU will strongly support the inclusion of a dedicated climate change course in the Core Curriculum. By identifying student needs and interests, we expect to see over 50% of students in support of implementing CCE into the CORE curriculum. This study will contribute to the broader dialogue on how higher education can best prepare graduates to respond to one of the most pressing global challenges of our time.

Acknowledgements: Senior Capstone for Environmental Horticulture

METABOLIC EFFECTS IN RAINBOW TROUT Oncorhynchus mykiss TISSUE DUE TO LOW DIET PH

Alyssa Harmel, Land Resources & Environmental Sciences; T. Gibson Gaylord; Madison Powell; Jacob Bledsoe; Abigail Bockus

Mentor(s): Christine Verhille, Ecology

Trout require an acidic stomach environment for digestion. To achieve a low pH in the stomach, the fish must spend energy pumping H+ into the stomach lumen and, consequently, HCO3- into the blood. If the fish were able to obtain these H+ from a low pH diet, it is possible that they would not need to spend the energy sourcing them from the body. For this project, the metabolism of stomach, gill, and muscle tissue was measured to determine the effect that diet pH has on energy expenditure before and after feeding in rainbow trout (Oncorhynchus mykiss). All tissue samples were first homogenized. The supernatant for each homogenized sample was then used for an Electron Transport System (ETS) plate assay. Color change of the sample wells was read by a spectrophotometer to

measure ETS enzyme activity. More color change correlated to more metabolic activity. Our results in gill tissue aligned with our hypothesis that energy used for digestion would decrease with a decrease in diet pH. The stomach tissue metabolic activity results at diet pH 3.9 also aligned with our hypothesis that metabolic activity during digestive time would decrease with a decrease in diet pH. This was further supported 6 hours post-feeding when diet pH 3.9 expressed a lower metabolic activity than the diet with a pH of 6.3. However, trends in metabolism in the muscle (via ETS measurements) did not complement the metabolic trends seen at the whole animal level (via oxygen consumption), which was unexpected.

Acknowledgements: USP - Undergraduate Scholars Program, CBE - MSU Center for Biofilm Engineering

Policies and Planning Strategies to reduce Wildfire Risk in Bozeman's Wildland Urban Interface

Emily Howell, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

This research acknowledges the increasing intensity and frequency of wildfires and provides policy recommendations aimed at answering the guiding question, how can land use planning and precautionary measures decrease wildfire risk to homeowners in Wildland Urban Interface in the Bozeman area? Research on wildfire risk in Bozeman is synthesized as well as research on effective plans and strategies for wildfire risk reduction. The information is synthesized from various materials such as websites with interactive maps, newsletters, articles, and master plan documents. Recommendations such as increased public lands, ignition resistant homes, and fuel treatment are presented, attributed to the Bozeman area, and their strengths and limitations are discussed.

Acknowledgements: USP - Undergraduate Scholars Program

Modeling plant species distribution at Chief Mountain on the Blackfeet reservation

Shawna Illig, Land Resources & Environmental Sciences

Mentor(s): Anna Schweiger, Land Resources & Environmental Sciences

Grazing animals have a large effect on plant species distribution. This project investigates the effects grazing patterns as well as topographic effects on the distribution of native and

invasive species at Chief Mountain on the Blackfeet Reservation. By systematically surveying plant species and documenting the presence of invasive species, this project aims to enhance understanding of the ecological role of buffalo and inform management strategies for native flora and fauna. We established random transects and recorded their precise coordinates. Over the course of two summers, we survey the presence of 31 plant species, including on invasive species, as well as the presence of buffalo or other grazers. In the lab, we calculated and extracted additional environmental information for each transect that might explain plant species presence, including slope, aspect, elevation, and soil type. Next, we are using logistic regression models to predict plant species presence using plant community, grazing and environmental data as predictors. This research supports species conservation and aims to preserve cultural practices associated with buffalo within the Blackfeet community. The project is scheduled is continued throughout the 2025 academic year.

Acknowledgements: USP - Undergraduate Scholars Program

A Human Story: How Framing of Climate Change is No Longer About the Polar Bear

Andrew Kostick, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

Climate change is a daunting task that no single person feels equipped to address. However, communicating that people are not alone and can be the change does not start with images of polar bears and smokestacks. People feel that these types of images can be overplayed and are cliché. These images lack a human connection and do not bring the problem home for why it should be an issue. Effective climate change communication needs to be focused on human stories, showing a more nuanced picture of climate change. This can help to not trivialize the issue and direct people to be the change.

Acknowledgements: USP - Undergraduate Scholars Program

Burning for the Future: The Role of Effective Forest Management and Fire in Climate Regulation Through Carbon Sequestration and Decreased Emissions

Broderick Maidesil, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

Fuel loading in the American West, specifically the Northern Rocky Mountains, poses a significant threat as wildfire events occur with greater frequency and intensity due to climate change. Increased wildfire events are a significant risk to the carbon sequestration capacity of forests in the Northern Rocky Mountains and produce large amounts of greenhouse gas emissions and particulate matter. This synthesis provides an in-depth look at the relationship between forest management techniques in fuel load reduction and the reduced risk of high-severity wildfire events. It was found that techniques such as prescription burning and mechanical thinning of tree stands create greater fire resiliency while minimizing potential emissions. When utilized effectively, these techniques have a negligible effect on the total carbon pools of these forests. Effective forest management and adequate policy are crucial to minimizing the effects of climate change and preserving forest health.

How can home gardening reduce the carbon footprint of students in Bozeman?

Lucas Marlatt, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

This paper explores home or community gardening and how certain strategies can reduce the carbon footprint of students in Bozeman, Montana. Despite the quadrupling of carbon footprint created by community gardening, several techniques can mitigate the environmental impact. A review of existing literature shares the benefits of no-till farming, composting, planting climate-specific crops, implementing cover cropping, and implementing rainwater harvesting. Research shows that no-till practices increase soil organic carbon levels by up to eleven percent (Alhamied, 2017) and that composting can reduce food waste emissions by up to fifty percent (EPA, 2025). Additionally, selecting crops that thrive in Bozeman's climate minimizes resource waste. By integrating these strategies, students in Bozeman can reduce their environmental impact while growing their own food.

What policies can the City of Bozeman implement to combat the effects of climate change on our water sources?

Helena Mazzarella, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

Rising temperatures across the country have significant impacts on snowpack in mountain towns and high elevation regions that rely on yearly snowfall for their water sources. In Bozeman, rising temperatures threaten the freshwater ecosystems and drinking water sources, which are primarily dependent on snowmelt. The city gets majority of its water from Hyalite Reservoir and Sourdough Creek, but with climate change altering precipitation factors, we are going to see a shift in snowpack and runoff timing for the water budget. Data from the Environmental Protection Agency (EPA) and the Montana Climate Assessment show a decline in snowpack with increasing temperatures, which has the potential to lead to severe water shortages in the future. In response to our water budget being threatened, Bozeman has implemented various policies in the last ten years to mitigate water shortages and promote sustainable water use. However, these policies tend to rely heavily on the resident's voluntary contribution to conservation measures, which might fall short of sufficient as we see increasing temperatures. The city will need to go in the direction of exploring alternative steps, such as strengthening conservation measures for landscaping and irrigation specifically. Policies for residential areas and urban expansion as well, and exploring potential alternate water sources that can be used under water rights (Gallatin Valley being in a closed basin) will promote the conservation of Bozeman's water source. As Bozeman's temperatures continue to rise balancing water conservation with economic growth and urban expansion will require proactive support from the City of Bozeman to make sure long-term sustainability efforts are being taken.

How can "Buy and Dry" practices such as those used by Aurora inform future water policy in Colorado under various warming trajectories?

Indigo Miller-Barnes, English

Mentor(s): Paul Lachapelle, Political Science

The city of Aurora owns 95% of the water rights in the Rocky Ford Canal and has also bought up substantial land (water rights attached) in Crowley County, which is located just 10 miles north of Rocky Ford. Auroa pipes this water approximately 150 miles to provide its growing population with water for household use. This is an example of a practice donned 'buy and dry' and Crowley County has become the poster child for the negative impacts it has on rural communities. These negative impacts include economic ruin, cultural loss, and environmental degradation. As climate change continues to cause drought and water scarcity to increase in Colorado this practice has become more prevalent. Aurora has policies in place to provide compensation to these communities in the form of monetary gifts, the use of Alternative Transfer Methods, installation of center pivots, and

rehabilitation of the fields back to native grasses, but these communities are still being left at a large disadvantage that money can't make up for. With the increase in drought leading to more water scarcity across Colorado, the failures of this relationship can be used to create new policies for other municipalities that protect the rural communities that are vital to the state. Such policy could include the limitation of growth in urban areas, protection of water specifically for agricultural use, and creating mutually beneficial relationships between urban and rural communities.

How do the Consequences of Climate Change Disproportionately Impact Communities of Color in America?

Madeline Minutelli, Earth Sciences

Mentor(s): Paul Lachapelle, Political Science

The effects of climate change disproportionately impact people of color by contributing to health vulnerabilities. Urban planning in America has historically played a role in these inequalities, contributing to the marginalization of people of color in the face of a changing climate. Studies have shown that black communities are most likely to suffer from physical and mental health issues related to climate change, specifically the accelerated rates of global warming. By addressing the question of how the consequences of climate change disproportionately affect minorities living in urban American communities, this project synthesizes multiple reports from case studies, scientific research, and geospatial analyses. This research provides evidence of the relationship between communities of color and the harms of climate change, focusing on urban tree canopy distribution, urban heat islands, and redlining. The results of this project identify how these communities are impacted by climate change in contrast with predominantly white communities. The findings of this project also highlight historical planning techniques and how systemic racism plays a part in exacerbating these vulnerabilities. This project is written from the lens of environmental justice which is currently being challenged in America. With new policies aimed at dismantling language and action around climate change, such as America's defunding of EPA environmental justice programs and pulling out of the Paris Accords, a call to action at the end of this project recommends individual and local efforts to navigate through these adversities to continue the fight for a cleaner, safer climate for everyone.

Acknowledgements: MSU College of Letters and Sciences

Artificial Intelligence and the Environment: Data Centers and Their Impact in the United States of America

Connor Munson, Computer Science

Mentor(s): Paul Lachapelle, Political Science

The rapid growth of artificial intelligence (AI) has significantly increased energy consumption in data centers, raising concerns about sustainability. Data centers currently account for approximately 2% of US electricity demand, with AI workloads projected to drive a 50% increase in power consumption by 2027 and up to 165% by 2030 (IEA, 2022; Goldman Sachs, 2025). According to Han et al., "training an AI model of the Llama3.1 scale can produce air pollutants equivalent to more than 10,000 round trips by car between Los Angeles and New York City" (2024). This study examines the environmental impact of AI-driven data centers in the United States, focusing on their energy demands and carbon footprint. Additionally, it explores strategies for reducing energy consumption, including renewable energy adoption, efficient cooling technologies, and optimized AI model training. Addressing these challenges is essential for ensuring the long-term stability of widespread AI usage across the country and ensuring long-term environmental sustainability.

Acknowledgements: College of Letters and Science

The Spring Subsidy Mechanism

Blake Nestor, Land Resources & Environmental Sciences; William Weinberg, Graduate Stundent; Andrew Felton, Ecology

Mentor(s): Andrew Felton, Ecology

Grasslands exhibit large spatial variability in their sensitivity to drought. One underexplored mechanism of this variability is the role of vegetation phenology: the timing and the seasonal patterns of vegetation activity. Specifically, evidence suggests that extreme drought can stimulate earlier vegetation growth during the spring, enhancing photosynthesis, which can partially offset later reductions in photosynthesis during the hotter and drier summer months. However, the variability, prevalence, and importance of this "spring subsidy" mechanism in predicting and explaining spatial patterns of drought vulnerability is unknown. To investigate this spring subsidy mechanism, I used gridded satellite data of the great plains to draw conclusions and convert these conclusions into readable data figures.

Acknowledgements: USP - Undergraduate Scholars Program

Digging Deeper into Factors Influencing Soil Bulk Density

Skyler Ochs, Ecology

Mentor(s): Tony Hartshorn, Earth Sciences

As part of a USDA-funded effort to characterize baseline soil conditions across the Blackfeet Nation in northern Montana, I measured soil bulk density (BD; typical units of g cm-3) for more than 850 soil samples. Soil bulk density is a 'keystone' soil property; while it can generally reflect soil organic matter (SOM; more SOM typically results in lower BD), it is essential to reporting the mass of any soil property such as soil organic carbon (SOC) per unit volume (e.g., Mg SOC ha-1 0.3m-1). Even so, one recent rangeland SOC metaanalysis reported that ⅔ of scientific studies omitted BD. I discovered values averaging (±1SD) 1.27 ± 0.31 g cm-3 consistent with the mix of glacial till and unglaciated parent materials. Historical sampling across the Blackfeet nation reported a much more narrow range averaging 1.47 ± 0.14 g cm-3, with n=49 samples (Haigh et al. 1979). While my expectation had been that I would be able to detect a statistically significant decline in BD with increasing time since a soil was glaciated, my regression of 342 topsoil samples showed a relatively low value ($R^2=0.04$, $p<0.001$). One of the reasons for such high unexplained variance could be due to our landform age estimates, which were drawn from Fullerton et al. 2004, and intended for much coarser-scale interpretation. Future analyses should explore slope, aspect and effective precipitation as potential factors influencing BD.

Acknowledgements: MSGC - Montana Space Grant Consortium, USP - Undergraduate Scholars Program

How will a changing climate affect the average volumetric flow of the Clark Fork River Basin?

Quinn Rahl, Plant Sciences & Plant Pathology

Mentor(s): Paul Lachapelle, Political Science

Changes in the Clark Fork River Basin's flows are explained by comparing observations to general trends and available data across Montana and the western United States sourced from Montana State University Library and Google Scholar's databases. Warmer temperatures brought on by climate change have resulted in lessened average snowpack as the state's winters are drier and spring occurs earlier. In combination with regional

drought requiring more intensive irrigation practices, the water flow of the Clark Fork Basin has been diminished. With the total water consumption in the Clark Fork Basin projected to further increase by the state in the latter half of the decade, the current best way to try to mitigate the effects of reduced water access is to try to move our most consumptive industries, namely agriculture, toward more efficient irrigation methods.

Acknowledgements: USP - Undergraduate Scholars Program

How Can Chevron Deference be Reinstated to Address Climate Change?

Grace Ramey, Political Science

Mentor(s): Paul Lachapelle, Political Science

The Supreme Court's decision to overturn Chevron deference has significantly weakened the ability of federal agencies to enforce climate policies. Without this legal principle, courts now have more influence over environmental regulations, which creates uncertainty and delays in implementing necessary climate actions. This shift forces states to take on more responsibility, leading to inconsistent policies and enforcement across the country. Research shows that these changes will slow regulatory processes, reduce federal oversight, and result in more legal challenges to environmental protections. One solution is to restore Chevron deference, which would allow federal agencies to rely on scientific expertise, streamline policy implementation, and minimize political interference. Reinstating it would help create a more stable and effective approach to addressing climate change. Moving forward, legislative action is needed to ensure that environmental regulations remain strong and adaptable to ongoing challenges.

Acknowledgements: USP - Undergraduate Scholars Program

Evidence of Gastropod Predation on Unionid Bivalves in the Cretaceous Hell Creek Formation in Garfield County, Montana

Carly Ross, Earth Sciences

Mentor(s): John Scannella, Earth Sciences

The uppermost Cretaceous Hell Creek Formation of Montana preserves terminal Mesozoic ecosystems. In 1999, a juvenile Triceratops (Museum of the Rockies [MOR] specimen 1110) was discovered approximately 17 meters below the K/Pg boundary in the upper unit of the Hell Creek Formation in Garfield County, Montana (MOR locality HC-250, "SG-5 West").

Surrounding the dinosaur remains was a shell bed assemblage of freshwater bivalves and gastropods. The sampled SG-5 West invertebrate assemblage collected by MOR consists of 198 bivalves (five genera and ten species of Unionidae) and 36 gastropods (two genera and two species of Viviparidae). At least 72 of the bivalve shells exhibit small boreholes that appear consistent with traces of gastropod predation. Freshwater gastropod predation on bivalves has not been widely studied but has been observed before between Viviparidae and Unionidae. These boreholes provide a rare view of predator-prey interactions between fossil freshwater invertebrates. Ongoing study of the SG-5 West invertebrate assemblage will further resolve interactions among invertebrates and the paleoecology of the terminal Cretaceous Hell Creek Formation.

Acknowledgements: Museum of the Rockies, Bureau of Land Management

Maximizing Household Waste Reduction Through Waste Reduction Strategies: How Can a Single Person Make an Impact That Will Affect the Whole World?

Zofia Skiba, Earth Sciences

Mentor(s): Paul Lachapelle, Political Science

On average, it is shown that Americans produces 4.9 pounds of trash per person per day. This thought might not be that concerning when considering how heavy 4.9 pounds is. However, this amount seems alarming when considering how many people there are on the planet and how long this waste has been collecting for. This research addresses the current state of waste production throughout households and how an individual can make a meaningful impact on reducing waste. Studies will be presented that show, common waste among households, waste production percentages, the effects of waste on our planet, and actions that individuals can take to help reduce their waste. By understanding the severity of the climate change issue and applying personal waste reduction strategies, individuals can help contribute to large-scale environmental changes that impacts many.

Understanding The Body Posture of a Wayan Formation Oryctodromeus: Is It Indicative of Death in a Burrow?

Ethan Spence, Earth Sciences; L.J. Krumenacker; Zakaria Hannebaum, Earth Sciences

Mentor(s): David Varricchio, Earth Sciences

Oryctodromeus cubicularis is a small orodromine dinosaur from the Cenomanian age that is the first of its kind to exhibit fossorial behavior. In 2013 an Oryctodromeus, IMNH 2438,

was recovered from the Wayan Formation of Idaho. IMNH 2438 is a highly articulated skeleton of Oryctodromeus contained in two blocks of fine-grained sandstone. Preparation was conducted using airscribes to remove the sediment around IMNH 2438. From one of the sandstone blocks the posterior end of INMH 2438 began to be exposed; bones identified have been two ilium, the sacrum, tibia and fibula, and the left foot containing metatarsals and phalanges. The left leg was resting ventral to the ilium showing that IMNH 2438 was buried in a tucked in or fetal like position. The goal of this research was to understand the death position of IMNH 2438. To achieve this, multiple methods of preparation were conducted to unveil more of IMNH 2438. Methods of preparation were the continued use of airscribes, multiple citric acid soaks, and a computer tomography (CT) scan to observe the bones in situ. IMNH 2438 was compared to other Oryctodromeus specimens from published literature found in both the Wayan Formation and the equivalent Vaughn Member of the Blackleaf Formation. These comparisons to other specimens were to gather a base of evidence to support the hypothesis that IMNH 2438's death position was indicative of death within a burrow. While preparation is still ongoing, the revealed skeleton shows little disturbance during burial adding support to this hypothesis.

Acknowledgements: USP - Undergraduate Scholars Program

Are Roundabouts Really Reducing Vehicle Emissions?

Aubrey Tuss, Political Science

Mentor(s): Paul Lachapelle, Political Science

This study will explore whether roundabouts have meaningful environmental benefits, especially in the terms of emissions from vehicles and whether investments in roundabouts are justifiable. Using data from multiple studies and emission simulations, they examine levels of many emissions such as CO2, CO, and NOx at stoplights and roundabouts. Traditional roundabouts reduce CO and CO2 emissions; however, they do increase NOx emissions. In contrast, smart roundabouts significantly reduce all emissions across all measured pollutants. Results showed that there was a 61.64% reduction in CO2, 63.93% in CO, and 47.83% N0x emissions with smart roundabouts. The research suggested that traditional roundabouts offer minimal environmental advantage for their high cost, however smart roundabouts provide a more sustainable and cost-effective alternative. The research utilized PEMS and other software for competitive analysis. Based on these findings we should prioritize smart roundabouts for future infrastructure projects aiming to reduce environmental impact.

A new elasmosaurid plesiosaur from the Cretaceous Bearpaw Shale of Eastern Montana

Emyr Weaver, Earth Sciences

Mentor(s): John Scannella

In the Late Cretaceous Period, the Western Interior Seaway bisected North America and was inhabited by a diverse array of marine reptiles, including crocodilians, turtles, mosasaurs, and plesiosaurs. Plesiosaurs ranged from formidable apex predators to slower-moving generalists. One of the most well-known groups of plesiosaurs is the elasmosaurs, which evolved small heads on sometimes extremely long necks. In 2006, the complete skull and partial neck of an elasmosaur (Museum of the Rockies [MOR] specimen 2577) were discovered in the Cretaceous Bearpaw Shale of eastern Montana. MOR 2577 is referable to elasmosauridae based on cervical vertebrae characteristics and cranial details such as an overall triangular head and a rostrum comprising less than half the skull. At least eight partial cervical vertebrae were collected. Both the upper and lower jaws are preserved and exhibit asymmetrical tooth counts with at least 68 total; however, only two teeth are preserved in place, with four additional teeth found associated with the specimen. The morphology of the preserved teeth is consistent with generalist predation on small-bodied prey. Affinities with other elasmosaurids are currently unclear, as the specimen does not exhibit autapomorphies of coeval taxa such as *Nakonanectes* and *Styxosaurus*. Further, MOR 2577 uniquely possesses only four premaxillary teeth, a reduced coronoid process and an elongate base of the braincase. As such, MOR 2577 may represent a new elasmosaurid taxon. Further study of this specimen's anatomy and relationships will provide a better understanding of the ecology and niche partitioning of the Western Interior Seaway.

Acknowledgements: USP - Undergraduate Scholars Program

How can information and communication technology's carbon footprint be reduced in both production and power consumption

Ryan Young, Political Science

Mentor(s): Paul Lachapelle, Political Science

This research reflects on greenhouse gas emissions generated by the gaming and information and communication technologies industry. Addressing the most obvious and

forefront problem that is the term “internet pollution” has been a popular term to describe the energy required to store and transmit data across the internet. For example, a study from Lancaster University found the PlayStation 4, developed by Sony, “has produced over 8.9 billion kilograms of CO2 since its release”(2024). These costs are only related to the production of the console and does not even begin to address the costs of developing the software itself. Even with the more sustainable switch to cloud server-based gaming, etc. From the same study done by Lancaster University, the researchers found that “almost 3.7% of all global greenhouse gas emissions” were from this energy usage. While the impact internet users could make on the world might seem small, over 50% of the entire world population has or does play video games, communicates over the internet with others, or will download and stream movies and other media. Simply by streaming games and media at slightly lower quality or sending emails with fewer filler words, the internet users of the world can make a difference. To put that in perspective “If every adult in the UK sent one less ‘thank you’ email, it could save 16,433 tons of carbon a year[mtCO2e]– the equivalent to taking 3,334 diesel cars off the road” according to energy company, OVO. This research highlights the impact of ICT on the environment and explores policy changes to combat its effects.

Effects of Exposure to Air Pollution in Unborn and Young Children on Brain Development and Cognitive Function

Mackenzie Ziegler, Political Science

Mentor(s): Paul LaChapelle, Political Science

With 93% of children under the age of 15 breathing in heavily polluted air (World Health Organization, 2018), the issue of air pollution and its effects on children are more important than ever before. Though a relatively new field, prenatal and youth exposure to severe air pollution has been shown to have serious negative effects for brain development and structure. Despite their claims, current regulations to limit air pollution are not strict enough to prevent serious damage to children. This research explores how exposure to air pollution in unborn and young children effect brain development and cognitive function. Ultimately, stricter regulations need to be implemented to ensure that children do not experience disruptions to brain health and structure. Policy changes to help implement these regulations target further research, improving traffic and industrial emissions, creating clean air zones for children, and providing additional support for at-risk individuals and communities.

ECOLOGY

Analyzing Temperature Effects on Salmonflies Using a Novel Millifluidic "Brain on a Chip"

Kuper Banghart, Chemical & Biological Engineering; Christine Verhille, Ecology; Stephan Warnat, ECE; Michael Neubauer, ECE

Mentor(s): Anja Kunze, Electrical & Computer Engineering; Mackenna Landis, Electrical & Computer Engineering; Kuper Banghart, Mackenna Landis, Stephan Warnat, Christine Verhille, Michael Neubauer, Anja Kunze, ECE, MONT, TEER, Dept of Ecology

Pteronarcys californica (giant salmonflies) are essential to Montana's ecosystem, supporting top predators such as adult trout. Their presence also serves as a strong indicator of ecological health. However, salmonfly populations are declining. Since these insects are ectotherms, it is hypothesized that rising temperatures due to rapid climate change have contributed to their decline. Current methods for testing salmonflies' response to temperature change involve raising the temperature in a controlled salmonfly habitat until the insect perishes. This method provides little insight into the physiological stress responses and underlying mechanisms of signal coordination and transduction inside the salmonfly's nervous system. We are developing a novel solution using brain-on-a-chip technology to address these limitations. Rather than simulating temperature changes in an artificial habitat, our approach isolates key brain regions, immersing them in nutrient broth, then transporting them through PDMS millifluidic channels. The brain regions are then captured in traps positioned over electrodes to record neuronal activity during temperature fluctuations.

This solution provides real-time quantitative data on how the brain responds to temperature changes, offering valuable insight into the mechanisms behind thermal stress in ectotherms. This tool could reshape experimental design for studying climate change's impact on insect populations, enabling more detailed and accurate ecological research.

Acknowledgements: MONT

Crayfish Burrowing Behavior Under Global Change

Lydia Bushey, Land Resources & Environmental Sciences

Mentor(s): Lindsey Albertson, Ecology

Biological invasions are one of the most pressing threats to ecosystem stability and biodiversity in freshwater systems. Crayfish are an invader of increasing concern across

Montana, due to their niche versatility and role as an ecosystem engineer (an organism that modifies its environment; effecting the availability of resources and habitats for other organisms) with regards to their bioturbation activities. The presence of burrows has the potential to buffer against climate stresses for other freshwater organisms by providing physical refuge in low flow conditions and maintaining biogeochemical cycling in the hyporheic by introducing oxygen and moving sediments downstream (decreasing local deposition). Montana FWP recently determined that all crayfish species within the state were non-native. One such species, the virile crayfish (Faxonius virilis) are one of the most successful (and least-researched) invaders across the contiguous United States. Most research regarding the impact of crayfish as invasive species in America regards the signal crayfish (Pacifastacus leniusculus) due to the widespread bank collapse caused by their burrows in Europe. It is likely F. virilis could have similar effects under global change, as related species have been shown to increase burrowing behavior when stressed. As water temperatures increase, virile crayfish have the potential to greatly impact the resilience of their environment through increased sediment movement and burrow construction. In this study, we aim to determine if F. virilis will exhibit increased sediment sorting behavior under elevated water temperatures in (1.) soft sediments mimicking a stream bank and (2.) larger loose gravels representing streambed surfaces.

Acknowledgements: USP - Undergraduate Scholars Program

Feeding Under Fear: The Unseen Influence of Parasitic Wasps on Aphid Feeding

Karli Gowen, Ecology

Mentor(s): Jessica Kansman, Plant Sciences & Plant Pathology

Predator-prey interactions are fundamental relationships within ecological systems. The risk of predation alone can have significant impacts on prey populations. Predation risk can induce various behaviors and responses in prey that can affect the prey's population size, considered as a non-consumptive effect on the prey. Insects provide an ideal system to investigate non-consumptive effects due to their size and key roles in ecosystems. One key interaction is parasitism, where female parasitic wasps lay their eggs inside of insect hosts, slowly killing the host as the larva develops. Previous research has found that parasitic wasps (Aphidius colemani) exhibit significant non-consumptive effects on aphid populations (Myzus persicae). For this project, we wanted to understand how parasitism risk influences aphid feeding by quantifying aphid-feeding behavior in the presence of parasitic wasps using the electrical penetration graph technique. The aphids were wired through a clip cage and then hooked up to the EPG system, and a wasp was added to the

cage during the recordings. Then, the wavelength outputs were analyzed and compared to the control cages without wasps. This experiment is novel because electrical penetration graph recordings of aphid feeding during parasitoid encounters have never been performed before. By using the EPG, we can acquire a better understanding of the interactions between parasitic wasps and aphids.

Acknowledgements: USP - Undergraduate Scholars Program

Exploration of Predatory Behavior versus Facilitation from Caddisfly Species

Elizabeth Herres, Earth Sciences

Mentor(s): Lindsey Albertson, Ecology; Samuel Fritz, Ecology

Net-spinning caddisflies (Trichoptera: Hydropsychidae) are both ecosystem engineers facilitate other stream macroinvertebrates and omnivores that can predate on those same macroinvertebrates. Yet the strength of caddisfly predation effects on macroinvertebrate communities is relatively unknown. We analyzed the diets of the net-spinner *Arctopsyche grandis* using flumes collected in the field stocked with varying numbers of *A. grandis* at different developmental stages (instars). We hypothesized that predatory behavior was associated with increased *A. grandis* density or mature *A. grandis* instars. We found a positive correlation between later instar stages and larger proportions of animal matter in the gut contents. This discovery highlights a previously unexamined ecological role of *A. grandis* and contextualizes the characterization of these insects as beneficial facilitators. It also corroborates prior research showing that developmental stage is an important driver of macroinvertebrate diet composition. *A. grandis* specimens contained more diatoms in their gut contents than previously described by other researchers. Differences in this data compared to previous research may be attributed to enhanced magnification during gut content analysis, a change in location, or a change in season. Our gut content analysis using a higher magnification shows the fuller extent of microscopic diatoms that compose a substantial portion of the gut contents. Our analysis suggests that instars may be a stronger driver of diet composition than population density, and that predation by net-spinning caddisflies could be an underappreciated biotic interaction that drives benthic macroinvertebrate community composition.

Acknowledgements: USP - Undergraduate Scholars Program

Characterizing Coldwater Habitats in Streams of Western Massachusetts

Max McGrath, Ecology; Allison Roy,; Anna Baynes, Department of Organismal and Evolutionary Biology, University of Massachusetts, Amherst; Melissa Rymaszewski, Department of Earth, Geographic, and Climate Sciences, University of Massachusetts, Amherst

Mentor(s): Allison Roy, US Geological Survey, Massachusetts Cooperative Fish and Wildlife Unit

In an age of global warming and changing climates, coldwater habitats may provide critical refugia for coldwater fishes with rising water temperatures and more frequent droughts. Coldwater habitats are pockets of water that are at least 2 degrees celsius colder in temperature than the rest of the stream. Coldwater fishes cannot inhabit warm streams and may die with sudden or gradual increases in water temperature. Our goal was to characterize spatial and temporal variability in coldwater habitats.We conducted surveys along four streams inhabited by coldwater fishes in Western Massachusetts to locate and monitor potential coldwater habitats. We used Forward Looking InfraRed cameras to search for cold water seeps along stream banks and a temperature probe to search for deeper coldwater habitats. Coldwater patches (i.e., areas >0.3 m2) were monitored biweekly for physical habitat (area, depth, bed texture, cover) and water quality (dissolved oxygen, pH, specific conductivity). Temperature loggers were installed to measure continuous temperature within coldwater patches throughout the summer. Combined with research on trout activity in these streams, this information may provide new and useful information on how coldwater species cope with increasing temperatures.

Acknowledgements: USGS and Massachusetts Division of Fisheries and Wildlife

Characterizing Environmental Effects on Grizzly Bear Consumption of Yampa and Ants in the Greater Yellowstone Ecosystem

Riley Parker, Ecology; Elise Loggers, Ecology

Mentor(s): Andrea Litt, Ecology

Grizzly bears (Ursus arctos) are opportunistic omnivores with a diverse and season-dependent diet; they consume more than 266 species in the Greater Yellowstone Ecosystem (GYE). The short growing season in the GYE, combined with grizzly bears being hibernators, constrain the amount of time that grizzly bears have to meet their annual energetic requirements. Bears consume vegetation in association with its caloric and protein content, factors that are correlated with environmental variables such as snowmelt timing, cumulative precipitation, and temperature. Additionally, fire mosaics, created by

variation in fire occurrence and severity, influence the presence of ants. Below-ground vegetation (e.g., roots, tubers) and ants (e.g., Formica spp., Camponotus spp.) collectively comprise about 50% of the diet of grizzly bears in the GYE. I am investigating how changes in snowmelt, precipitation, fire presence and severity, and other environmental variables affect when and where grizzly bears consume different foods, with a specific focus on yampa (Perideridia gairdneri borealis) tubers and ants. By integrating information from historical surveys of radio-tracked grizzly bears and remotely sensed environmental data in the GYE, I am testing hypotheses that will allow us to understand how consumption of food resources important to grizzly bears changes with variation in the environment.

Acknowledgements: USP - Undergraduate Scholars Program

An assessment of ecological resilience of plant communities to climate change across the United States

Aidan Peers, Microbiology & Cell Biology; Alyssa Walters, Department of Ecology; Monica Lohr, Department of Earth Sciences; Michael France, Department of Ecology

Mentor(s): Israel Borokini, Ecology

Climate change is predicted to have expansive impacts on species persistence and the dynamics of ecological communities. However, these impacts are expected to vary across spatial scales and in different ecological regions. As a result, this study aimed to investigate how plant communities have responded to climatic perturbations in the last 10 years, as a proxy for assessing their resilience to a changing planet. We leveraged the long-term field surveys of plant presence and percent cover information collected by the National Ecological Observatory Network (NEON), using data from one site in each of the 20 ecological domains. We used temporal turnover metrics to assess changes in plant composition and abundance between the oldest possible and the most recent (in this case, 2023 data) surveys in over one hundred 1 m2 plots. Results from analyses in some of the 20 sites show different responses. We observed overall increases in species composition and abundance in the following places: Healy, Alaska (29 of 40 plots); San Joaquin Experimental Range, California (13 of 18 sites); Guánica Forest, Puerto Rico (98 of 126 sites); and Harvard Forest and Quabbin Watershed, Massachusetts (74 of 138 sites). However, overall floristic decreases were noted in Lyndon Johnson National Grassland, Texas (15 of 18 plots). These 15 NEON sites experienced minimal human activities so we can attribute these observed floristic changes to climate variability. Thus, findings highlight varying degrees of resilience in plant communities and ecological regions and can be used to inform conservation priorities in policy. Moreover, this study shows the importance of

long-term datasets in evaluating the vulnerability of species and communities to climate change.

Alyssa Walters[1#*], Aidan Peers[2], Monica Lohr[3], Michael France[1*], and Israel Borokini[1**]
[1] Department of Ecology, Montana State University, Bozeman [2] Undergraduate student, Department of Microbiology and Cell Biology, Montana State University, Bozeman [3] Post-Baccalaureate student, Department of Earth Sciences, Montana State University, Bozeman
* Graduated from the Department # Recipient of USP research grant **Faculty mentor

Acknowledgements: USP - Undergraduate Scholars Program

Disparity in range size and ecological niches of flower color polymorphic species and their monomorphic sister taxa

Karl Raban, Ecology; Aislinn Kisner, Biochemistry; Aliyah Poxleitner, Agriculture

Mentor(s): Israel Borokini, Ecology

This study addresses whether species exhibiting flower color polymorphism occupy larger geographic ranges and ecological niches compared to their closely related monomorphic sister taxa, thus assessing the adaptive significance of flower color variability for ecological niche breadth and geographical distribution. We identified 70 pairs of floral polymorphic species and their monomorphic sister taxa from existing literature and phylogenetic analyses. Geographic distribution data were obtained from the Global Biodiversity Information Facility (GBIF). We calculated range sizes using Area of Occupancy (AOO) and Extent of Occurrence (EOO) metrics. Climatic and edaphic niche overlap between species pairs was analyzed using Principal Component Analysis (PCA) and Schoener's D niche overlap metrics, coupled with niche equivalency randomization tests. Floral polymorphic species had significantly larger geographic ranges compared to monomorphic relatives, with an average nine-fold greater AOO and approximately double the EOO. Niche overlap among species pairs was generally high (Schoener's D ranging from 0.001 to 0.92), with niche stability predominant in 68 of the 70 analyzed pairs. Although most pairs exhibited niche conservatism, niche divergence occurred in eight cases. Additionally, monomorphic species' geographical range size was positively correlated with niche overlap. Floral polymorphism is strongly associated with larger geographical distributions and broad ecological niches, likely reflecting an adaptive advantage in response to spatially variable biotic and abiotic conditions. Flower color polymorphism may thus promote persistence and ecological success across diverse environmental gradients.

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***Temperature and riverbed substrate effects on salmonfly nymph (Pteronarcys californica) behavior, performance, and acclimation*.**

Ryan Rintala, Ecology; Chris Sailors, Ecology

Mentor(s): Christine Verhille, Ecology

Giant salmonflies (Pteronarcys californica) are native to coldwater streams of North America. This aquatic invertebrate is indicative of clean water, and fish populations are known to be seasonally reliant on salmonflies as a food source. This research investigates the interactive effects of substrate size (refuge pore space) and temperature exposure on the performance and acclimation of salmonfly nymphs in simulated river environments. Our two-phased experiment manipulates substrate conditions across an ideal (15C) and an elevated (20C) water temperature to assess how these variables interact and affect nymph performance, acclimation, and behavior. Nymphs were kept in riverine flumes to best mimic a fluvial environment, and nymphs in flumes were tracked daily to assess habitat structure interactions and feeding activity. Resting metabolic rate (RMR) and thermal tolerance (CTmax) were quantified post-exposure to assess physiological acclimation. Results will reveal the extent to which substrate size and warming temperatures influence nymph behavior, growth, and metabolic rates, with implications for understanding how climate change may impact freshwater invertebrate species reliant on coldwater habitats with ideal stream sediment.

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Acknowledgements: USP - Undergraduate Scholars Program

How do the effects of climate change affect trout populations in the Madison River?

Eli Willard, Political Science

Mentor(s): Paul Lachapelle, Political Science

The introduction details the how climate change is affecting rivers within Montana and is likely affecting the Madison River. The literature review highlights sources and the evidence they provide regarding the Madison River. The evidence provided supports claims of climate change affecting the Madison River. The results and discussion focus on the outcomes of climate change and what damage it is going to bring to the future trout and rivers across Montana.

EDUCATION

Bringing the Excitement of Eclipse Ball to Your Program

Keegan Beier, Health & Human Development; Ellen Olson, FSNK; Seth Norlsien, FSNK; Mady Osler, FSNK; Mya Hadley

Mentor(s): Karie Orendorff, Health & Human Development

Presented at the Hawaii Association of Health, Physical Education, Recreation, and Dance (HAHPERD) Conference in Honolulu, Hawaii, this engaging session introduced over 40 participants to the dynamic and fast-paced net game of Eclipse Ball. With more than 100 attendees at the conference, this session provided an opportunity for educators to experience firsthand how Eclipse Ball can energize students and promote skill development in a fun and inclusive way. Eclipse Ball combines the camaraderie of volleyball, the spontaneity of badminton, and the excitement of tennis, all while emphasizing teamwork, strategy, and continuous play. Designed with action and enjoyment in mind, the game encourages vigorous volleys that aren't easily terminated, giving players a "second chance" to keep rallies alive and extend the excitement of each play. This unique combination fosters an engaging, low-pressure environment where students of all skill levels can participate and thrive. Participants in this session actively engaged in gameplay, explored the fundamental skills and rules of Eclipse Ball, and discussed strategies for integrating it into their physical education curriculum. By incorporating Eclipse Ball into the classroom, educators can create a dynamic and inclusive learning experience that promotes movement, cooperation, and fun—all while reinforcing essential motor skills. This session demonstrated that, with Eclipse Ball, the thrill of an eclipse doesn't have to be a rare occurrence—it can happen time and time again in your classroom!

Acknowledgements: EHHD Travel Fund

eDucATE: Building Montana's Agricultural Educators

Breanna Blain, Department of Agricultural and Technology Education

Mentor(s): Emily Sewell, Department of Agricultural & Technology Education

Recruitment and retention of agricultural educators is critical for the future of agriculture, youth and student development, and our societal needs. The Department of Agricultural and Technology Education at Montana State University is the state's primary institution for preparing agricultural education teachers and extension educators. eDucATE is an upcoming opportunity for high school students in Montana to explore formal and informal agricultural education, build relationships with alumni, stakeholders, and future peers, as well as be exposed to agricultural education practices. The purpose of this research study

is to determine if the eDucATE Academy is influencing its participants toward a college major and career as educator for the agricultural industry. Four research objectives guide this study: 1) Describe level of satisfaction for experiences during eDucATE, 2) Determine the impact of eDucATE on participants' intention to pursue Agricultural Education as a college major, 3) Determine the impact of eDucATE on participants' intention to pursue Agricultural Education as a career choice and 4) Describe the influence of peer mentorship experiences in creating a sense of belonging during eDucATE and beyond. Satisfaction in the academy will be measured through survey and qualitative research methods with the participants. Presumably, students will indicate a significant difference in their intent to teach agricultural education after attending eDucATE and will share purposeful stories of their peer mentorship experiences. However, eDucATE is scheduled to take place in June 2025 and we are currently in the planning phase of this experience and research study.

Acknowledgements: USP - Undergraduate Scholars Program

Teaching with SHAKA Style: A Day of Teaching and Service in Hawai‘i

Rayna Gehring, Health & Human Development; Peter Townsend, FSNK; Wyatt Theard, FSNK; Charles Peake, FSNK; Mary Sanchez

Mentor(s): Karie Orendorff, Health & Human Development

Kahuku High & Intermediate School (KHIS) has been a cornerstone of academic, artistic, and athletic excellence in Hawai‘i since 1897. With a vision of "Learning today for lifelong success in College, Career, and Community," KHIS embraces the Spirit of ‘Ōhana and values the engagement of all stakeholders in fostering a safe and equitable learning environment for all students. Known for its dominant football program—boasting the most state championship wins in Hawai‘i and, at one point, having a graduate on every NFL team—KHIS stands as a beacon of resilience, pride, and achievement. KHIS would be the equivalent of an inner-city school in major metropolitan areas like Los Angeles, Houston, or Atlanta. Leveraging professional connections in Hawai‘i, we seized the opportunity to extend our conference experience beyond professional development and into service. Since the HAHPERD Conference was only one day, we chose to spend an additional day teaching Middle School and High School Physical Education at KHIS. Throughout the day, we taught four periods, each consisting of 3-4 classes, engaging students in a diverse range of activities. These included games we presented at the HAHPERD Conference (Eclipse Ball, Theraband Slingshots), games we learned in MSU courses (ROCKS, YOSHI, Hula Hut Throw Down), and new activities we discovered at the HAHPERD Conference (Fitness Handshakes).

This experience not only allowed us to apply our skills in a real-world setting but also reinforced the importance of service, adaptability, and cultural exchange in physical education. By sharing innovative and engaging activities with KHIS students, we contributed to their learning while gaining invaluable teaching experience in a unique and vibrant school community.

Acknowledgements: EHHD Travel Fund

Fitness Fun with MSU

Cassidy Hoffman, Health & Human Development; Oliver Woodford, FSNK; Ryder Wald, FSNK; Olive rWoodford, FSNK; Ady Sawyer

Mentor(s): Karie Orendorff, Health & Human Development

The fun, enthusiastic and knowledgeable Health Enhancement (HE) students from Montana State University presented an engaging and dynamic session at the Hawaii Association of Health, Physical Education, Recreation and Dance (HAHPERD) in Honolulu, Hawaii. The session was filled with innovative fitness activities designed to inspire movement, creativity, and fun! Drawing from cutting-edge ideas and best practices they have gathered at national conferences across the country, these future educators introduced participants to a variety of interactive exercises that promote both physical activity and cognitive engagement. We gave over 25 attendees the opportunity to experience unique and exciting challenges, such as Theraband Slingshots—a fun and effective way to enhance strength and coordination—and interactive fitness games that seamlessly incorporate academic concepts like States and Capitals to reinforce learning through movement. This session was designed to teach activities for students at all ages and fitness levels, whether you're looking to expand your exercise repertoire, discover fresh approaches to physical education, or simply enjoy an action-packed experience with others. It was a great opportunity to teach the PE teachers of Hawaii different games to get active, learn something new, and engage with the MSU HE students as we showcased our passion for health, wellness, and creative movement!

Acknowledgements: EHHD Travel Fund

Impact of Teacher Clarity on High School Senior Educational Outcomes

John Shelton, Education

Mentor(s): Josh Herring

Sentinel High School in Missoula, Montana aims to implement a standardized, school-wide procedure for delivering teacher clarity to classes for the 2025-26 school year. Teacher clarity is a strategy for educators to justify their lessons in the classroom by explaining "what we will be learning, why we will be learning it, and how I will know I've learned it." This project aims to quantify learning results related to this initiative by establishing a benchmark level of "student direction awareness" (the formative knowledge of how and why classroom activities are being delivered) in three sections of Senior English. In the lead up to a unit on The Handmaid's Tale that I, a student teacher, will be leading, students will receive a survey whose aim is to answer how frequently they knew the reasoning for lessons and curriculum choices in the classroom. Throughout the four-week testing period, each lesson will begin with a recitation of the "what, why, and how" while students will randomly be surveyed during the period on those exact aforementioned questions. At the end of the unit, a final survey will be administered to monitor student engagement with the unit after having received this classroom intervention.

Belonging and Learning Immersion: Insights from African International Graduate Students in the U.S.

Emmanuel Teye, Education

Mentor(s): Bryce Hughes, Education

Higher education institutions benefit significantly from international students who bring diverse perspectives and experiences, fostering innovation and enrichment across various academic fields. However, engaging these students presents a challenge due to their high enrollment numbers and frequently inequitable experiences. Research on their engagement, integration, and motivational factors is still underdeveloped. Specifically, there is limited understanding of how a sense of belonging may predict learning immersion among African international graduate students in the United States.

This study utilizes data from 108 piloted survey of African international students, analyzed through structural equation modeling (SEM), to examine the relationship between a sense of belonging and dimensions of learning immersion. Findings suggest that while a sense of belonging (Mean=4.534) positively impacts academic enjoyment (Mean=3.979), at [S.E =0.333*] it does not significantly influence intrinsic motivation (Mean=0.2.770) at [S.E = 0.123] and the absorption dimension (Mean=0.2.134) at [S.E = -.83] of immersion. These mixed results highlight crucial implications for researchers and higher education policymakers. It is vital for institutions to understand these students' needs and tailor services to enhance their integration and learning experiences. Drawing on the

acculturation stress perspective, the study contends that international students may allocate cognitive resources to managing adaptation challenges, a process that may impede their academic engagement and motivation and as such warrants follow up research. The paper discusses possible intervention areas that higher education institutions can consider to better support these students.

ENGINEERING AND TECHNOLOGY

Experimental Analysis of the Modal Dynamics of Tapered Hydrofoils and their Effect on Propulsion

Brock Anderson, Mechanical & Industrial Engineering; Brysen Mitchell

Mentor(s): Sarah Morris, Mechanical & Industrial Engineering

The propulsion of aquatic and aerial species often relies on flexible, deformable appendages that interact dynamically with surrounding fluids. Research has shown that tapered hydrofoils, which exhibit varying stiffness along their chord, can generate efficient thrust through traveling wave kinematics. This study aims to investigate the effects of heaving amplitude on the modal dynamics, vortex wake structures, and propulsion efficiency of tapered hydrofoils. Extensive effort was put towards the design and development of a system capable of providing specific vibratory inputs to a prototyped tapered hydrofoil while synchronously gathering response data. The integrated components that were designed around were a scanning laser vibrometer for modal characterization, vibratory shaker for wing inputs, and a force-torque transducer for force measurement. Through design iteration we have completed a minimally invasive fully integrated testing system which is capable of providing desired inputs and collecting data without significant interference with fluid response. Experimental measurement of fluid response was done with fluorescein dye flow visualization for flow field qualification, as well as preliminary data collection from the integrated force-torque transducer. Flow visualization was conducted across the frequency ranges of 0.4hz to 5.45hz and amplitude ranges of 0.5mm to 3.0mm (3.7E-3 Lchar to 20E-3 Lchar). This testing revealed reverse Von Karman Streets, which is consistent with the findings in other traveling wave research and examples in aquatic animals. By synchronizing data from these methods, we aim to continue to identify the correlations between traveling wave phenomena down the chord of the wing and their effects on efficiency, forces, and drag-power coefficients.

The outcomes of this research will enhance the understanding of bioinspired propulsion mechanisms and contribute to the optimization of flexible hydrofoil designs for engineering applications.

Acknowledgements: USP - Undergraduate Scholars Program

Utilizing Bio-mineralization to Mitigate Acid Mine Drainage and Heavy Metal Runoff

Avery Auth, Civil Engineering

Mentor(s): Ellen Lauchnor, Civil Engineering

Acid mine drainage (AMD) occurs when pyrite and other sulfide-containing materials are oxidized, resulting in the formation of acidic runoff and the leaching of harmful metals. This research explores the potential of using microbially induced carbonate precipitation (MICP) to inhibit AMD from coal mine waste. Since oxidation typically occurs on the surface of the mine tailings, a carbonate coating has the potential to greatly reduce acid production. Previous research has demonstrated the ability of the bacterium to precipitate calcium carbonate through ureolytic reactions. MICP has the potential to form a carbonate coating on mine waste rock, reducing contact between the waste material and runoff water. Bench-scale tests were conducted to assess the potential of this process. Urea, calcium, and pH were measured, followed by a leaching test and microscopy to determine the effectiveness of MICP treatment. This research demonstrates the ability of S. pasteurii to form a carbonate coating on the mine tailings, and explores the feasibility of using bacteria to inhibit acid production and heavy metal runoff from the sample.

Acknowledgements: NSF EcoStart Program

Methods to evaluate biofilm removal from coupons in the Industrial Surfaces Biofilm Reactor, a novel system for industrial coating defacement testing

Kalena Awram, Chemical & Biological Engineering; Kylie Bodle, Center for Biofilm Engineering; Ghazal Vahidi, Center for Biofilm Engineering; Brent Peyton, Center for Biofilm Engineering; Heidi Smith, Center for Biofilm Engineering

Mentor(s): Brent Peyton, Chemical & Biological Engineering

The Industrial Surfaces Biofilm Reactor (ISBR) is a novel type of biofilm reactor used to cultivate biofilms under intermittently wet, high gas transfer environments. Within the ISBR, biofilm is grown on reusable polycarbonate “coupons”. Coupons must be thoroughly cleaned between experiments to ensure accurate experimental results, because the sterilization process may not kill specific spores and fully remove the biofilm matrix. If not thoroughly cleaned, the risk for new cell growth increases as the biofilm matrix can provide nutrients for new cells post autoclaving. This study assessed the completeness of biofilm

removal with increased coupon cleaning stringencies. Cell counts were used to verify the absence of viable cells on coupons after cleaning. Biofilm matrix removal was assessed by determining coupon-associated protein concentrations, as protein is a major component of the biofilm matrix. Both methods were used to quantitatively assess how increased cleaning stringency positively impacted biofilm removal. Lastly, microscopy was used to qualitatively evaluate how completely biofilm was removed under different cleaning stringencies. This experiment is part of a larger project in which ISBRs will be used to grow biofilms on different industrial coatings and resulting coating defacements will be evaluated. The ultimate objective is to identify specific coating formulations that will minimize biofilm growth on military vehicles and thus reduce vehicle maintenance needs.

Acknowledgements: USP - Undergraduate Scholars Program

Engineering the Properties of Bioplastics with the Addition of Cellulose Nanofibers

Ritu Bajwa, Mechanical & Industrial Engineering

Mentor(s): Dilpreet Bajwa, Mechanical & Industrial Engineering; Ismat Ara, Mechanical & Industrial Engineering

The increasing demand for sustainable materials has driven research into bioplastics as alternatives to petroleum-based polymers. While bioplastics such as polylactic acid (PLA) and Solanyl (SL) offer biodegradability and reduced environmental impact, their mechanical limitations hinder broader adoption. This study explores the reinforcement of PLA and SL with cellulose nanofibers (CNF) and cellulose nanocrystals (CNC) to enhance mechanical strength, thermal stability, and water resistance while maintaining biodegradability.

Bioplastic composites will be fabricated using twin-screw extrusion and direct-drive pellet extrusion-based 3D printing. Twelve formulations were developed by varying the bioplastic type (PLA or Solanyl), nanofiller type (CNF or CNC), and nanofiller concentration (1%, 3%, and 5%), with a 1% maleic anhydride coupling agent included for improved interfacial bonding. Following ASTM standards, the composites are characterized for melt flow index (MFI), water absorption, and mechanical properties, including flexural strength and impact resistance. Fourier transform infrared spectroscopy (FTIR) analyzes chemical interactions between the nanofillers and polymer matrix.

This research contributes to advancing bio-based composite materials for packaging and other applications, supporting sustainability efforts, and reducing dependence on petroleum-derived plastics. By optimizing nanofiber reinforcement, this study provides

insights into developing high-performance biodegradable plastics, aligning with global initiatives to mitigate plastic pollution and promote eco-friendly materials.

Acknowledgements: USP - Undergraduate Scholars Program

Engineering Value-Added Biodegradable Plastics from Bio-Based Polyhydroxyalkanoates

Taylor Carey, Chemical & Biological Engineering; Dilara Dulger, Chemical and Biological Engineering

Mentor(s): Brent Peyton, Chemical & Biological Engineering

Plastic pollution remains a global environmental crisis, with micro- and macro-plastic waste comprising a large portion of marine and landfill debris. This research investigates the potential of the thermophilic bacterium Thermus thermophilus HB8 to convert oxidized petroleum-based plastics, specifically low-density polyethylene (LDPE), into biodegradable polyhydroxyalkanoates (PHAs). PHAs are polymeric and are a biocompatible alternative to conventional plastics, finding applications in cosmetics and food packaging, medical devices, and textiles, among other uses. Our previous work demonstrated that T. thermophilus grew on glucose and sodium gluconate media, and indicated the potential for producing PHAs under nitrogen-limited conditions. Current experiments here at MSU are focused on cultivating T. thermophilus in a minimal medium with oxidized plastics as the primary carbon source. Fluorescent microscopy using Nile Red staining indicated likely PHA granule formation in LDPE-grown cultures. FTIR analysis further supported the presence of PHAs by matching known polymer spectral signatures. Recent advancements include the integration of Raman laser imaging, which has revealed prominent spectral peaks in regions consistent with PHA structures. While these images and spectra are still under evaluation, they present promising evidence for PHA bioplastic synthesis. Ongoing analyses using Raman spectroscopy, FTIR, GC, and HPLC-QTOF aim to verify and quantify PHA production. This research supports the upcycling of plastic waste by converting environmental pollutants into value-added, biodegradable materials through thermophilic microbial pathways.

Acknowledgements: USP - Undergraduate Scholars Program

Lens-less Microscopy: A Subpixel Shifting Light Source for Super-Resolution Imaging

Molly Coonfield, Electrical & Computer Engineering

Mentor(s): Stephan Warnat, Mechanical & Industrial Engineering

Widefield microscopy is used in many research areas, such as the study of microbial cells, biological research, and other microscopic organisms or materials. Although widely used, traditional microscopy optical components have a high cost and significantly limit the field-of-view. In this work, we propose ultra-widefield lens-less imaging using shadow projection and a super-resolution method to significantly increase FOV while maintaining the image quality in traditional widefield microscopy. Others have developed lens-less imagers that show the potential to replace traditional brightfield microscopy systems. Most projects involve producing custom imagers for specific applications. This work's unique contribution to lens-less imaging is the implementation of a commercially available imager. So far in this project, we have developed an algorithm to combine subpixel-shifted images to create a super-resolution image, which is referred to as the super-resolution method. Ongoing research is focused on integrating a light source and imager by taking pictures of 10μm polystyrene beads in the fluidic channel to demonstrate the large FOV. Currently, two different imagers are being tested, rolling and global shutter image sensors, two different images, rolling and global shutter image sensors, are being tested against two different light sources, LED and LCD screens. Current experiments resolve which combination offers the least amount of resolution loss from image data capture and light source and imager compatibility. Incompatible components can cause issues such as banding in images. The light source will be subpixel-shifted to specific locations specified in our super-resolution method to produce the high-resolution image. Once this process is developed and implemented, a fully automated process to combine the super-resolution method with the subpixel-shifted light source will be able to execute ultra-widefield lens-less imaging of the 10μm polystyrene beads.

Acknowledgements: USP - Undergraduate Scholars Program

Microfluidic Chip Optimization for Higher Flow Rate Testing for Precise Extracellular Vesicle Isolation

Sidhee Sarit Das, Chemical & Biological Engineering

Mentor(s): Anja Kunze, Electrical & Computer Engineering

Extracellular vesicles (EVs) are membrane-bound carriers of molecular information generated by all types of cells, including neurons. Neuron-derived EVs can cross the blood-brain barrier and transport disease-related biomarkers, making them promising candidates for diagnosing neurodegenerative diseases such as Alzheimer's. Effective isolation of EV subpopulations (exosomes, microvesicles and apoptotic cell bodies) is crucial for

understanding their roles as disease biomarkers. Traditional isolation methods are expensive, inefficient and lack size specificity. Inertial microfluidics offers an alternative isolation method, employing the inertial effects of fluid flow in curved microchannels to sort and manipulate different sizes of microparticles. In a curved microchannel, a combination of Dean forces and wall-induced lift forces facilitates size-based focusing of particles. Focusing efficiency depends on channel dimensions, fluid properties, velocity, and flow regime. Higher flow rates in spiral microchannels enhance lift forces, improving focusing efficiencies. However, higher flowrates introduce greater pressure drops within the microchannel, necessitating stronger bonding between polydimethylsiloxane (PDMS) microfluidic chips and glass substrates. This project aims to enhance PDMS-glass bonding strengths to enable higher flowrate testing and improve isolation efficiency. Previous bonding methods involved oxygen plasma treatment (45W, 60s), followed by thermal curing (65℃, 30 min). This study explores two bonding strategies: (A) an optimization of previous O2-plasma treatment by extended thermal bonding with weighted compression, followed by an additional PDMS reinforcement layer; (B) the application of a PDMS as an adhesive between the microchip and the glass, as literature suggests that sub-0.5 μm adhesive layers can be used with negligible impact on microchannels ≥15 μm in height. By refining and comparing PDMS bonding techniques, this work aims to enhance the structural integrity and performance of spiral microfluidic devices for EV isolation. Future studies will evaluate how these modifications improve EV recovery, ultimately advancing the development of EV-based biomarkers for neurodegenerative diseases.

Acknowledgements: USP - Undergraduate Scholars Program, INBRE - IDeA Network for Biomedical Research Excellence, Montana Microfabrication Facility

Force and pressure measurement system for studying the role of the paw in agility dogs performing weave poles.

Jasmine DeVlieg, Mechanical & Industrial Engineering

Mentor(s): Perrin Schiebel, Mechanical & Industrial Engineering

Current legged robots, such as Boston Dynamics' Spot, rely on simple rubber ball feet, which limit their performance on complex terrain. Since agile movement is essential for tasks like search and rescue, understanding foot-ground interactions is crucial. We want to take inspiration from agility dogs performing the weave pole obstacle to analyze how paw mechanics enhance grip, with the goal of applying these insights to robotic design. To achieve this, we must first understand the forces generated by the paw and the kinematics of the dog. To support this, I have been developing a system in LabVIEW that synchronizes

force data with video recordings using an LED signaling circuit. These findings will contribute to the development of more agile and adaptable robotic locomotion.

Acknowledgements: USP - Undergraduate Scholars Program

Droplet-Based qPCR: A Microfluidic Device for Single-Cell Gene Expression Analysis

Grace Ducharme, Chemical & Biological Engineering; Camden Long, Chemical and Biological Engineering Department; Stephanie McCalla, Chemical and Biological Engineering Department; Andrew Lingley, Electrical and Computer Engineering Department

Mentor(s): Emma Loveday, Microbiology & Immunology

This project aimed to simplify and execute on-chip, in-drop quantitative polymerase chain reaction (qPCR). The method of qPCR enables researchers to amplify nucleic acids to measure gene expression over time. However, current methods cannot preform this technique within microfluidic drops, limiting our ability to evaluate gene expression heterogeneity between cells. Building on previous research from the Loveday and McCalla labs, we designed a microfluidic device that aims to preform single-cell qPCR in drop-based systems. A key challenge in this project was maintaining the stability of aqueous microfluidic drops during temperature fluctuations required for qPCR. To address this, devices were fabricated using etched silicon wafers bonded to glass wafers instead of traditional PDMS, which destabilizes at high temperatures. Additionally, custom CNC-machined clamps were developed to secure the device's inlet and outlet ports to ensure adequate sealing during heating. Experimental workflow involved running recombinase polymerase amplification (RPA) reactions at room temperature before transitioning to high-temperature PCR. Using computer-aided design (CAD) platforms, we designed various device geometries, fabricated them in the Montana Microfabrication Facility (MMF), and evaluated their overall performance. This system aims to enable single-cell nucleic acid quantification, improving the ability to analyze heterogeneous cell populations. Through interdisciplinary collaboration, this project contributes to the development of an integrated platform for on-chip single-cell qPCR.

Acknowledgements: USP - Undergraduate Scholars Program

Grassroots Ankle Flex

Gregory Flynn, Mechanical & Industrial Engineering

Mentor(s): Corey Pew, Mechanical & Industrial Engineering

Ankle dorsiflexion is critical for daily activities, with limited ankle dorsiflexion (LAD) associated with ankle injuries and muscle and joint stiffness, leading to compensatory gait patterns, increased fall risk, and knee pain. Current rehabilitation methods include stretching and, more effectively, Mulligan Ankle Mobilization, a technique requiring a therapist to apply force while the patient performs dorsiflexion. The Ankle Flex is a home-use device designed to replicate this technique, allowing for regular, self-paced therapy at home. This project aims to evaluate the efficacy of the Ankle Flex on ankle range of motion, toe clearance, and functional mobility. Previously collected data included six individuals (age 45+/- 9 years) with clinically diagnosed LAD. Baseline clinical examinations determined initial values for metrics of interest and motion trials were conducted utilizing a marker-based motion capture system. Spring 2024 research focused on correcting errors in the Motion Capture System using Cortex software and preparing C3D files for Visual 3D analysis. Marker signal gaps were addressed using Cubic and Rigid Body (RB) Join interpolation methods, and a 6 Hz filter was applied to reduce high-frequency noise.

A total of 126 motion capture files were processed, covering straight walking, ramp and stair navigation, squatting, and sit-to-stand activities. Current analysis in Visual 3D is assessing changes in dorsiflexion range of motion, toe clearance, and mobility. These results will help determine the effectiveness of the Ankle Flex as a rehabilitation tool. This project can potentially enhance mobility and quality of life for individuals with LAD while advancing rehabilitation device development.

Acknowledgements: USP - Undergraduate Scholars Program

The Effects of Aqueous and Organic Solvents on the Catalytic Conversion of 5-Hydroxymethylfurfural to Furan-2,5-dicarboxylic Acid

Zachary Fredericks, Chemical & Biological Engineering; Joel Swartzentruber, Chemical Engineering

Mentor(s): Stephanie Wettstein, Chemical & Biological Engineering

As the consumption of plastics continues to increase, the use of plastics derived from fossil fuels, such as polyethylene terephthalate (PET), is becoming increasingly concerning due to its taxing impact on the environment, thus, prompting interest in sustainable alternatives such as polyethylene furanoate (PEF). PEF can be produced starting from sugars found in biomass and offers superior properties than PET. However, PET faces challenges in the conversion of 5-hydroxymethylfurfural (HMF) to 2,5-furandicarboxylic

acid (FDCA), a key monomer and the reaction step immediately preceding FDCA production. This step requires high temperatures, expensive noble metal catalysts, and suffers from FDCA's low solubility. This research focuses on optimizing platinum catalysts supported on activated carbon for FDCA production. In addition to coauthoring a literature review paper on FDCA. Atomic layer deposition (ALD) was chosen for its precise control over platinum deposition, ensuring uniform catalyst distribution and maximizing surface area. However, the vacuum conditions in ALD pose challenges, causing carbon wafers to break apart. Multiple preparation methods were tested to enhance reproducibility and stability, achieving wafers with a mass of 0.7 ± 0.015 g and improving surface uniformity. Further work aims to refine ALD processes for carbon-supported catalysts, characterize them using inductively coupled plasma (ICP) and laser mass spectrometry, and explore alternative noble metals. Overcoming these challenges will enhance catalyst performance and advance sustainable plastic production.

Acknowledgements: USP - Undergraduate Scholars Program, MSGC - Montana Space Grant Consortium

Comparing enzyme oxidative decarboxylase to iron-zeolites

Anna Gates, Chemical & Biological Engineering

Mentor(s): James Crawford, Chemical & Biological Engineering

The enzyme, oxidative decarboxylase, is capable of decarboxylating bio-derived lipids into fuel additive olefins. However, as a bio-based molecule, this enzyme does not remain useful in industry settings as it denatures at elevated temperature and pH extremes. Here the search begins for a material that performs the same function as oxidative decarboxylase, but with increased stability and industrial compatibility. Zeolites are microporous materials with important similarities to enzymes, namely, optimal pore structures and transition metal active sites. Aided by computational analysis of all known zeolite structures, a list of candidate zeolites, functionally like oxidative decarboxylase was derived. Among the candidate zeolite structures, three standout materials were selected for further modification. By employing a controlled synthesis process, solid-state ion exchange, we will generate uniform, highly dispersed, Fe(II) active sites on zeolites that are well matched with the enzyme. Once synthesized, we will characterize our Fe-zeolites with X-ray diffraction, Raman spectroscopy, and electron microscopy. Once characterized, we will attempt oxidative decarboxylation of industry relevant biolipids. In summary, we are directing efforts to finding industry compatible Fe-zeolite catalysts inspired by the already successful, yet industry incompatible oxidative decarboxylase. Such a catalyst discovery

would be transformative in global efforts to generate renewable liquid fuels from oily biomass.

Acknowledgements: USP - Undergraduate Scholars Program, Empower Program

Using Convection Diffusion Modeling as an Analog for Wildfire Modeling

Anthony Gilden, Chemical & Biological Engineering

Mentor(s): Ryan Anderson, Chemical & Biological Engineering

Wildfires are powerful, destructive, and unpredictable phenomena that occur worldwide, burning millions of acres annually. Their unpredictability is a major factor in their danger. While fire spread is known to involve the ignition of fuel particles through radiation and convective heat from nearby burns, the exact mechanisms and spread rates remain unclear.

Despite numerous attempts to model these processes, none have fully captured the complexity of large-scale wildfires. Current models are limited to one-directional fire spread and steady-state conditions, which are inadequate for real-world scenarios. More advanced models, though more accurate, are slow to compute—an issue when time is crucial. This project aims to develop a more efficient model that balances accuracy with faster computing. Initial models were constructed by using data from a controlled fire that was conducted by the U.S. Forest Service's Missoula Fire Sciences Lab. From there, the models were extrapolated to explore the analogous variables in the convection diffusion model and how they would intuitively correlate to the behavior of real-life fires. Exploration of the parameter space yielded three major correlations between the analogous model and real-life fires: velocity field represents the wind speed, diffusion coefficient acts as the rate of fire spread, and the reaction rate constant would be analogous to the combustion rate of the fire burning up fuel. This extensive research has created a strong basis for further development of this model.

Acknowledgements: USP - Undergraduate Scholars Program

Device-Specific Optimization of Etching Techniques for High-Performance Wire Grid Polarizers

James Graham, Electrical & Computer Engineering; Owen Saltzman, Electrical & Computer Engineering; Jordan Baker, Electrical & Computer Engineering

Mentor(s): Wataru Nakagawa, Electrical & Computer Engineering

Wire grid polarizers (WGPs) are critical optical components used in telecommunications, imaging, remote sensing, and biomedical optics. This research refined etching techniques to fabricate WGPs with more precisely controlled structural parameters, including period, fill factor, etch depth, and profile. The objective was to develop application-specific etch recipes by optimizing reactive ion etching (RIE) parameters such as gas flows, pressures, RF power, and temperature. The study began with data collection and process characterization to analyze how process parameters influenced etch depth, rate, and profile. Insights from this phase guided the development of customized etch recipes tailored to specific WGP designs. Using 175 nm features, we developed etch processes capable of achieving aspect ratios (AR = depth divided by feature size) of 1, 2, and 3. For a target depth of 175 nm (AR = 1), we achieved 171 nm; for 350 nm (AR = 2), 349 nm; and for 525 nm (AR = 3), 519 nm. Each result was within ±5% of its target, demonstrating reliable depth control across a range of aspect ratios. The processes also enabled tunable profile control, allowing fabrication of structures with vertical sidewalls or application-specific undercut profiles. Profilometry and scanning electron microscopy (SEM) verified etch quality and precision. These results demonstrate the successful fabrication of sub-micron WGP features with tightly controlled geometries. Ongoing work aims to extend these processes to higher aspect ratios while maintaining precision. Together, these advancements contribute to improved fabrication strategies for high-performance optical components and expand the design space for WGP-enabled devices.

Acknowledgements: USP - Undergraduate Scholars Program

Preliminary Design and Testing of a Compact Insect- and UAV-Detection Lidar

Henry Hamp, Electrical & Computer Engineering

Mentor(s): Joseph Shaw, Electrical & Computer Engineering

Light detection and ranging (lidar) technologies have grown rapidly in recent years as researchers find more and more applications for it. Montana State University's Optical Remote Sensor Laboratory (ORSL) is currently well situated to research and design a compact, unoccupied aerial vehicle (UAV) and insect detection lidar - two applications that have drawn industry interest. The exponential growth in availability and use of UAVs has created broad interest in the ability to detect and monitor UAVs in flight. Similar to rotating propellers on UAVs, flapping wings can also be used to detect and monitor insect and pest populations for precision agriculture applications. Researchers at MSU have shown that lidar systems can be used to detect insects and early research suggests that the same

technology can be used to detect rotor-based UAV systems. This proposal is to begin the design of a low-cost, compact version of this lidar that operates at eye-safe wavelengths in the short wave infrared range. This project will focus on the optical and electrical design specifications of the new UAV-detection lidar system.

Acknowledgements: USP - Undergraduate Scholars Program

Optimizing Zeolite for Nitrogen Contaminant Removal: The Impact of Antibiotics and Viruses on Adsorptive Efficiency

Cora Rose Hannigan, Civil Engineering; Sabine Olds, Civil Engineering

Mentor(s): Adrienne Phillips, Civil Engineering

Microbially Induced Calcite Precipitation (MICP) is a biocementation process where urease-producing bacteria, such as Sporosarcina pasteurii, induce calcium carbonate precipitation. While MICP has applications in soil stabilization and bio-concrete production, it produces ammonium as a byproduct, which can contaminate water sources. Elevated ammonium levels harm aquatic life, contribute to eutrophication, and make water unsuitable for various uses. Our research shows that zeolite, when incorporated into a hydrogel matrix with S. pasteurii cells, can remove about 90% of ammonium from MICP effluent. This zeolite-hydrogel system (ZAPs) demonstrates high efficiency in ammonium removal, offering a promising solution for mitigating nitrogen pollution in biocementation waste. We are extending our research to address ammonium contamination in agricultural wastewater, which also contains antibiotics and viruses. These contaminants can negatively impact water quality, harm ecosystems, and contribute to antibiotic resistance. We aim to evaluate the effectiveness of zeolite and ZAPs in removing ammonium and mitigating these pollutants in agricultural wastewater. A challenge is the lack of standardized synthetic models for agricultural wastewater. To overcome this, we are characterizing MICP effluent to develop a synthetic model that mimics wastewater from swine, bovine, and poultry operations. Key parameters such as pH, biological oxygen demand (BOD), chemical oxygen demand (COD), ammonium levels, and salts will be analyzed to ensure the model accurately represents agricultural waste. This will allow us to compare ammonium removal and pollutant mitigation in both MICP and agricultural wastewater, broadening the applicability of ZAPs.

Acknowledgements: USP - Undergraduate Scholars Program

Experimental Investigation of Aspect Ratio and Rayleigh Number on Cavity Formation in Submerged Ice

Gage Hartley, Mechanical & Industrial Engineering; Kari Perry, Mechanical & Industrial Engineering

Mentor(s): Sarah Morris, Mechanical & Industrial Engineering

Understanding the melting behavior of ice is not only a key component in climate science, but also critical for predicting the future of polar and glacial environments, which continue to be affected by global warming. Ice melt directly impacts sea-level rise, with significant consequences for coastal communities, ecosystems, and weather patterns. The complexity of ice melt necessitates further studies to fully grasp the mechanisms involved. Current research highlights that several factors influence how ice melts, including water temperature, the flow dynamics around the ice, and the shape of the ice itself. Recently, Yang et al. (2024) numerically demonstrated that the initial shape, or aspect ratio, of ice affects local melting rates in quiescent water. This study aims to further investigates the interplay between aspect ratio (γ) and Rayleigh number (Ra) on the cavity formation and melt dynamics of ice submerged in water, specifically in circular and elliptic cylinders. This is achieved by experimentally testing the findings of Yang et al. (2024), which suggest that circular objects do not exhibit the slowest melting rates. Ice samples of varying aspect ratios were melted in a quiescent freshwater tank at room temperature. Flow visualization using fluorescein dye and stereo-photogrammetry were employed to examine cavity formation and identify critical points of flow separation for various aspect ratios. Preliminary findings reveal a distinct relationship between aspect ratio and cavity geometry. These results demonstrate that cavities emerge at higher Rayleigh numbers, with the critical flow separation point playing a pivotal role in shaping the cavity's size

Acknowledgements: USP - Undergraduate Scholars Program

An Analysis of Amorphous Silica's Contribution to Calcium Removal from Phosphate Rock in Phosul Fertilizer

Ella Herring, Chemical & Biological Engineering

Mentor(s): Paul Gannon, Chemical & Biological Engineering

Modern fertilizers are often unsustainable, economically inefficient, and environmentally detrimental. Traditional phosphorus fertilizer uses sulfuric acid and intensive processing to produce phosphoric acid providing easy, water soluble P, uptake in plants. Since phosphoric acid is water soluble much of the fertilizer washes into water systems. While

nitrogen also contributes to eutrophication, phosphorus is usually the limiting nutrient in water ecosystems and critical for limiting runaway algae growth. Phosul is a newly developed fertilizer that allows phosphate rock to break down slowly to plant available citrate soluble P in the soil minimizing run-off and eliminating intensive chemical processing. Any development of phosphorus fertilizer must establish a separation method to remove calcium as it prevents phosphate rock from breaking down in soil naturally. Phosul uniquely uses amorphous silica as a calcium sink allowing the phosphate rock to be acidulated naturally for plant uptake. It is not well understood how amorphous silica contributes to calcium removal from phosphate rock. Phosphate rock mainly consists of mineral apatite which is composed of calcium, phosphate, and halides or hydroxide in a tightly woven lattice. Samples of amorphous silica and amorphous silica mixed with dilute sulfuric acid and pulverized phosphate rock were analyzed for composition and structure using FE-SEM and XRD. Imaging showed the formation of anhydrite crystals on the amorphous silicas surface suggesting that amorphous silica serves as a nucleation site for removal of calcium during phosphate rock acidulation.

Acknowledgements: USP - Undergraduate Scholars Program

miRNA Split Transduction

Kyra Herronen, Chemical & Biological Engineering; Esther Stopps, Chemical & Biological Engineering

Mentor(s): Stephanie McCalla, Chemical & Biological Engineering

MicroRNAs (miRNA) are small, non-coding RNA that play a large role in gene regulation: miRNAs interact with messenger RNA (mRNA) to inhibit or reduce the rate of translation into a protein. Recently, miRNAs have gained attention due to their altered expression patterns in response to irregular protein expression; this often occurs in the presence of disease, specifically cardiovascular, cancer, and neurological disorders. Identifying the specific miRNAs that change in the presence of disease can enable earlier detection. MiRNAs are only 20-22 nucleotides in length and may vary by one or two nucleotides, making it challenging to accurately differentiate between the strands. The current detection methods rely on expensive thermocycling equipment and have limited specificity and sensitivity. The goal of this research is to design two DNA probes that are partially complementary to a target miRNA molecule. The resulting 3-strand complex is then used to initiate an isothermal amplification reaction that can be analyzed using a fluorescent output. We hypothesize that this reaction scheme will demonstrate higher specificity and allow for more definitive diagnostic results. To test this hypothesis, we designed a series of

probes with varying parameters, including the length of complementary binding sites, the inclusion of primers and ligase, and different reaction conditions. This approach allowed us to systematically optimize the reaction's specificity for the most accurate and reliable results.

Acknowledgements: USP - Undergraduate Scholars Program, INBRE - IDeA Network for Biomedical Research Excellence

Application of Colloidal Silica Gels for Permeability Control in Enhanced Geothermal Systems

William Hyatt, Civil Engineering

Mentor(s): Robin Gerlach, Chemical & Biological Engineering; Adrienne Phillips, Civil Engineering

The circulation of fluids in a fluid fracture network is essential for efficient energy collection in Enhanced Geothermal Systems (EGS). Lost circulation, caused by undesired fractures in the subsurface reservoir, leads to inefficient energy production and halted circulation. This research focused on using LUDOX® HS-30, a colloidal silica suspension, as a potential gelling agent to block or divert flow temporarily. Diluted LUDOX® suspensions (15% wt. silica) were gelled with varying concentrations of NaCl and at different pH values in stainless steel reactors at 175-225°C, identifying optimal gel strength and gel time. Research showed that at elevated temperatures, the initial pH of the suspension had a varied influence on gel time and strength; in contrast, the NaCl concentration was the most significant factor for gel time and strength. A suspension with 0.26% wt. NaCl (0.05M) displayed higher average gel strength than their 0.53 and 0.13% wt. (0.1 and 0.025M) counterparts. This data can be applied to gel placement in subsurface fractures as a strong gel can withstand the reservoirs' high temperatures and pressures. Future research will focus on revising the reactors to quantitatively determine a phase change of the suspension, collecting more accurate data on gel time. An experiment will be conducted that tests the permeability of colloidal silica gels in granite cores at elevated temperatures - resembling in-situ conditions of subsurface geothermal reservoirs.

Acknowledgements: USP - Undergraduate Scholars, funding through the United States Department of Energy DE-EE0009789.

Optimizing Cryopreservation of Algal Cultures for More Sustainable and Effective Practices

Anna Johnson, Chemical & Biological Engineering; John Kaffer, Microbiology

Mentor(s): Robin Gerlach, Chemical & Biological Engineering

Algal cultures are often a complex environment of algae and bacteria. Currently, in the Gerlach lab there are 15 flasks and 50+ slant tubes of algal cultures that must be maintained, meaning transferred monthly to keep the cultures alive; this process is labor- and material-intensive. The goal of this research project is to cryopreserve our algal and bacterial cultures in a -80 ℃ freezer to reduce labor intensity and material costs. This practice is well established for bacteria but not for eukaryotes or mixed cultures. In this project, two different alga- and one cyanobacteria-dominated cultures were cryopreserved using three different cryopreservation methods: Nitzchia inconspicua strain Hildebrandi GAI339 (Hildy), Chlorella sp. strain SLA-04 (SLA-04), and Cyanobacterium strain PNNL-SSL1 (SSL1). Each culture was xenic (meaning while dominated by the organism of interest, other organisms, such bacteria, were also present). To test the effect of cryopreserving & resuscitating the cultures, biomass samples were taken before freezing and after regrowing cultures from freezer stocks. Marker gene (16S & 18S rRNA) shotgun sequencing is currently being performed to determine culture compositions before and after freezing. This work is determining the effect of cryopreservation on microbial community composition and whether algae can be preserved, similarly to bacteria, through storage at -80 ℃. The benefits of this research go beyond one lab as many algal research labs must keep their cultures alive monthly. The establishment of an effective cryopreservation method has the potential to save costs and decrease waste generation while providing improved culture integrity over time.

Acknowledgements: USP - Undergraduate Scholars Program

Investigating Muscle Activation Patterns Related to Jump Landing Errors and ACL Injury Biomechanics

Luke Juergensen, Mechanical & Industrial Engineering; Asal Aflatounian, Mechanical & Industrial Engineering

Mentor(s): Scott Monfort, Mechanical & Industrial Engineering

Anterior cruciate ligament (ACL) injuries are common among athletes, particularly in sports requiring rapid directional changes in response to external stimuli. The quadriceps create knee extensor moments to absorb landing energy and contribute to ACL loading. This study examined differences in quadriceps muscle activation between successful and unstable landings during a single leg jump landing task using surface electromyography (EMG). We

hypothesized that there will be a significant increase in muscle activation during the successful jump landings compared to the unsuccessful trials. For the protocol, the participant jumps off a box in response to an on-screen cue, which varies by trial condition and dictates whether they should land on the left or right leg, then hold their balance for at least 2 seconds, or land on both feet before immediately jumping upward. EMG sensors recorded muscle activation of right leg quadriceps muscles: the Rectus Femoris, Vastus Lateralis, and Vastus Medialis. Raw EMG data were filtered and analyzed with paired t-tests to determine statistical significance.

Preliminary results indicated no statistically significant differences in EMG activation for any of the examined quadricep muscles (Rectus Femoris: $p = 0.11$, Vastus Lateralis: $p = 0.34$, Vastus Medialis: $p = 0.64$). These findings suggest that neuromuscular activation patterns in the quadriceps may not be the primary differentiator between successful and unsuccessful landings, contradicting the hypothesis. However, this is a preliminary finding based on fifteen participants data, and as research progresses, more data will increase the statistical power to detect differences, if they exist.

Acknowledgements: USP - Undergraduate Scholars Program

Using Artificial Neural Networks to Predict 2,5-Furandicarboxylic Acid Solubility for Solvent Selection

Van Ledger, Chemical & Biological Engineering; Jacob Molinaro, Chemical & Biological Engineering

Mentor(s): Stephanie Wettstein, Chemical & Biological Engineering

There has been a large push recently to reduce dependence on petroleum products and transition to a biobased market. One opportunity is to produce a renewable plastic from biomass through 2,5-furandicarboxylic acid (FDCA); however, FDCA solubility in solvents is an issue. Although running experiments to evaluate solubility are straight-forward, the solvents can be expensive, bad for the environment, and every combination would take up too much time to test. This study developed and evaluated the accuracy of a two-layer artificial neural network (ANN) model to predict the solubility of FDCA in different solvent mixtures. Hansen Solubility Parameters consists of three variables that divide a system's enthalpy of mixing based on chemical interactions and can be obtained from existing literature and through software (HSPiP). FDCA solubilities ranging from 0 to 30.8 wt% were separated by alcohols and non-alcohols and used to train ANN models. Model accuracy was then evaluated with prediction error indices and Akaike information criterion was used to determine the optimal number of hidden nodes. Additionally, to evaluate the effect of

input independence on model accuracy, secondary models were run with inputs first assessed and transformed by principal component analysis (PCA) to produce completely linearly independent sets of inputs. For unmodified inputs, the developed models had R-values of 0.99 and 0.96 for the alcohol and non-alcohol models, respectively.

Acknowledgements: USP - Undergraduate Scholars Program

Pilot Integration of Virtual Windows at a Critical Access Hospital in Montana

Sophie Mayers, Mechanical & Industrial Engineering; Julie Ruff, College of Nursing; Elizabeth Johnson, College of Nursing

Mentor(s): Bernadette McCrory, Mechanical & Industrial Engineering

Lighting significantly impacts patient recovery and healthcare provider well-being in hospital environments. The absence of natural light in intensive care units and other hospital settings disrupts circadian rhythms, contributing to stress, fatigue, and an increased risk of delirium. This study explores the integration of virtual windows and full-spectrum lighting as a cost-effective solution to enhance patient and provider experiences at Phillips County Hospital, a 6-bed critical access hospital in rural Montana. This research will determine optimal placements for virtual windows, ensure seamless hospital integration, and evaluate their impact using surveys, stress assessments, cognitive performance evaluations, and eye-tracking analysis. Building on prior research at the BioReD Hub Laboratory, this project applies engineering principles to improve hospital environments. By integrating virtual windows into rural healthcare settings, this study aims to enhance patient recovery, reduce provider fatigue, and advance biophilic design in healthcare. Findings will guide future implementations, improving hospital environments through engineered solutions.

Acknowledgements: USP - Undergraduate Scholars Program

Rational Biomimetic Catalyst Design via Computational Comparisons of Enzymes and MOFs

Thomson McCarthy, Mathematical Sciences

Mentor(s): James Crawford, Chemical & Biological Engineering

Enzymes are biological catalysts with high activity under low severity conditions. However, enzymes pose challenges in industry since they are difficult to produce, maintain, and

recover. Metal-organic frameworks (MOFs) are materials that have been synthesized to address the industrial limitations of enzymes. They are porous crystalline structures composed of metal ions connected by organic linkers. MOFs are great candidates for biomimetic catalysts due to their enzyme-like structure, thermal stability, recoverability, and high performance. Through manual comparison, researchers are beginning to find successful MOF-enzyme mimics. With over 16,000 synthetic MOFs already reported, the manual comparison process is slow, serendipitous, and extremely difficult. And if a MOF is chosen for a desirable biomimetic quality, there are often many additional options that were simultaneously overlooked. For this reason, we are interested in optimizing and automating the selection process for biomimetic MOFs. For these reasons, we have initiated a screening strategy comparing the metal sites and the surrounding ligands in enzymes and MOFs. In its current form, this approach has identified MOF-enzyme mimics concurrent with existing literature, such as the MOF MFU-4l-OH which is a known mimic of the enzyme carbonic anhydrase. In my presentation, I will discuss these matches and how additional chemical and structural screening criteria will enhance the quality of matches and enable a ranking system that provides a user-friendly comparison of enzymes and MOFs.

Acknowledgements: USP - Undergraduate Scholars Program

Silver Nanoparticle Ink for Electrohydrodynamic 3D Printing of Microscale 3D Integrated Electronics

Daniel McInnes, Mechanical & Industrial Engineering

Mentor(s): Yang Cao, Mechanical & Industrial Engineering

This research aims to advance 3D printing technology for fabricating complex three-dimensional microscale integrated electronics. Current photolithography technologies are complex and allow for mostly 2D and some limited 3D geometries. However, 3D integrated electronics have significant applications in MEMS, metamaterials, and biomedical devices. Electrohydrodynamic (EHD) printing enables the deposition of conductive nanoparticle inks with micron-level precision, but its success relies on fine control over the rheological and electrical properties of the ink. The subject of this investigation is to establish the relationship between ink composition and its relevant rheological properties. Typical inks consist of a conductive nanoparticle, a solvent, and a polymer binder, with ratios and material selection influencing the final ink properties. High silver nanoparticle load ratios are necessary to print freestanding 3D geometries but pose challenges due to particle agglomeration. A promising ink formulation has demonstrated the ability to print high

aspect ratio freestanding structures, though reliability remains an issue, with nozzle clogging being the primary obstacle. To address this, formulation methods are being tested to enhance ink stability and prevent clogging. Once complete, ink composition data and corresponding rheological properties will be integrated into a machine learning model. This model will predict ink formulations based on the desired rheological characteristics necessary for EHD printing.

Acknowledgements: USP - Undergraduate Scholars Program

Markerless Motion Tracking for Canine Biomechanics: 3D Reconstruction Using DeepLabCut

Carly Nigro, Mechanical & Industrial Engineering

Mentor(s): Perrin Schiebel, Mechanical & Industrial Engineering

Traditional motion capture systems require markers and specialized equipment, limiting their practicality for studying animal biomechanics in natural environments. This research aims to develop a markerless video tracking method to analyze canine movement, specifically weaving maneuvers and paw-ground shear force interactions, for applications in quadruped robot design. Using DeepLabCut and the SuperAnimal model, a neural network was trained and refined to track key reference points in 2D video frames without the need for physical markers. High-speed video data was collected using five synchronized GoPro Hero 12 cameras, allowing for multi-angle reconstruction of movement. Initial results demonstrate successful tracking of a wand weaving through the course, validating the model's ability to detect key motion patterns. Additionally, multiple camera perspectives have been used to reconstruct and quantify a 3D representation of movement, providing a foundation for accurate biomechanical analysis. These findings highlight the potential of deep-learning-based tracking to simplify motion capture while maintaining precision. The ultimate goal of this research is to use this tracking data to quantify shear forces between the dog's limbs and the ground. By understanding these forces, this work aims to inform the design of improved robotic foot structures that enhance traction, stability, and overall performance in legged robots. Future work will focus on refining 3D reconstruction accuracy, improving model generalization across different subjects, and integrating additional movement metrics. By bridging biomechanics and robotics, this research demonstrates the viability of markerless tracking for studying animal locomotion and developing more agile, adaptive quadruped robots.

Acknowledgements: USP - Undergraduate Scholars Program

Understanding the influence of thermochemical pretreatments on metal-zeolite catalysts synthesized from chlorides

Hannah O'Connell, Chemical & Biological Engineering

Mentor(s): James Crawford, Chemical & Biological Engineering; Rio Moore, Chemical & Biological Engineering

Despite many efforts to reduce the emission of greenhouse gases, climate change is still an ongoing issue predominantly caused by anthropogenic activity. To best eliminate human effects on the climate, methods need to be developed that both decrease new emission and capture greenhouse gases that already exist in the atmosphere. Modeling after urease found in nature (a nickel-dependent metalloenzyme), we are working to generate a biomimetic nickel-based catalyst that facilitates the reverse urea hydrolysis reaction. In this long-term pursuit, we are first focusing on the synthesis process used to generate a biomimetic nickel catalyst. Zeolites are excellent hosts for biomimetic metal sites. Here, we evaluated the ion exchange process between zeolite mordenite and nickel(II)chloride. To obtain high quality Ni-mordenite catalysts, they must be free of residual chloride and retain high crystallinity/porosity. The aim of this project was to determine what method most successfully removed excess chlorine. The conditions tested were 1) high temperature heat treatment, 2) high temperature heat treatment + high temperature reduction, and 3) high temperature heat treatment + aqueous washing. Based on XRD and FE-SEM characterization, we determined that the high treatment heat treatment was sufficient in removing chlorine ions from the zeolite and templating Ni cations.

Acknowledgements: USP - Undergraduate Scholars Program, MONT Empower Scholars, Center for Biofilm Engineering, Montana Nanotechechnology Facility

Microbially Induced Calcite Precipitation (MICP) for Cold Region Soil Stabilization Applications

Jess Rahn, Civil Engineering; Adrienne Phillips, Civil Engineering; Pukar Joshi, Civil Engineering; Sabine Olds, Civil Engineering

Mentor(s): Mohammad Khosravi, Civil Engineering

Microbially Induced Calcite Precipitation (MICP) is gaining traction as a bio-geotechnical solution for soil stabilization, providing a greener alternative to traditional methods. Utilizing the metabolic functions of ureolytic bacteria like Sporosarcina pasteurii. MICP

induces calcium carbonate formation in the soil, boosting its strength and stability. While effective in temperate climates, its performance in cold regions such as Montana, where temperatures frequently fall below freezing, poses additional challenges. These include reduced microbial activity at lower temperatures and changes in calcium carbonate precipitation kinetics due to freezing conditions.

This research aims to refine MICP for better performance in cold environments, focusing on enhancing microbial activity and calcite precipitation under these conditions. The study will experiment with different bacterial injection techniques. Each injection is done in cylindrical soil columns at room (22°C) and cold temperatures (4°C) to achieve uniform calcite distribution. It will also evaluate the impact on soil's thermal conductivity and mechanical strength, key factors for infrastructure resilience in cold climates. The methodology includes adapting column mold designs for controlled experiments, incorporating a thermal conductivity probe, and using Ladd's modified wet tamping method for even soil compaction. Various sands will be tested to check the adaptability of the findings across different soil types.

Acknowledgements: USP - Undergraduate Scholars Program

OpenAquaponics

Bau Sauvage, Computer Science; Luna Richards, Computer Science; Elias Obrist, Computer Science

Mentor(s): Clem Izurieta, Computer Science

Aquaponics is a food production system that combines raising fish with cultivating plants, allowing them both to mutually benefit. By sharing water, the plants can filter the fish's waste and use it as fertilizer to help them grow. While this is much more efficient and less wasteful than traditional aquaculture or hydroponics alone, the system can be difficult and time-intensive to build and manage. To reduce those barriers, we developed a prototype automated care system - equipped with an automated feeder, an automated lighting system, a camera, and a variety of sensors - that allows the user to monitor and control the condition of the aquaponic environment remotely. This prototype integrates easily accessible commodity hardware to provide automatic and adjustable control over the environment within the aquaponic system. Building a simple and modular aquaponics platform is a useful endeavor for several reasons. It can lower the barrier to entry for industries like indoor farming, and potentially allow for smaller and/or scaleable indoor farms to exist. Alternatively, it could be a useful project for enthusiasts who want to experiment with growing their own produce and herbs, or for children, elderly people, or

anyone who cannot manage such a system on their own. Designing and building such a system with easily accessible off-the-shelf components only increases accessibility and aims to drive down costs for the end user.

Acknowledgements: Software Factory

Characterizing Foot-Snow Interactions For The Development of All-Terrain Quadruped Robots

Mikael Savage, Mechanical & Industrial Engineering

Mentor(s): Perrin Schiebel, Mechanical & Industrial Engineering

We want legged robots that can transverse snow for various applications, such as search and rescue or remote exploration. However, little is known about foot-snow interactions, and as a result, robot feet are not well-designed for these environments, limiting their capabilities. To learn more, we constructed a gantry to perform systematic foot intrusions into snow and measure reaction forces as a function of geometry. We fabricated and tested 2D-foot profiles using acrylic circles of different diameters and 3D feet with radially symmetric toes. Combined, the collected data will act as a basis for understanding the construction of a quadrupedal foot applicable to snow.

Acknowledgements: USP - Undergraduate Scholars Program

Use of OpenCap to Assess Kinetic Values for Single Leg Vertical Jump Tasks: A Pilot Study

Sophia Stemler, Biomedical Engineering; Fatemeh Aflatounian, Mechanical Engineering; Alexandra Lynch, Mechanical Engineering

Mentor(s): Scott Monfort, Mechanical & Industrial Engineering

Measuring changes in joint kinetics, such as the knee extensor moment (KEM), provides quantifiable metrics to identify athletes with unresolved deficiencies following an injury. However, collection of these variables requires costly motion capture setups that are impractical for clinical use. Newly developed low-cost motion capture (i.e., OpenCap) provides a practical alternative. Given previously reported agreement in kinematics between traditional motion capture (MoCap) and OpenCap, we hypothesized there would be a significant correlation in KEM. For this pilot study, eight healthy athletes completed six single leg vertical jump (SLVJ) trials on each leg, recorded with OpenCap and a marker-

based motion capture system. KEM was estimated using standard inverse dynamics for MoCap with force plates or a dynamic musculoskeletal simulation for OpenCap with modeled foot-ground contact dynamics (without force plate data). Peak KEM (pKEM) values were determined for propulsion and landing phases of the jump. Neither propulsion ($r = -0.44$, CI: [-0.87, 0.38], $p = 0.12$) nor landing ($r = 0.48$, CI: [-0.22,0.85], $p = 0.09$) phases were found to have a significant correlation between OpenCap and MoCap pKEM values. These pilot data reveal challenges with estimating KEM from SLVJ tasks via an OpenCap and simulation workflow, motivating the need for refinement to obtain more robust kinetic estimates. Future work includes expanding the sample size beyond the pilot group, capturing SLVJ trials with different camera orientation, and revisiting the foot-ground contact model to improve kinetic estimates before considering future clinical application.

Acknowledgements: USP - Undergraduate Scholars Program

Shape tracking of tandem ice cylinders in a cross flow

Carson Wolfe, Mechanical & Industrial Engineering; Kari Perry, Mechanical Engineering

Mentor(s): Sarah Morris, Mechanical & Industrial Engineering

Icebergs break off from large ice sheets, releasing freshwater as they drift through the ocean. Understanding glacier melt is essential due to its impact on sea levels, ecosystems—particularly biological productivity and carbon sequestration—and water resources, including sea ice formation. Scientists use large-scale ocean models to predict iceberg melting; however, these models are often oversimplified and inaccurate. Having precise simulations to estimate how ice melts is crucial. Specifically, the melting behavior of groups of icebergs, such as tandem (one in front of the other) icebergs, in a cross-flow is not well understood. To improve our understanding, we study how tandem ice configurations melt by tracking their shape profiles over time. We conduct experiments by towing two ice cylinders through water at 1cm/s at a specified distance apart. The ice is infused with fluorescein dye and their shape changes are imaged over time. We developed a MATLAB program to visually track shape changes, flow separations points, and the ice effective diameter by tracking data points on the ice-water boundary. It was found that the ice cylinders exhibited non-uniform shape changes during melting. The upstream ice cylinder's shape change was primarily controlled by the cross-flow rate, while the downstream ice cylinder was influenced by the meltwater from the upstream cylinder. These experiments aim to improve glacier ice melt models, leading to more accurate predictions of iceberg behavior in ocean environments.

Acknowledgements: Montana State University

HEALTH AND HUMAN DEVELOPMENT

PHYSIOLOGIC AND BIOMECHANICAL EFFECTS OF CHANGING POLE LENGTH IN PARA NORDIC SIT-SKIERS

Sage Blickensderfer, Health & Human Development; Madeline Inman, Health & Human Development

Mentor(s): James Becker, Health & Human Development

Unlike able-bodied skiers, sit-skiers rely solely on poling for forward propulsion, making poling mechanics crucial to performance. While longer poles correlate with reduced oxygen uptake in able-bodied skiers, it's unclear if this is true for sit skiers. Manipulating pole length may also influence cycle kinematics, a change with potential direct bearings on performance as faster sit-skiers have longer cycle lengths. Therefore, the purpose of this study was to evaluate the physiologic and kinematic effects of changing pole lengths on Para Nordic sit-skiers. Six (M:3, F:3, age: 31+/- 9 yrs) elite Para Nordic sit-skiers participated in this study. Oxygen consumption and pole kinematics were recorded while skiing on a roller ski treadmill using four different pole lengths: habitual (H), ~ 2.5 cm shorter (S), ~ 2.5 cm longer (L1), and ~ 5.0 cm longer (L2). Linear mixed-effects models were used to evaluate the effects of dependent variables across pole lengths. There were no significant fixed effects of pole length for any physiologic variables ($p > .05$). However, there were significant fixed effects of pole length for CT ($p < .001$), CR ($p < .001$), CL ($p < .005$), PT ($p < .001$), and ST ($p < .005$). Pairwise comparisons showed that CT, CL, PT, and SW all increased from the habitual condition to the L2 condition, while CR decreased (all $p < .05$). Changing pole length does not influence metabolic cost but does affect cycle metrics in sit-skiers. Increasing pole length may improve efficiency in sit-skiing with no additional metabolic cost.

Acknowledgements: USP - Undergraduate Scholars Program, EHHD travel scholarship

Biomechanical Comparison of Pin and Freeride Ski Mountaineering Bindings in Recreational Skiers

Isaac Burgess, Health & Human Development; Sami Samuels, Education, Health, and Human Development

Mentor(s): James Becker, Health & Human Development; John Seifert, Health & Human Development

Previous studies on competitive ski mountaineering (skimo) have shown that increasing equipment weight increases metabolic cost. However, whether differences in weight influence skinning kinematics or efficiency and energy cost in recreational skiers remains unknown. As participants generally choose between lightweight pin (P) or heavier freeride (FR) bindings, making this an important question. The purpose of this study was to compare the lower body kinematics and energetic demands of uphill skinning between the P and FR bindings in recreational skiers. Sixteen skiers with 2+ years of skimo experience participated in this study. Whole body kinematics were recorded while participants skinned on a treadmill on P or FR bindings, mounted on matching skis, for 3-minute stages at grades of 8% or 15%. Kinematics and heart rate (HR) over the last 30 seconds of each stage were recorded. Following the skinning protocol, participants completed a graded exercise test to exhaustion, where $\dot{V}O_2$, RER, and HR were used to establish a linear relationship between for calculation of aerobic metabolic rate and mechanical efficiency for each stage in the skinning protocol. Cycle metrics and lower limb joint angles were calculated in Visual 3D. Fixed effects of binding and grade were compared using linear mixed effect models. Differences in joint kinematics across the entire gait cycle were analyzed using statistical parameter mapping. Differences in ankle, knee, and hip angles and cycle metrics were found between bindings; however, the changes were relatively small. No differences in metabolic rate or mechanical efficiency were found between bindings. In laboratory settings, binding type did not influence lower limb biomechanics or energetic cost while skinning.

Acknowledgements: Ellen Kreigbaum Movement Science Endowment, Atomic, EHHD Travel Advancement Grant

How Stress Impacts the Exercise Habits of College Undergraduates

David Cullinane, Health & Human Development; Elyza Swenson, College of Education, Health & Human Development

Mentor(s): Dawn Tarabochia, Health & Human Development

Nationwide, college students are experiencing greater academic stress. These high stress levels are linked to many poor health outcomes that have been shown to increase risk for cardiovascular disease. Research has suggested that increased physical activity can mitigate these risks associated with elevated stress. This study aimed to investigate the relationship between academic stress levels and exercise practices among undergraduate college students. The participants of this study involved 45 undergraduate students at Montana State University using convenience sampling from two courses. Participants self-

reported their perceived stress levels using the Perceived Stress Scale- 4 (PSS-4). They were also asked questions relating to their exercise frequency, type, and intensity, which was measured using the Borg CR10 scale for Rating of Perceived Exertion (RPE). Data was analyzed using correlation tests in IBM SPSS Statistics to determine the relationship between academic stress and exercise intensity. Results showed a moderate negative correlation between PSS-4 and RPE, meaning that higher stress was associated with lower exertion during exercise. Elevated stress levels in college students have been associated with more sedentary lifestyles, and these findings suggest that this may be due to engaging in lower-intensity exercise. Although exercise has been shown to reduce stress-related health impacts, those who are experiencing more stress, namely college students, may actually be exercising less. This fuels the need for more physical activity opportunities and directives for these college students.

Acknowledgements: USP - Undergraduate Scholars Program

Psychology of Return to Sport After Anterior Cruciate Ligament Injury

Elleigh Fisher, Health & Human Development; Jordan Carr, College of Education, Health, & Human Development; Matt Farina, College of Education, Health, & Human Development; Makayla Barnes, College of Education, Health, & Human Development

Mentor(s): Dawn Tarabochia, Health & Human Development

The aim of this study is to determine whether a student's decision to return to sport correlates with their confidence in their rehabilitated knee. The study consisted of 14 college aged students who currently attend Montana State University and have had an ACL injury while participating in sports at the time of injury. Data was collected using a Google Forms questionnaire which included confidence questions about their rehabilitated knee. Additionally, the six-question ACL-RSI scale, adapted from a twelve-item scale used in previous research, was used. This data was then used for a descriptive study. In our sample, the trend indicates that those who have suffered an ACL injury are likely to return to sport following rehabilitation regardless of their confidence.

Lower Extremity Muscle Activity in the Para-Alpine Skier

Lindsey Frishmuth, Health & Human Development; Isaac Holmgren, Health and Human Development; Lauryn Lundberg, Health and Human Development; Madeleine Brozey, Health and Human Development

Mentor(s): John Seifert, Health & Human Development; James Becker, Health & Human Development

Imagine gliding down a mountain at high speeds, expertly carving through the snow with a prosthetic leg—how do body kinematics adapt to meet the demands of alpine skiing? Downhill skiing requires precise coordination and control, with the skier's center of mass and lower extremity muscle activity both playing critical roles in maintaining balance and performance. The purpose of this project was to analyze muscle activation patterns in a para-alpine skier to better understand the adaptations associated with skiing with a prosthetic lower limb. It was hypothesized that compensatory muscle activation, particularly in the trunk and intact limb, would occur to maintain stability and control during downhill skiing. In this study, electromyography (EMG) was used to analyze lower extremity muscle activation in a 25-year-old female downhill para-skier (height: 1.80 m; weight: 56.7 kg) with a right limb below-knee amputation, seven years post-amputation. Muscle activation was compared between the left leg and the residual right leg, which was fitted with a prosthetic. Surface EMG sensors were placed bilaterally on the erector spinae (ES), vastus lateralis (VL), gluteus medius (GM), and semitendinosus (ST) muscles. Three trials were completed, each consisting of 30 to 40 ski turns on a groomed, consistently graded slope. The trials were normalized to the average of the maximal EMG seen during each run, which allowed for comparisons in the muscle activation between the left and right legs. Results showed a significant difference between the right and left erector spinae, with a greater EMG signal seen in the left ES. Additionally, no difference was seen between the right and left GM, VL, and ST. The difference in erector spinae usage likely stems from compensatory rotation in the trunk. Although underlying strength differences between the left and right GM, VL, and ST may also exist, normalizing the data reduced any disparity in usage, resulting in the observation of a nonsignificant difference between limbs.

Acknowledgements: The Department of Food Systems, Nutrition, and Kinesiology at Montana State University

30-minutes of Aerobic Exercise Elicits a Decrease in Lipid Mediators

Shae Gurney, Health & Human Development; Gwendolyn Cooper, Chemistry; Prabina Bhattarai, EHHD; Benjamin Schwarz, Unaffiliated with MSU; Nathan Brandes, Graduated

Mentor(s): Mary Miles, Health & Human Development; Brian Bothner, Chemistry & Biochemistry

Acute exercise is known to increase reactive oxygen species and alter downstream inflammatory and oxidative stress biomarkers, including lipid mediators (LM) Purpose: To

determine the effects of acute aerobic exercise on LMs in healthy adults. Methods: A submaximal graded treadmill test to 85% HRmax followed by linear extrapolation of HR and VO2 was used to determine subjects' predicted VO2 max. They then completed a 30-minute session at 75% of VO2 max. Venous blood was collected pre- and 15 minutes post-exercise, spun to plasma, and snap-frozen for later analysis via liquid chromatography-tandem mass spectrometry (LC-MS/MS). A targeted analysis of 65 metabolites, including eicosanoids, was completed. A simple linear mixed-effects model was run on R 4.4.1 to test the impact of exercise on LMs with subject as a random effect. Age, sex, and VO2 max were used as covariates in the analysis. Summary data is presented as mean±SD, with a significance of $p<0.05$. Results: 23 females and 24 males completed the 30-minute session. In response to exercise, 35 metabolites from multiple synthetic pathways were changed, with 12 decreasing and 1 increasing by 50+%. Linoleic acid was decreased for females ($p=0.015$) and males ($p=0.029$) following exercise, while no change for arachidonic acid was observed ($p>0.05$) for either gender. A decrease ($p<0.001$) in 8-isoprostaglandin F2**α** was seen in females and males, respectively. Conclusions: These findings suggest that a single bout of moderate-intensity exercise resulted in significant changes in LMs associated with inflammation, which may reflect decreased synthesis or increased clearance.

The Link Between Food Insecurity and Diabetes in the Latino Population of The Gallatin Valley

Hayden Kaufman Schiller,

Mentor(s): Sally Moyce,

Food insecurity is defined as limited access to nutritious and sufficient food. Research shows that food insecurity can have significant health impacts on individuals, with one of the most concerning impacts being diabetes and pre-diabetes. The prevalence of diabetes is notably higher among Latino communities struggling with food insecurity. Understanding how food insecurity exacerbates the risk of chronic diseases is crucial for developing targeted and beneficial interventions for Latino communities. The research we conducted aims to explore the relationship between food insecurity and diabetes in the Latino population of the Gallatin Valley. Focusing on how economic instability, access to healthy foods and quality healthcare intersect to aggravate these issues. By examining these factors and the data we collected, our study seeks to identify potential ways for improving health outcomes as well as recognizing and attempting to reduce the disparities in this underserved and under researched population. During community-based primary health

clinics, we screened for diabetes using the A1C test, asked participants if they experienced food insecurity and tested the associations between food insecurity and diabetes using regression models. We found pre-diabetes in 83 and diabetes in 47 participants. We will present findings on regression analysis at the poster sessions. Our findings from this study offer valuable insights that help inform public health interventions and better policies that aim to reduce diabetes disparities in Latino communities. Ultimately our goal is to improve access to quality healthcare and promote better health outcomes for everyone in our community.

Acknowledgements: USP - Undergraduate Scholars Program

Investigating the Metabolic Response to Uphill and Downhill Walking

Ellie Keller, Health & Human Development; Elsie Crouse, Health & Human Development; Cheyenne Maddox, Health & Human Development; Caroline Hawkes, Health & Human Development; Shae Gurney

Mentor(s): Mary Miles, Health & Human Development

Introduction: An insulin-resistant individual may exercise at higher intensities to promote carbohydrate (CHO) burning, while someone wanting to burn fat may exercise at lower intensities. Although downhill walking is typically less intense than uphill walking, the eccentric contractions occurring in the leg muscles may lead to more CHO utilization than expected. Purpose: To compare CHO and fat utilization while walking at a 6% incline and decline. Methods: Participants (n=5) aged 18-30 were asked to walk uphill, downhill, and mixed on a treadmill at a 6% grade for 30 minutes. Indirect calorimetry and a graded exercise test were used to assess aerobic fitness and CHO and fat utilization at different exercise intensities. Results: The preliminary data shows that two participants burned more CHO than expected and three participants burned less CHO than expected when walking downhill. The two participants who burned more CHO than expected had a higher VO2 max and greater max fat burning (in g) compared to those who burned less CHO than expected. Conclusion: The data suggests that aerobic fitness and ability to burn fat may be factors that influence CHO utilization during concentric and eccentric contractions. More data should be collected on additional participants to further analyze substrate utilization in incline and decline walking.

Planting Good Seeds into our Children's Hearts: An Indigenized, School-Based Curriculum for promoting Healthy Relationships

Roni Knows Gun, Health & Human Development; Sarah Allen, Suzanne Held, Erena Kolb, Southern Utah University

Mentor(s): Vanessa Simonds, Health & Human Development; Alma McCormick

Community members have identified the need for culturally relevant intervention programs for Indigenous youth in Montana. Implementing programs built upon Indigenous values and Indigenous ways of knowing are more impactful to these communities as compared to existing Western-based curricula. Planting Good Seeds into Our Children's Hearts is a community-based participatory research project established in 2017 through a partnership between Montana State University and the Apsáalooke (Crow) tribe. The purpose of the project is to create Indigenous child well-being surrounding healthy relationships with family and peers through a curriculum that focuses on the unique cultural values of the Apsáalooke people. This presentation describes the formation of the 10-lesson curriculum through a process of ongoing community advisory board meetings and piloting. Each curriculum session consists of 30-minute lessons aimed at strengthening Apsáalooke cultural values facilitated by key leaders from the community. The Planting Good Seeds into Our Children's Hearts team developed the curriculum based on requests from the community advisory board identified as important topics Apsáalooke youth need to have healthier relationships with their family and friends. The curriculum has a plan to implement within a school-based setting to fifth grade Apsáalooke students. A series of family nights will occur prior to the beginning of the program to inform families of the project.

Acknowledgements: INBRE

Effects of Backpack Weight While Alpine Skiing

Henry Nelson, Health & Human Development; Isabella Comai, Lucas Mills, RyanO'Neil, lHuman Health and Development

Mentor(s): John Seifert, Health & Human Development; Isaac Burgess, Health & Human Development

Although backcountry skiing is the second-fastest growing sport in the US, there is a lack of research on the impact of carrying essential tools with a backpack while skiing. Previous research has shown an increase in pressure on the anterior foot and heel region, along with altered gait and lower limb/trunk muscle activity while carrying a backpack during hiking. However, there is no research analyzing pressure during alpine skiing. The purpose of this study was to determine the effects of backpack weight on foot pressure patterns during

alpine skiing. Pressure insole data was collected on one 20-year-old male advanced alpine skier. Three symmetrical runs were completed with three backpack weight conditions (T1: no weight, T2: 2.257kg,T3: 4.122kg). Results indicated an increase in rearfoot pressure as backpack weight was increased (Left Rearfoot: T1; 33.21 kPa, T2; 43.10 kPa, T3; 46.97 kPa) . Pressure in the forefoot remained constant across all weights (Left Forefoot: T1; 33.95 kPa, T2; 28.07 kPa, T3; 26.29 kPa). These findings show that wearing a backpack while skiing impacts pressure distribution. The posterior translation of pressure could be due to the torque created by the backpack, which caused the participant to sit further 'backseat' compared to the control trial. However, due to the lack of biomechanical data, few conclusions can be drawn regarding skiing form, injury risk, or training suggestions.

Acknowledgements: KIN492 Ski Research Class

Exercise in Rural Communities: A Qualitative Study Exploring Impacts of Past Experiences on Current Exercise Practices

Bryant O'Leary, Health & Human Development and Tasha Shaffer, Health and Human Development

Mentor(s): Dawn Tarabochia, Health & Human Development

As the aging population continually grows, understanding how to keep older adults engaged in exercise is of increasing importance. This is critical as exercise trends show that engagement dramatically decreases with age. Moreover, older adults are more likely to live in rural communities as compared to urban communities (Cohen & Greaney, 2023). Previous studies explored barriers related to the overall decrease in exercise engagement, yet few have focused on older adults' motivation to maintain exercise practices. The purpose of this project was to explore how past experiences with exercise influence current exercise participation among rural, older adults. Residents engaging in exercise and aged 55+ (n=42) from a western state were recruited using convenience sampling (partnership with local Extension agents and social media outlets). As part of a larger online survey, participants completed an open-ended questionnaire specific to past experiences with exercise. Participant results were analyzed using Van Manen's (1990) hermeneutical approach with three members of the research team developing themes from participant responses. Trustworthiness was established by a peer reviewer to assess the themes for accuracy. Researchers identified five themes associated with how past experiences influenced current exercise practices. These included health and wellness (18), accessible instruction/resources (17), friends and family (13), community programming (10), and

youth activity (4). By understanding past experiences, outreach professionals may find more impactful early or later life supports to promote exercise across the lifespan.

Acknowledgements: Travel funds from college of EHHD and Graduate School

Supplementation with a Highly Branched Cyclic Dextrin Solution during Ski Mountaineering: A Randomized Clinical Trial

Bryce Peterson, Health & Human Development; Rachel Topf, Health and Human Development; Adrianna Yeats, Health and Human Development; Prabina Bhattarai, Health and Human Development

Mentor(s): Mary Miles, Health & Human Development

Introduction: To help hydration of ski mountaineering (skimo) athletes, solutions made with a highly branched cyclic dextrin (HBCD) and fructose were utilized. HBCDs have a low osmolarity and quick gastric emptying timing, potentially beneficial for hydration in high endurance exercise. Purpose: To compare how solutions containing 6% and 18% HBCD+ fructose (3:1) influence drink palatability, hydration, GI distress, and performance. Methods: Participants (n=15) were experienced skimo racers ≥18 years who had participated in skimo ≥ one year or competed in ≥ two races. A double-blind, randomized, crossover research design was completed to compare 6% (30g CHO/500 mL/h) and 18% (90g CHO/500 mL/h) solutions during an 11.3 km race. Paired t-tests were used to determine the difference between the two conditions. Results: Palatability (mean ± SD, 7.6 ± 1.76 vs. 7.2 ± 2.37, p=0.424) and change in urine specific gravity (0.0014 ± 0.0059, 0.0004 ± 0.008, p=0.596) were not different between conditions. GI distress scores trended lower in 6% (0.07 ±1.44, 2.4 ± 2.75, p=0.073), and four participants in the 18% condition had GI distress scores >4. Overall race time (105.34 ± 17.01 vs 107.13 ± 17.31 min, p=0.135) and lap time change compared to the first lap (p=0.324) did not differ between conditions. When those experiencing GI upset (> 4) were excluded, lap time increases were attenuated in the 18% condition (p=0.01). Conclusion: An 18% CHO solution did not confer an overall performance benefit when compared to 6% but may produce a performance benefit when gastrointestinal distress is not experienced.

Acknowledgements: Funded by the Kreighbaum Endowment

Exercise in Rural Communities: A Qualitative Study Exploring Impacts of Past Experiences on Current Exercise Practices

Tasha Shaffer, Health & Human Development; Byrant O'Leary, Department of Food Systems, Nutrition, and Kinesiology; Tasha Shaffer, Department of Food Systems, Nutrition and Kinesiology

Mentor(s): Dawn Tarabochia, Health & Human Development

As the aging population continually grows, understanding how to keep older adults engaged in exercise is of increasing importance. This is critical as exercise trends show that engagement dramatically decreases with age. Moreover, older adults are more likely to live in rural communities as compared to urban communities (Cohen & Greaney, 2023). Previous studies explored barriers related to the overall decrease in exercise engagement, yet few have focused on older adults' motivation to maintain exercise practices. The purpose of this project was to explore how past experiences with exercise influence current exercise participation among rural, older adults. Residents engaging in exercise and aged 55+ (n=42) from a western state were recruited using convenience sampling (partnership with local Extension agents and social media outlets). As part of a larger online survey, participants completed an open-ended questionnaire specific to past experiences with exercise. Participant results were analyzed using Van Manen's (1990) hermeneutical approach with three members of the research team developing themes from participant responses. Trustworthiness was established by a peer reviewer to assess the themes for accuracy. Researchers identified five themes associated with how past experiences influenced current exercise practices. These included health and wellness (18), accessible instruction/resources (17), friends and family (13), community programming (10), and youth activity (4). By understanding past experiences, outreach professionals may find more impactful early or later life supports to promote exercise across the lifespan.

Acknowledgements: Travel funds from College of EHHD

Nutritional Characterization of Indigenous Plant-Enriched Yogurt – A Collaboration with Senegalese Women Farmers in Ndangane Village

Shelby Smith, Health & Human Development; Katie Elliot, Food and Nutrition; Chidimma Ifeh, Sustainable Food Systems

Mentor(s): Wan-Yuan Kuo, Health & Human Development

Background

With 285 million people in West Africa experiencing food insecurity and over 65% of children in Senegal being iron deficient, leveraging local food resources by enhancing nutrient bioavailability through fermentation may help alleviate these difficulties.

Integrating indigenous plant ingredients into fermented dairy products offers a promising strategy to address micronutrient deficiencies and improve gut health in the Western African population. Objective

This study examines the nutritional characteristics of Indigenous plant-enriched yogurt via lactic acid fermentation of cow's milk mixed with sorghum and baobab fruit, particularly focusing on oligosaccharide composition. Methods

Our study established a novel protocol to analyze fermentation-derived compounds. Data was assessed through liquid chromatography-mass spectrometry (LC-MS), generating heat maps to visualize differences in compound presence and patterns. Results

Liquid chromatography analysis revealed significant differences in oligosaccharide profiles between fermented and non-fermented samples, identifying a series of triose oligosaccharides with clear distinctions in monomer and trimer peaks after fermentation. According to the literature, prebiotic compounds improve digestion, enhance nutrient absorption, and reduce gastrointestinal infections. The enriched yogurt provides 10% of the daily value (DV) for vitamin C, 16% DV for protein, 4% for iron, and 20% DV for calcium, making it highly nutritious. Conclusion

Future research will characterize additional bioactive compounds in these fermented products to clarify their health characteristics further. By collaborating with Ndangane women farmers, this study highlights the potential of utilizing indigenous foods to improve community nutrition.

Acknowledgements: INBRE - IDeA Network for Biomedical Research Excellence, USP - Undergraduate Scholars Program, McNair Scholars Program, Empower Program

Comparison of Fasting Metabolomic Profiles After 12-weeks of Lentil Consumption

Meghan Spears, Health & Human Development; Gwendolyn Cooper, Chemistry and Biochemistry; Brett Sather, Chemistry and Biochemistry; Morgan Chamberlin, Food Systems, Nutrition, and Kinesiology; Stephanie M. G. Wilson, Food Systems, Nutrition, and Kinesiology

Mentor(s): Mary Miles, Health & Human Development

Incorporating lentils into the diet may reduce cholesterol levels and improve blood sugar regulation. Metabolomics offers a deeper understanding of the metabolite changes and metabolic pathways potentially influenced by lentil consumption. The aim of this study

was to evaluate the impact of long-term lentil consumption on fasting metabolite profiles in adults with increased metabolic disease risk.

Adults (n = 38) with an elevated waist circumference and elevated triglycerides were enrolled in this randomized clinical controlled trial. For 12 weeks, participants consumed daily lunch meals either with or without 140g of green lentils. Fasting metabolite profiles were assessed before and after the diet using untargeted LC/MS. Metaboanalyst 6.0 was used to evaluate metabolite changes and metabolic pathway enrichment.

Over 100 metabolites were altered ($p < 0.05$) following 12-weeks of lentil consumption. Among these metabolites, a phosphatidylcholine increased in abundance ($p = 0.005$), and lentil consumption biomarker, lenticin ($p=0.0002$). Pathway analysis revealed enrichment of linoleic acid metabolism and pantothenate synthesis. Linoleic acid, an n-6 polyunsaturated fatty acid, showed greater abundance after 12-weeks of lentil consumption compared to baseline ($p = 0.049$). Additionally, pantetheine, a form of vitamin B5, was in greater abundance following the lentil diet compared to the control diet ($p = 0.094$). We observed metabolic changes induced by 12 weeks of lentil consumption in adults with increased metabolic risk. Metabolite changes were related to fatty acid transport and energy production pathways. These results highlight the potential health benefits of incorporating lentils into the diet related to metabolic pathways.

Assessing Allostatic Load in Latinx Immigrants in Montana

Reyna Sundell, Health & Human Development

Mentor(s): Sally Moyce,

Allostatic load is a measure of physiological dysregulation, which is a result of stress responses. These stressors can be both chronic or acute. Long term release of catecholamines and glucocorticoids that emerge during a stress response may result in metabolic, immune and cardiovascular disturbances. Allostatic load is an emerging factor in studying social determinants of health in minority populations across the United States. Racial minority groups in the United States tend to experience greater chronic stress as a direct result of discrimination and social disadvantage and therefore experience the physiological effects of Allostatic load, leading to an increase in morbidity and mortality rates. Studying allostatic load provides a mechanistic link between stressors and health disparities. This research project aims to assess the level of Allostatic Load in the Latinx population in the Gallatin Valley. The variables that are used to assess this level for the purpose of the study were blood pressure, BMI, A1C, GAD stress scale and PHQ depression scale. These results will be presented.

Acknowledgements: USP - Undergraduate Scholars Program

Skimo Athlete Fueling And Hydration Knowledge, Practices And Barriers

Adrianna Yeats, Health & Human Development; Rachel Topf, Health and Human Development; Prabrina Bhattarai, Health and Human Development; Bryce Peterson, Health and Human Development; Mary Miles, Health and Human Development

Mentor(s): Mary Miles, Health & Human Development

Ski mountaineering (skimo) is a high intensity endurance sport with races lasting 1.5-3 h where athletes ascend and descend mountainous terrain. Little is known about skimo athletes' knowledge and current practices of carbohydrate supplementation and hydration or the barriers to achieving ideal nutrition during a race. Purpose: The purpose of this study was to identify current nutrition knowledge and practices of skimo athletes and the barriers to fueling during skimo events. Methods: Participants were 18+ years old and had at least one year of skimo experience or had completed two individual-style skimo races. A 21-question survey was distributed as a google form to the local community by word-of-mouth, social media, and at regional skimo events to evaluate the experience, knowledge, and practices of skimo athletes about race fueling and hydration. Descriptive statistics were used to analyze data. Results: Survey respondents (n=63) reported 4.2 ± 2.7 (mean ± SD) competitive seasons and 4.89 ± 3.68 races per year. A minority (16.4%) had formal sports nutrition education, and a majority (81.7%) were self-educated. Participant responses regarding knowledge of carbohydrate and hydration recommendations per hour for a 1.5 to 3 h event ranged from 30-200g and 500-1200mL. Participants reported wide ranges of typical carbohydrate and hydration consumption (0-200g/h and 32-1200mL/h). Top reasons for not fueling during racing include cold temperatures, accessibility issues, not feeling hungry/thirsty, and high intensity. Conclusion: Many skimo athletes lack accurate nutrition knowledge of carbohydrate and hydration recommendations. Future research should address the barriers to fueling during a skimo race.

Acknowledgements: Ellen Kreighbaum Fund

HUMANITIES

International Native Forest Restoration Internship, Corporación Nacional Forestal and Instituto Forestal, Chile

Lindsay Browder

Mentor(s): Cara Nelson and Jannine Montauban

Native forest restoration in Chile is a field of increasing importance due to increased wildland fire activity resulting from widespread plantation of exotic, highly flammable tree species and increased instances of ignition due to human activity.

This international internship provided invaluable work experience and Spanish immersion in professional native forest restoration and wildland fire prevention in Chilean Patagonia. From January to April 2025, the experience consisted of work with the Corporación Nacional Forestal (CONAF) in Torres del Paine National Park, a federal agency charged with managing national parks and monuments, and Instituto Forestal (INFOR), another state-funded agency dedicated primarily to forestry research, on the island of Chiloé. Internship activities involved collecting and managing data regarding species composition in experimental restoration and reference plots, processing native seed for nursery production, and wildland fire prevention education of both agency professionals and national park visitors. While not only developing technical skills in specific restoration research techniques and contributing to invaluable investigation, this experience presented a truly interdisciplinary combination of natural resource management and the Spanish language. Challenges included navigating professional norms, laboral expectations, and interpersonal communication within a new cultural context and linguistic environment.

Acknowledgements: Franke Sustainability Fellowship, University of Montana

Climate change impacts on the success of bird migrations in Montana in relation to vegetation growth and insect emergence

Lauralee Bruce, Political Science

Mentor(s): Paul Lachapelle, Political Science

Migratory birds are important to their ecosystems as both predator and prey, yet their habitat could shrink as a result of climate change and increased drought conditions. A reduction in desirable space will drive birds away from Montana, but reduction to their food sources in their winter home means they may not successfully migrate. Humans studying bird migration and population movement face challenges in being separated by region or department when trying to study birds that have no regard for human constructs. Despite the difficulties of conservation, the abundance of wildlife in Montana should not be taken for granted and should be a motivating factor in acting against climate change.

Negative Stereotypes of Greek Life and their Effect on Fraternity and Sorority Members

Elizabeth Clary, English

Mentor(s): Doug Downs, English

This project's objective is to understand how negative media coverage of Greek life affects those who take part in it. News media commonly talk about Greek life in a negative light, but people continue to be strongly affiliated with these communities. Studies of media coverage have shown that it has a negative impact on mental health (National Library of Medicine), whereas many studies of Greek life have shown a positive trend on mental health of its participants (Newport Institute). My study, however, examines the intersection of such findings: how media portrayals of Greek life affect those in it. I want to look at the common stereotypes of this community to try to understand where they come from and their effects. Montana State University's divided student population (Greek and non-Greek) offers a good opportunity for the study of the translation of such stereotypes from news media to student attitudes. My study engages the Greek life community through an initial survey and then, where applicable, follow up interviews. Additionally, I have interviewed university faculty who work with the fraternities and sororities to broaden perspective on this topic. Although this research is still in progress, survey results are demonstrating that members of the fraternity-sorority life community feel negative effects from what they hear around campus and on social media that most often leads to members not wanting to wear their Greek letters out and refraining from telling others of their association. My presentation will review further findings and discuss what would be required to reshape the discourse.

Acknowledgements: USP - Undergraduate Scholars Program

How have Mormon beliefs contributed to the past and ongoing disappearance of the Great Salt Lake

Amelia DiGiano, Film & Photography

Mentor(s): Paul Lachapelle, Political Science

The aridification of the Great Salt Lake can be attributed to many factors, including drought and global climate change. Since 2023, Mormon beliefs and conservatism have largely prevented any large-scale response to the Wasatch Valley's greatest ecological crisis. While there exists a Mormon tradition of environmental stewardship, it has been largely overshadowed by the Mormon priority of spiritually-driven wealth acquisition, leading to unchecked industrial growth throughout the Wasatch valley. Additionally, ecological crises in the Wasatch valley align with the Mormon belief that Christ's second coming will be

preceded by an apocalyptic period, thus creating a sense of apathy among Mormons regarding environmental reform. By re-integrating the Mormon tradition of stewardship into Utah policy, in turn consecrating nature, Mormon ideals can be used as a political tool to protect the Great Salt Lake.

Automobiles, Isolation, and the Production of Suburban Space: A Lefebvrian critique of the American built environment.

Jonathan High, Architecture

Mentor(s): Ezgi Balkanay, Architecture

This thesis examines the proliferation of the American suburbs from the post war era to the present, through an analysis of the political, economic, and social factors that shaped this dominant model of growth and development. Using the theoretical framework of Henri Lefebvre's Spatial Triad – "conceived space", "perceived space", and "lived space" – this paper critiques the ways in which automobile dependence, widespread privatization, and market-driven planning and development have enabled the degradation of the environment and communities, fostered social isolation, and led to a homogenized built environment that lacks a true sense of place. Building off historical and theoretical analysis, this thesis applies Lefebvre's concepts to a case study of contemporary suburban development in Bozeman, Montana – a rapidly growing town that is exhibiting many of the issues associated with suburban sprawl yet presents an opportunity to explore new models of community-led development and suburban retrofitting in order to better serve both human and ecological needs. By examining current and historic growth models, community survey responses, city planning initiatives, zoning law, demographic data, and current real estate development projects, this research will highlight the ongoing failures of conventional suburban growth and explore the potential for alternative spatial practices that promote connectivity, equitability, and a more sustainable future. This paper develops the argument that rethinking suburban development and spatial understanding through the lens of Lefebvre's theoretical framework can provide a pathway to a more socially and environmentally responsible built environment, providing a contemporary alternative to the entrenched ideals of post war America.

Between Easy and Hard Problems of Life: What Does Simpson's Paradox Reveal?

Truman Kluempke, History & Philosophy; Gordon Brittan, History and Philosophy; Yves Idzera, Physics

Mentor(s): Prasanta Bandyopadhyay, History & Philosophy

In their work on the emergence of life, Sara Walker and Paul Davies define “Easy Problems” and “Hard Problems”. The easy problems being replication, compartmentalization, and metabolism, which could plausibly be explained by current chemistry and physics. They write “The hard problem of life is the identification of the actual physical mechanism that permits information to gain causal purchase over matter” They “suspect” that “a full resolution of the hard problem will not ultimately be reducible to known physics.” We apply Simpson’s Paradox (SP) to the debate over the easy and hard problems of life. SP is the reversal of the direction of a comparison when data are pooled. We argue that there is an intermediate position between the easy and hard problems, where an account of the causal purchase of matter could be instantiated through SP. In the debate on the emergence of life, we will evaluate the charge of reaction inefficiencies in both the Metabolism First Theory and RNA World Theory, and explore how locally inefficient reactions, when pooled, could become globally efficient through SP. Though it is theoretically possible to show how life could emerge, a causal narrative regarding how molecules interact in chemical reactions to result in living matters is yet to be known. However, we argue this stance leaves open possibilities for future hypothesis based on known physics. We will argue how the emergence of life through SP is neither a case of easy nor hard problems.

Acknowledgements: USP - Undergraduate Scholars Program

"Miscegenation" in the Rocky Mountain West

Lukas Kosel, English

Mentor(s): Kirk Branch, English

There is little research on the rhetoric surrounding interracial relations in the Rocky Mountain West despite the 19th and 20th century prominence of anti-miscegenation legislation. My research looks at the impact of the word “miscegenation” in the Rocky Mountain States as it contributed uniquely to the development of the region's identity throughout the 20th century. The Western American identity has historically been seen as distinct from other regions throughout the country, often being depicted as whiter and less “miscegenated” than other regions. While population densities did play a role in this perception, I argue that Rocky Mountain media portrayals of interracial relations made these relations effectively invisible in the region. My research analyzes the rhetoric and the historical context of newspaper publications, oral histories, and other archival materials from the Rocky Mountain West. Newspapers and public sources shaped Rocky Mountain

views of interracial relations, often placing the Eastern and Southern states as sole perpetrators. This narrative reinforced the region's self-image as morally and racially exceptional, with deflective rhetoric on "miscegenation" and the omission of interracial relations in the Rocky Mountain West further solidifying this perception. The belief that the region is exceptional because of its whiteness and racial purity affects not only mixed-race people, but everyone in the region as they develop identities in a heterogeneous space that refuses to acknowledge its own diversity.

Acknowledgements: USP - Undergraduate Scholars Program, AYCSS Hilleman Scholars Program

The Climate Humanities: A Strategy for Climate Engagement on the Bobcat Campus

Shane Skiff, History & Philosophy

Mentor(s): Paul Lachapelle, Political Science

Many contemporary psychologies of motivation and philosophies of environmental action point to emotion and emotional connection as a key element of behavioral change (Shiota et al, 2023, Berkman 2018). This is the central tenant of the "climate humanities," a field of research and study that explores the role imagination, emotion, and collective stories play in addressing the climate crisis. Numerous universities around the United States have implemented climate humanities curriculums, but as of 2025, Montana State University is not one of them. This research investigates how and why the climate humanities are an effective tool in addressing the climate crisis and outlines several ways the humanities department (Arts, English, History, Philosophy) at Montana State University could increase access to and awareness of the climate humanities through improved communication of course offerings and professorial interests.

Where Their Cradles Stood: A Novel

Gavin Thorson, Chemistry & Biochemistry

Mentor(s): Nick Ehli,

The story of my maternal grandfather's family has long been a source of familial consternation due to their turbulent and mysterious past. My grandfather and great aunt were born to ethnic German parents whose families had lived for decades in Volhynia, a historical region of modern-day Ukraine. When the Eastern Front collapsed in 1943, their relatives were scattered—from the Siberian Gulag to villages in northern Germany to the

fields of northern Iowa, where I was born. For two decades, my great aunt researched our family history, tracing it from the late 18th century to the present, yet significant gaps remain. One of the most perplexing mysteries is the still unexplained disappearance of my great-great-grandfather in 1924/1925. Despite extensive research, no one has crafted a full, cohesive narrative of the family's journey. This ongoing work blends family documents, historical records, memoir, and literary invention to bridge these gaps, straddling the line between biography and historical fiction. The narrative begins in 1899 with my great-great-grandmother, Rosalie Scheming, as a child and follows key family members through wars, displacement, and survival, ending in 2024 with the passing of my great-grandmother, Minna Wedmann. By reconstructing their experiences, this project highlights my family's role as witnesses to some of Eastern Europe's great tragedies and sheds light on facets of world history often overlooked.

Acknowledgements: USP - Undergraduate Scholars Program

More Than a Museum Visit: Strengthening Caregiver-Child Interactions Through Early Learning Classes

Taylor Young, Psychology; Natasha Gesker, Department of Mathematical Sciences; Sophia Rodriguez, Education, Health, and Human Development

Mentor(s): Kalli Decker, Health & Human Development

Purpose: This research investigated how children and caregivers are influenced by participating in museum-based early learning classes. Museums can be a place that support early learning opportunities for children, and they can also support caregivers to connect with their children. Methodology: Our research took place at a regional natural history museum. We invited children's caregivers who attended early learning classes to participate in a survey that included questions about demographics, the caregiver, and the child(ren) who attends classes. The survey included questions about why caregivers attend classes, how they feel the classes influence their child(ren) or their interactions with their child(ren). A total of 74 caregivers participated. Preliminary analyses have included Exploratory Data Analysis to obtain summary statistics, visualize the data, and review variable relationships. Next steps will include ordinal regression. Results: Caregivers reported that early learning classes are a great way to spend quality time with their child(ren). Caregivers' perception about quality time positively predicts that they felt classes are meaningful to their relationship and that they have learned new ways of interacting with their child(ren) by attending. However, quality time is not a predictor of caregivers talking to their child(ren) about what they learned or did in classes. We will now

analyze if the age of child(ren) affects these correlations. Caregivers' experiences and expectations may differ based on the age of the child(ren) or type of caregiver (ex: parent, grandparent, nanny). This information could be used to inform programming for different ages or caregiver types.

Acknowledgements: McNair Scholars Program

MATHEMATICS

Investigating the Role of Road Network Shape and Accident Severity

Kyla Andersen, Computer Science; Jack Ruder, College of Engineering

Mentor(s): Brittany Fasy, Computer Science; Chris Organ, Earth Sciences

Understanding the structural characteristics of road networks at the site of an accident is essential for identifying patterns that may contribute to crash frequency or severity. This project investigates whether the shape of the road network at an accident is correlated with accident outcomes. Using traffic accident data from California from 2007 to 2017, we extract local road network snippets centered around accidents and represent each snippet using the Weighted Euler Characteristic Transform (WECT). The WECT is a topological descriptor that captures the connectivity of a road segment in a compact and mathematically comparable form. To establish a reference space, we are constructing a database of WECT descriptors computed from a sample of road snippets that are not associated with an accident. The goal is to query this database using accident site descriptors and find topologically similar road structures that will enable us to analyze whether road shape plays a meaningful role in traffic outcomes. We are currently in the data collection and preprocessing phase, working on extracting and processing road snippets from 2017 and 2007 California accident data and generating graph representations from OpenStreetMap for each site.

These accident-centered graphs serve as the query set. In parallel, we are building our database of general road network snippets from a broader sampling of the California road network. Our preprocessing also includes converting the graph representations into simplicial complexes and computing WECT descriptors for both sets. Our next step is to evaluate whether the nearest neighbors of each accident, based on WECT similarity, exhibit related accident characteristics.

Future directions include expanding the dataset to other years and regions, incorporating additional traffic features, and exploring how predictive these road network shapes may be in real-time risk assessment or infrastructure planning.

Acknowledgements: USP - Undergraduate Scholars Program, McNair Scholars Program

Using Statistical Models to Assess Likert-Scale Data Related to Museum Programming for Young Children

Natasha Gesker, Mathematical Sciences; Taylor Young, Sophia Rodriguez

Mentor(s): Samidha Shetty, Mathematical Sciences; Kalli Decker, Health & Human Development

The Museum of the Rockies in Bozeman offers an Early Learning Program for ages 0-6, which allows even the youngest museum patrons a chance to engage with museum content. Program leaders create age-appropriate activities and content for three different classes for both children and their caregivers to enjoy: Sensational Babies, Little Learners, and Preschool Pioneers. However, limited access to demographic data and caregiver feedback creates a barrier for program leaders to understand the program's impact. To address this gap in understanding a convivence sample of caregivers who attend the Museum of the Rockies' early learning classes was surveyed in late 2024. Participants were asked about their demographics, the demographics of the children in attendance, their involvement with the program, and their perception of the program. The responses of interest assess how the adult and their child have been impacted by this program. These questions were measured on a Likert-scale from 0 to 10. A total of 74 caregivers were surveyed. Using a Proportional Odds Models, data will be analyzed to further understand what factors relate to caregivers' perceptions of the classes. Preliminary results from exploratory data analysis suggest that caregivers' mindset is associated with their takeaways. For example, there appears to be an association between how much a caregiver views this time as "quality time" with their child and how they engage with their child outside of the classroom. Further analysis aims to clarify these relationships and communicate them in terms of probability.

Acknowledgements: MSU Faculty Excellence Grant (Awarded to Kalli Decker)

Analyzing the Cell-Cycle Regulation of Cryptococcus Neoformans Using the Inherent Dynamics Pipeline

Heidi Hansch, Mathematical Sciences

Mentor(s): Breschine Cummins, Mathematical Sciences

Across a diversity of organisms, regulation of the cell cycle occurs via small groups of core transcription factors and regulators that interact to control global, oscillatory gene expression. While these genetic networks are well-studied in model organisms such as the yeast, Saccharomyces cerevisiae, the cell cycle regulation of other organisms such as Cryptococcus neoformans is more uncertain. C. neoformans is a fungal pathogen and the causative agent of cryptococcosis infection, which primarily impacts the brain and lungs of immunocompromised patients. Cryptococcosis has a 20% mortality rate in North America, and a mortality rate of up to 70% in other regions of the world. Understanding the cell cycle regulation of C. neoformans may elucidate a means of halting the pathogen's host invasion and curbing its virulence. Network models of gene expression may be investigated using the computational process of Iterative Network Hypothesis Reduction from Temporal Dynamics (the Inherent Dynamics Pipeline). This three-step sequence involves a node-finding phase, an edge-finding phase, and a network-finding phase. Beginning the pipeline process with a local approach enables a robust ranking of pairwise regulator interactions. In turn, pairing the local with a global approach enables the removal of false positive nodes and edges that fail to contribute to dynamic oscillatory behavior. Altogether, the process generates candidate gene networks informed by experimental time series data. This study uses the Inherent dynamics pipeline to analyze the cell-cycle regulation of C. neoformans. Through several runs of the pipeline and the optimization of network-finding parameters, the study aims to find candidate networks that clarify the pathogen's regulatory activity.

Optimizing Hard Thresholding for Sparse Model Discovery

Derek Jollie, Mathematical Sciences

Mentor(s): Scott McCalla, Mathematical Sciences

Model selection remains an important tool for forecasting and understanding the underlying system for experimental data. A popular algorithm in this field is Sparse Identification of Nonlinear Dynamics (SINDy) due to its capability of learning interpretable and physics-based dynamical systems. We propose a method of refining the optimization scheme of SINDy by adding randomness to each iteration in a simulated annealing-like process in hopes of exploring more of the parameter space. Furthermore, we introduce the optimization scheme of hard thresholding pursuit with and without annealing to the SINDy architecture to increase prediction accuracy. The algorithms' effectiveness is demonstrated through comparisons on nonlinear equations pulled from models for

convective flows, excitable systems, and populations. Then, we demonstrate the capabilities on a real experimental projectile motion system.

Acknowledgements: USP - Undergraduate Scholars Program

Investigating and Determining Discrete Morse Extension Algorithms

Jolene Niglio, Mathematical Sciences; Ben Holmgren, Mathematics/Computer Science at Duke University

Mentor(s): Binhai Zhu, Brittany Fasy

Robert Forman developed discrete Morse theory as a combinatorial analog to classical Morse theory by creating matchings on discrete topological structures such as simplicial complexes. A Morse matching describes a set of pairs formed by a discrete Morse function and has two conditions: there is at most one edge per simplex, and the graph has no directed cycles. Discrete Morse theory allows us to simplify complexes by collapsing (or removing) simplices paired in the matching while preserving the complex's topological invariants. A type of matching of heavy research is a maximum number of possible pairings produced by a discrete Morse function (maximum Morse matching or MaxMM). The problem of computing a maximum Morse matching is NP-hard, and researchers have created a variety of approximations. In this project, we have developed an algorithm that we conjecture provides a two-thirds approximation by removing pairs that form a directed cycle. Although a complete proof is still needed, we have made great strides by creating a construction for path length and proving the minimum path length required to form a directed cycle.

Acknowledgements: USP - Undergraduate Scholars Program

MICROBIOLOGY AND CELL BIOLOGY

Characterizing the S. aureus virulence factors responsible for inhibition of Complement Dependent Aggregation Interference

Tate Baker, Chemical & Biological Engineering

Mentor(s): Jovanka Voyich, Microbiology & Immunology

Staphylococcus aureus (S. aureus) is a significant human pathogen that causes mild to life-threatening infections. Biofilm formation by S. aureus is a virulence mechanism that protects the bacteria from innate immune clearance. This study characterizes mutant

strains of S. aureus during interaction with human blood components. The objective of the research is to determine how S. aureus interacts with the human immune system, specifically what S. aureus genes work together to prevent complement-mediated inhibition of aggregation. To achieve this goal, I am comparing three mutant strains of S. aureus during growth in media and in blood. The strains used are a mutant in the two-component regulatory system saeR/S, a deletion ΔC7, lacking seven genes regulated by saeR/S deemed to be important in complement-mediated inhibition of aggregation, and the parental wildtype strain LA clone (LAC). I have performed bacterial growth curves in media, human blood assays, and will soon begin neutrophil assays. Data from strains grown in nutrient rich media was collected and there were no significant differences between the strains. Ongoing studies are comparing how human blood with complement components impacts growth of the strains. Future studies will also compare the strains during interaction with human neutrophils. Findings from this project will help gain insight into the mechanisms by which bacteria resist innate immunity and lay the groundwork for treatments for biofilm infection.

Acknowledgements: USP - Undergraduate Scholars Program

Investigating the role of Aqp3b in convergent extension in Xenopus laevis embryonic development

Ava Banionis, Microbiology & Cell Biology; Rhoda Adjartey, Micribiology & Cell Biology

Mentor(s): Christa Merzdorf, Microbiology & Immunology

I am investigating the role of Aquaglyceroporin 3b (Aqp3b) in convergent extension (CE) in Xenopus laevis embryonic development. CE is a process occurring in late gastrulation in which cells of the dorsal marginal zone (DMZ) of the mesoderm undergo intercalation and elongation to result in the development of the notochord, the precursor to the central nervous system. I will observe how Aqp3b is involved in the regulation of CE of the dorsal mesoderm through the noncanonical Wnt/PCP signaling pathway, which activates small GTPases to induce cytoskeletal rearrangement for CE. Previous research in the Merzdorf lab elucidated that Aqp3b is required for convergent extension, and aqp3b knockdown still resulted in CE when RhoA mRNA was injected, but not Rac1. Analysis of injected embryos will be used to determine whether Aqp3b activates the small GTPases RhoA and Rac1 during convergent extension, and whether Aqp3b regulates CE through RhoA only. Testes and eggs are harvested from X. laevis to generate embryos. Embryos are injected into two dorsal blastomeres at the 4-cell stage at the with aqp3b mRNA to overexpress Aqp3b, and aqp3b morpholino oligonucleotides to inhibit Aqp3b expression. Keller explants of the DMZ

are harvested at early gastrula stage 10.5 once the DMZ has involuted and expressed proteins incurring neural tissue differentiation. Proteins are extracted from lysed Keller explants to examine the activation of the small GTPases RhoA and Rac1 using pulldown assays, a technique which detects the active, GTP-bound forms of the small GTPases. SDS-PAGE is used to denature the proteins and permit detection of the active GTPases by Western blot. Data is continually collected for this project, so current investigation is focusing on protein detection by western blot. I am examining whether Aqp3b mediates CE by indirectly activating RhoA and not Rac1; or, if RhoA rescues convergent extension through another unobserved pathway. I hypothesize that Aqp3b activates RhoA, while Rac1 acts in a parallel signaling pathway requiring Wnt/PCP-mediated activation. Revealing the cellular signaling process through which aqp3b activates GTPases in the Wnt/PCP pathway is necessary to understand the signaling cascade by which CE is regulated, and therefore formation of the central nervous system.

Acknowledgements: USP - Undergraduate Scholars Program

Nitrogen Fixation in Cold, Dark Subglacial Ecosystems

Patric Baumann, Microbiology & Cell Biology; Eric Boyd, Microbiology & Cell Biology; Annie Shoemaker, Microbiology & Cell Biology

Mentor(s): Eric Boyd, Microbiology & Immunology

Saline cryospheric habitats—such as those found beneath glaciers—provide some of the best modern-day Earth analogs for the subsurface oceans of Europa, Enceladus, and Earth's many "snowball" periods. This study aims to experimentally determine whether bacterial nitrogen fixation can occur in microbes inhabiting subglacial environments, and perhaps more valuably, under below-freezing conditions. Nitrogenase is the only known enzyme capable of nitrogen fixation. Nitrogenase is a multimeric enzyme consisting of NifHDK and this complex undergoes at least four dynamic cycles of NifH associating with NifDK to deliver electrons for substrate reduction. As such, cold-temperatures would be expected to require structural adaptations to allow for enzyme dynamics. Here, I describe an acetogen isolated from beneath Bench glacier, Alaska, USA. Using shotgun genomic sequencing, genes encoding molybdenum nitrogenase were identified in the organism. Cultures grown with N_2 gas as its sole nitrogen source, under both near-freezing and below-freezing conditions, demonstrate that nitrogenase is active under these conditions. Results indicate growth under near-freezing conditions, supporting the idea that fully functional nitrogen cycles may exist within Europa and Enceladus.

Acknowledgements: USP - Undergraduate Scholars Program

Microbial Interactions Trigger Helminth Development

Jack Bright, Microbiology & Cell Biology; Karlin Blackwell, Microbiology and Cell Biology

Mentor(s): Douglas Kominsky, Microbiology & Immunology; Seth Walk, Microbiology & Immunology

The Kominsky and Walk labs are interested in studying the murine-specific intestinal roundworm, Heligmosomoides polygyrus bakeri (H. poly). H. poly develops outside the host through three larval stages to its infectious form where it then goes on to establish an infection within the small intestines of mice. However, in order to properly cultivate H. poly in a laboratory setting, Escherichia coli must be introduced during its larval stages. Otherwise, the H. poly larvae will not properly mature and eventually die. Little is known about the microbial interactions between E. coli and H. poly larvae that triggers development and this project aims to describe these microbial interactions. Previous research in this lab has investigated the effects of different E. coli treatments on H. poly larval development. These treatments include live, sterile-filtered, heat-killed, and a combination of sterile-filtered/heat-killed E. coli. Of these treatments, H. poly larval development was only observed with live E. coli. Further experiments found that the live E. coli needs to be metabolically active to trigger larval development. Currently, what the E. coli may be utilizing from the growth media is being investigated. These experiments tracked E. coli growth in Luria broth (LB), nematode growth media (NGM), carbon-free NGM, and glucose-NGM (carbon sources replaced with glucose). These experiments have shown that E. coli is only metabolically active in NGM and LB, indicating a source of amino acids is critical. Overall, these findings indicate live, metabolically active E. coli utilizing amino acids is required for proper H. poly larval development.

Acknowledgements: USP - Undergraduate Scholars Program

Determining the trigger for the ppl phage defense system

Danielle Cahill, Microbiology & Cell Biology; Wijemuni Senuri Udara De Silva, College of Agriculture, Department of Microbiology and Cell Biology

Mentor(s): Blake Wiedenheft, Microbiology & Immunology

Bacteriophages are viruses that infect and replicate within bacteria and are among the most abundant biological entities on Earth, with an estimated number of 10^31 phage types known. The large range of distribution drives constant interactions with bacteria,

promoting rapid co-evolution. This dynamic relationship can be characterized as an "arms race" due to the continuous development of bacterial defense systems and corresponding phage counter-defense systems.

Our research focuses on the ppl defense system originally identified in Salmonella enterica, which has demonstrated effective protection against T3 and T7 phages. The primary goal of our study was to determine the specific T3 phage protein responsible for triggering the ppl immune response. To achieve this, we analyzed populations of T3 phages that could escape the ppl defense system, called phage escaper mutants. By amplifying the phage titer of the T3 escaper mutants, purifying their genomes, and then using Nanopore sequencing, we identified mutations in the Tail Fiber protein of T3 phages, which we attribute to giving the escapers ability to evade detection by ppl, therefore preventing an immune response. This discovery led us to hypothesize that the T3 Tail Fiber protein is a trigger for ppl defense activation and also gives crucial insight into designing subsequent experiments for studying the mechanism of ppl in rendering phage defense.

Overcoming PRV superinfection exclusion: evaluating the effects of resource allocation during viral co-infection

Lauren Campbell, Microbiology & Cell Biology

Mentor(s): Taylor Matthew, Microbiology & Immunology

Superinfection exclusion (SIE) is a well-documented phenomenon in which an initial viral infection prevents secondary infection by the same or related viruses. Previous work from the Taylor lab demonstrated that Pseudorabies virus (PRV) SIE permits secondary immediate-early (IE) gene expression at high inoculation doses using an immediate-early transcriptional reporter. However, secondary late gene expression is largely suppressed. This project investigated the mechanisms underlying late gene suppression, secondary viral progeny output, and resource allocation in PRV SIE. PK15 cells were infected with red fluorescent protein-labeled PRV-180 (MOI = 10) At two hours post-infection, the cells were infected with cyan fluorescent protein-labeled PRV-950 (MOI = 50). Fluorescent microscopy tracked viral capsid distribution at twelve hours post-infection, followed by the quantification of both primary (PRV-180) and secondary (PRV-950) viral progeny by viral plaque visualization.

At twelve hours post-infection, primary viral capsid expression was robust, whereas secondary viral capsid expression was minimal. Despite the lack of secondary reporter expression at twelve hours post-infection, robust late gene expression was observed in the form of viral plaques, indicating successful secondary viral progeny output. The results of

the experiment indicated the presence of a possible “gene-snatching” mechanism by the secondary virus during late gene transcription. Further research is needed to confirm this proposed molecular mechanism and to investigate the possibility of host resource sequestration by the viruses.

Acknowledgements: USP - Undergraduate Scholars Program

Impact of Nicotine and Cotinine on Gardnerella vaginalis Growth: Implications for Vaginal Dysbiosis

Emilie Courchesne, Microbiology & Cell Biology

Mentor(s): Joanna-Lynn Borgogna, Microbiology & Immunology

An optimal vaginal microbiome is primarily composed of Lactobacillus species, which help maintain an acidic environment through lactic acid production. This low pH inhibits pathogenic microbes, preventing infections and overgrowth of harmful organisms, such as Gardnerella vaginalis. which is a dysbiotic vaginal state linked to adverse health outcomes, such as sexually transmitted infections, infertility, and preterm birth. Lifestyle behaviors such as smoking can influence the vaginal microbiome. For example, cigarette smoking is associated with low abundance of protective lactobacilli, but a high abundance G. vaginalis. However, a mechanistic evaluation of the impact of tobacco constituents remains undetermined. This study investigates how nicotine and cotinine concentrations affect G. vaginalis’ growth. Growth curves were conducted where G. vaginalis was exposed to physiological concentrations of nicotine (398.38 ng/mL, low; 1529.29 ng/mL, high) and cotinine (1043.60 ng/mL, low; 1618.61 ng/mL, high). Growth was quantified through optical density (OD) measurements at 600 nm, and pH measurements, taken every half hour until stationary (~25 hours). Growth rates were performed in triplicate. Results suggest that the high physiological concentrations of nicotine and cotinine promote the growth of G. vaginalis ($p<0.05$). The growth curves yielded only preliminary data which needs more trials and larger sample sizes to validate the results. The data does suggest that nicotine and cotinine exposure promote the growth of Gardnerella vaginalis, which contributes to the development of bacterial vaginosis.

Acknowledgements: USP - Undergraduate Scholars Program

Gut microbiome impacts inter-vivarium and inter-individual responses to arsenic toxicity in a mouse model

Emma Dardenne-Ankringa, Microbiology & Cell Biology; Trenton Wolfe, Microbiology and Cell Biology

Mentor(s): Seth Walk, Microbiology & Immunology

Over 100 million people worldwide drink water containing dangerous levels of the environmental toxicant and group 1 carcinogen, arsenic. In similarly exposed populations, only some individuals develop arsenic-associated disease (arsenicosis) and factors like human genetics do not adequately explain epidemiologic patterns. Our objective is to evaluate the gut microbiome's role in arsenicosis. Previously, we established a mouse model of inter-individual susceptibility to arsenic exposure that requires antibiotic perturbation of the gut microbiome. We noticed that susceptibility varied in groups of mice purchased from different vendors even though their genetic backgrounds were virtually identical. Other studies found that mice from different vendors host distinct gut microbiomes and that this variability drives differences in the onset and progression of diseases unrelated to arsenic. Here, we tested two hypotheses. First, we tested whether isogenic mice from different vendors and of different substrains harbor different baseline microbiomes that could impact model outcomes. Second, we tested whether arsenic metabolism deficient mice exhibit inter-individual susceptibility in the same model. Stool microbiome composition was evaluated throughout the arsenicosis model in C57BL6/J mice from Montana State, C57BL/6J and C57BL/6N mice from Jackson, and C57BL/6N mice from Taconic using 16S-rRNA Illumina sequencing. We expected that microbiome composition would be dependent on the vendor mice were purchased from, and would affect their morbidity and mortality. Next, we evaluated arsenic methyltransferase deficient C57BL/6 mice (As3mt-KO) in the model and compared the levels of arsenic-containing compounds (arsenicals) in liver, blood, urinary bladder, and stool using HPLC-ICP-MS. Results from these mice were compared to their wild type (WT) and heterozygous (WT x As3mt-KO) counterparts. We expected that WT mice would have greater amounts of methylarsonic acid (MMA) and dimethylarsinic acid (DMA) in all samples than As3mt-KO mice, while heterozygous mice would have intermediate levels of MMA and DMA.

Acknowledgements: USP - Undergraduate Scholars Program

The Effect of Palmitate on Streptococcus pneumoniae Growth and Virulence Gene Expression

Annika Gao, Microbiology & Cell Biology; Tim Borgogna, Center for Biofilm Engineering; Maria Predtechenskaya, Microbiology; Ritu Bajwa, Microbiology

Mentor(s): Jovanka Voyich, Microbiology & Immunology

Purpose: Palmitic acid, a major lung surfactant component, reduces neutrophil plasma membrane damage in response to Staphylococcus aureus, suggesting it protects host cells from lysis caused by bacteria. This study examines whether Streptococcus pneumoniae (S. pneumoniae) exhibits a similar response by assessing the effects of palmitic acid on its growth and pneumolysin (ply) expression, a key virulence factor involved in neutrophil damage.

Methods: S. pneumoniae was grown to mid-log phase and exposed to varied concentrations of palmitate. Growth was assessed via absorbance and CFU/mL measurements. RNA was extracted using concentrations of palmitate that did not significantly reduce growth, and ply expression was analyzed via RT-qPCR, normalized to the housekeeping gene lytA using the ΔΔCt method.

Results: S. pneumoniae growth was significantly inhibited at palmitate concentrations above 32 μM. Thus S. pneumoniae was incubated in PBS containing concentrations of palmitate at 32 μM and 16 μM since they did not significantly impact growth compared to the control. CFU/mL measurements showed no significant difference in the growth between the treated and control groups following the one hour incubation, confirming 32 μM and 16 μM as the highest non-inhibitory levels. RT-qPCR analysis showed no significant change in ply gene expression relative to lytA.

Conclusion: After exposing S. pneumoniae to varied concentrations of palmitate, a negative correlation between palmitate concentration and bacterial growth was observed. However, RT-qPCR analysis showed no significant change in ply gene expression in response to palmitate suggesting that virulence gene expression is not reduced in S. pneumoniae due to the presence of palmitate. Future research will explore other virulence factors that may be modulated by palmitate and will also investigate expression of pneumolysin following additional incubation times in palmitate.

Bacterial-Fungal Interactions in Multidomain Biofilms: Implications for Biofouling in the ISS Wastewater Recycling System

Amanda Haab, Microbiology & Cell Biology

Mentor(s): Elizabeth Sandvik, Center for Biofilm Engineering; Matthew Fields, Microbiology & Immunology

Microbial biofouling poses a significant challenge in the International Space Station (ISS) wastewater recycling system, where bacterial-fungal interactions may contribute to persistent biofilm formation. This study investigates the impact of bacterial-fungal co-

cultures on biofilm development, biomass accumulation, and hyphal colonization patterns using fluorescent tagging methods. We examined interactions between Lecythophora mutabilis and various bacterial species, including Methylobacterium organophilum, Ralstonia insidiosa, Burkholderia contaminans, and Cupriavidus metallidurans. Preliminary findings indicate that Burkholderia forms large cellular aggregates with fungal conidia, while Cupriavidus and Ralstonia induce dense floc formation. In contrast, Methylobacterium exhibited minimal biofilm formation and weak fungal interaction. Future research will optimize staining techniques, explore multi-species biofilm dynamics, and assess bacterial aggregation mechanisms under membrane-separated conditions. These insights contribute to the development of biofilm mitigation strategies for long-term space missions.

Acknowledgements: MSGC - Montana Space Grant Consortium

Characterizing and Identifying Human Brain Endothelial Cell Response to Encephalitic Orthobunyaviruses

Katherine Hanson, Microbiology & Cell Biology

Mentor(s): Alyssa Evans, Microbiology & Immunology

Jamestown Canyon Virus (JCV) and La Crosse Virus (LACV) are part of the California serogroup (CSG) of orthobunyaviruses. LACV is identified as the leading cause of pediatric arboviral encephalitis in the United States of America while JCV is linked to severe neuroinvasive disease cases in adults. No current treatments or vaccines exist for these viruses as they are poorly understood. This undergraduate research study aimed to identify the difference in response to JCV and LACV in human brain endothelial cells (HBECs) and the viral gene that contributes most to these changes. To accomplish this, HBECs were infected with a virus and RNA was isolated at subsequent times post-infection for analysis of gene expression via quantitative Polymerase Chain Reaction (qPCR). This study is ongoing, with the first phase of the experiment in progress. In the first phase, JCV and LACV-infected cells are analyzed for differences in gene response. In the second phase, LACV and JCV viruses with swapped NSm genes (“recombinant viruses”) will be sampled to clarify the role of the NSm protein in neuroinvasion. It is hypothesized that the glycoproteins from LACV will induce gene expression changes in the HBECs while the JCV glycoproteins will not and that the NSm protein does not play a role in neuroinvasion. This presentation will summarize the findings to date.

Acknowledgements: USP - Undergraduate Scholars Program

Evaluating the Interactions Between Burkholderia contaminans and Coniochaeta mutabilis Within a Biofilm

Andrew May, Center for Biofilm Engineering

Mentor(s): Brent Peyton, Chemical & Biological Engineering; Madelyn Mettler, Chemical & Biological Engineering

The International Space Station (ISS) has had multiple instances of clogging in the wastewater system caused by biofilm buildup. This research focused on two isolates from the ISS wastewater tank: a fungus, Coniochaeta mutabilis, which is thought to be the scaffold for the biofilm within the ISS wastewater system, and one bacterium, and a bacterium: Burkholderia contaminans, which is the second most prolific microbe within the ISS biofilm and has been shown to have antifungal properties. The interactions between these microbes were tested by growing them as biofilms in a CDC reactor on Inconel and Teflon, both common materials in the ISS water system. Experiments were conducted with each microorganism grown individually and in consortium. Each experiment used a 33-component media simulating the conditions in the ISS wastewater tank and lasted seven days, the last six of which were under continuous flow conditions. Experimental iterations included simultaneous and staggared inoculation of the consortium and each microbe being inoculated individually. It was shown that when the C. mutabilis is inoculated 24 hours before the B. contaminans and inoculated simultaneously, both microbes' growth is similar to the growth shown when inoculated individually. When B. contaminans is inoculated 24 hours before the C. mutabilis, the growth of the B. contaminans is similar to when grown alone, but the growth of C. mutabilis is about three to four orders of magnitude lower than when grown individually.

Acknowledgements: USP - Undergraduate Scholars Program, MSGC - Montana Space Grant Consortium

Determining the Relationship Between Aquaporin-3b and Calcium Transients

Josephina Moretti, Chemical & Biological Engineering; JoshHarrington, Cell Biology and Neuroscience

Mentor(s): Christa Merzdorf, Microbiology & Immunology

The objective of this project is to determine if Aquaporin-3b (Aqp3b) influences neurulation by facilitating or otherwise changing Ca2+ waves in neural plate cells. Neurulation is the

closure of the neural tube. When neurulation goes awry, birth defects such as spina bifida, anencephaly, and craniorachischisis can occur. These birth defects are life-threatening and are common in humans. Researching neurulation has great significance in developmental biology and has biomedical applications. To study the effects of Aqp3b on calcium signaling in the neural plate, time-lapse live imaging of Xenopus laevis embryos will be performed and Python programming will be used to analyze the time-lapse series for calcium waves. Xenopus laevis frog embryos will be used and Aqp3b will be inhibited using a morpholino oligonucleotide, and on control embryos for reference. We will perform the fertilizations, injections, and imaging, and perfect the Python program. We hypothesized that Aqp3b and calcium waves are related and play a key role in apical constriction, a fundamental process for neurulation. We expect to see a decrease in amplitude, length, and amount of calcium waves when Aqp3b is inhibited.

Acknowledgements: USP - Undergraduate Scholars Program

Optimizing the Lipid Production of Hidden Lake Algae for Biofuel Applications

Abby Novak, Plant Sciences & Plant Pathology; Kathryn Zimlich, Microbiology; Jessica B. Wood, Microbiology

Mentor(s): Matthew Fields, Microbiology & Immunology

Algal biofuels are a promising method of renewable industrial fuel production. Certain algae are currently grown on an industrial scale to produce lipids which can be harvested and converted into biodiesel, however, improvements to the efficiency of production and harvesting are needed. Hidden Lake Algae (HLA) is a green alga isolated from Hidden Lake in the Beartooth Mountains of Montana which shows potential for significant lipid production when compared to other green algae. Optimizing the lipid production of HLA is currently in progress. Methodologies include determining preferred nutrients, growth in a hydrogel environment, and analysis of the endemic microbial community associated with algal cells, known as the phycosome. Phycosome analysis includes investigating the impact of silica and diatoms on HLA, as Hidden Lake has a high concentration of dissolved silica. Growth curve and lipid staining experiments have shown an influence of silica on the growth of HLA, although the exact nature of this relationship (cooperative, commensal, competitive, etc.) has yet to be determined. HLA is also being cultured in a 3D-printed hydrogel environment that suspends cells in a resin matrix. This helps to understand growth by monitoring individual cells over time, along with potential future lipid harvesting and phycosome analysis applications. Cell growth is visualized through confocal microscopy and image analysis. Additionally, phycosome members were isolated and their

16S rRNA were genes sequenced to identify possible microorganisms that interact with HLA. These findings advance the current understanding of algal growth methods and optimization, creating a more sustainable future for our fuel.

Acknowledgements: EcoStart Internship Program

Metabolic Response of Chondrocytes to Physiological vs Injurious Mechanical Loading

William (Liam) Rockwell, Chemical & Biological Engineering; Aidan Gregory, Mechanical & Industrial Engineering; Priyanka Brahmachary, Mechanical & Industrial Engineering; Ron June, Mechanical & Industrial Engineering

Mentor(s): Ron June, Mechanical & Industrial Engineering

Osteoarthritis (OA) is a chronic joint condition that occurs when the protective cartilage cushioning the ends of bones deteriorates. Articular cartilage provides a low-friction surface for joint articulation and contains a single cell type, the chondrocyte. Chondrocytes are the cells that support the health of cartilage by maintaining its structure through mechanotransduction, the act of converting mechanical stimulation to biochemical signals. Deterioration of cartilage in OA leads to increased friction, pain, and stiffness in the affected joints, most commonly the knees, hips, hands, and spine. Age, genetics, injury, and lifestyle factors, like obesity, all impact and can accelerate this disease's development. Traumatic joint injuries increase the risk for the development of OA, leading to metabolic dysfunction and abnormal loading conditions on the joint. Metabolism is a complex network of biochemical reactions by which the body converts food into energy to support cell functions and overall growth. There is a knowledge gap in understanding how chondrocyte metabolism responds to normal physiological mechanical loading as well as injurious mechanical loading. I assisted graduate student Aidan Gregory in his project that aimed to increase knowledge on how chondrocyte metabolism responds to different levels of mechanical stimuli. Samples of healthy bovine and OA human chondrocytes from male and female donors were subjected to either (a) physiological cyclical compression to model walking or (b) high-strain compression to model injury. Previous studies explored tissue-level effects of injury. However, the specific cellular response to injury has yet to be fully defined. Oxygen levels and metabolite concentrations were analyzed immediately, as well as 1, 4, and 24 hours after mechanical stimulation. Controls were unloaded. Targeted metabolic profiling was used to assess metabolic shifts between groups, providing insight into how mechanical stress influences chondrocyte function. These results increase understanding of how mechanical loading

affects chondrocyte metabolism and may lead to novel therapeutics and improved clinical decisions for patients with osteoarthritis.

Acknowledgements: VPRED

Investigating the Role of Trp14 in Sustaining an Anti-inflammatory Environment in Mouse Models Lacking the Txndc17 Allele

Zoe Seaford, Microbiology & Cell Biology

Mentor(s): Ed Schmidt, Microbiology & Immunology

Research conducted in the Schmidt Lab focuses on the reduction of cellular oxidants through thiol oxidation, particularly under conditions of significant oxidative stress. Redox homeostasis in the cell is thought to be maintained by the reduction and oxidation of sulfur (S)-containing cysteine (Cys) amino acid residues through nicotinamide adenine dinucleotide phosphate (NADPH)-dependent disulfide reductase systems. In order to investigate the role of the thioredoxin-related protein of 14 KD (Trp14) in sustaining an anti-inflammatory environment mouse models lacking Txndc17, the gene encoding TRP14, were directly compared with normal livers under conditions of oxidative stress. This oxidative stress was generated in the liver through a bile duct ligation (BDL) procedure. These models, exemplified by TRP14-null livers, are relevant for studying oxidative stress conditions that enzymes, cystathionine β-synthase (CBS) and cystathionine γ-lyase (CSE), can both form and cleave carbon-sulfur (C-S) bonds of amino acids including cystathionine, serine, cysteine, homocysteine, and others. Here we assessed the ability of TRP14 to utilize these enzymes to counteract oxidative stress. Our hypothesis suggests that animals lacking TRP14 will be more robust than the WT livers due to their ability to utilize PLP-dependent enzymes CBS and CSE. Liquid-chromatography Mass Spectrometry (LC-MS) is a method of identifying molecules based on phase interaction and mass to charge ratio of low molecular weight, and high molecular weight compounds. From this we are able to observe the quantities of the various sulfur metabolites such as cystathionine, cysteine, and glutathione containing products utilized by these animals. A western blot was performed for visualization of CBS, CSE, and Trp14 proteins. Tissue analysis revealed that CBS and CSE are upregulated in TRP14 mice with BDL compared to that of WT mice that also received the surgery. In comparison, this reveals the crucial role of CBS and CSE in maintaining cellular redox homeostasis under stress conditions wherein disulfide reductases become deficient.

Acknowledgements: USP - Undergraduate Scholars Program, McNair Scholars Program

NEUROSCIENCE

Theory of Mind and Language Development in Neurodivergent Children

Grace Clark, Microbiology & Cell Biology; Nadezhda Modyanova, Mechanical and Industrial Engineering

Mentor(s): Nadezhda Modyanova, Mechanical & Industrial Engineering

The relationship between Theory of Mind (ToM) and language development in neurodivergent children, specifically those with Autism Spectrum Disorder (ASD) and Developmental Language Disorders (DLD) was studied. The combination of ToM and language-gesture research reveals the influence that gestures and language determiners ("the") have on comprehension. Ongoing studies aim to address gaps in services for neurodivergent children in rural areas. The findings could lead to more inclusive educational strategies and better healthcare.

The language-gesture task guided participants through a computer game that posed questions regarding characters, Fishy and Turtle. It focused on determining if the participant understood which object was the subject of linguistic determiners and could attribute that understanding to the characters on the screen. Eye tracking was used to plot gazes and track attention. ToM videos, known as "finding bear," featured a hider, hiding a toy bear under one of two boxes out of view of the participant, and a communicator who pointed to the location of the bear. Several conditions were assessed to ensure that the communicator was reliable and whether the participant could remember the switched location of the bear. To show attentive ToM, participants had to identify the correct location of bear. The Fishy-Turtle study underscores the positive impact of multimodal applications on language comprehension and suggests that gestures may be helpful in improving comprehension. Ongoing ToM research explores how collaborative efforts may enhance educational strategies. Future research aims to incorporate EEG (electroencephalography) data; findings can potentially serve as biomarkers for ASD and DLD diagnosis.

Acknowledgements: USP - Undergraduate Scholars Program, INBRE - IDeA Network for Biomedical Research Excellence

Screening the Drosophila melanogaster brain and ventral nerve cord for multi neurotransmitter neurons

Lizetta Dardenne-Ankringa, Microbiology & Cell Biology; Marta Chaverra

Mentor(s): R. Steve Stowers, Microbiology & Immunology

Neurotransmitters are chemical messengers which convey information between neurons and to effector cells. The two types of neurotransmitters are small-molecule transmitters and neuropeptides. Small-molecule transmitters are released from vesicles at the axon terminals of neurons and include the classical neurotransmitters glutamate, GABA, and acetylcholine. They also include monoaminergic neurotransmitters, such as octopamine, dopamine, serotonin, and histamine. Neuropeptides are molecules with autocrine and paracrine functions. The co-release of different combinations of one small-molecule transmitter and one or more neuropeptide from a single neuron has been well-documented in Drosophila melanogaster and other model organisms. Additionally, many cases of dual neurotransmitter neurons, which release combinations of two different small-molecule transmitters, have been identified in several experimental models in recent years. Neurons that release three small-molecule transmitters have not yet been identified in Drosophila melanogaster, although they have been documented in mice. We aim to screen the brain and ventral nerve cord of Drosophila melanogaster for multi neurotransmitter neurons that release serotonin, glutamate, and octopamine. To do so, we will use the split-GAL4 system to express epitope-tagged variants of VMAT, the vesicular monoamine transporter that packages both serotonin and octopamine into vesicles, and VGLUT, the vesicular glutamate transporter, only in neurons that express tryptophan hydroxylase (TRH), the rate-limiting enzyme in serotonin synthesis, and tyrosine decarboxylase 2 (Tdc2), an enzyme necessary for the production of octopamine. After preparing brain and ventral nerve cord dissections of our experimental organisms, we will perform immunohistochemistry to attach fluorescent labels to tagged neurons and capture images of these neurons using high resolution confocal microscopy. We expect to observe fluorescence indicating the presence of multi neurotransmitter neurons in the brains and ventral nerve cords of our experimental flies. Research on this topic is clinically relevant, as neurotransmitters have been implicated in human health conditions including depression, schizophrenia, and neurodegenerative disease.

Functional Analysis of Dual Neurotransmitter Neurons innervating the Male Reproductive System of Drosophila Melanogaster

Jace Tolleson Knee, Microbiology & Cell Biology; John Paul Toney, Microbiology & Cell Biology; Martha Chaverra, Microbiology & Cell Biology; Lizetta Ankringa, Microbiology & Cell Biology

Mentor(s): Steven Stowers, Microbiology & Immunology

The importance of dual neurotransmitter neurons is being increasingly recognized for normal cognition as well as mental health disorders. In the Stowers Laboratory, ongoing research to identify previously unknown dual neurotransmitter neurons has identified two novel subsets of dual neurotransmitter neurons that are glutamatergic-serotonergic and glutamatergic-octopaminergic. The purpose of this research project was to determine the function of these dual neurotransmitter neurons located in the posterior tip of the ventral nerve cord, which innervate the male reproductive system of D. melanogaster. The neuronal function was analyzed by selectively silencing them using a specific set of split-Gal4 drivers paired with UAS-botulinum toxin. Additionally, protamine, a specific nuclear sperm protein, was tagged with a green fluorescent protein reporter (GFP) to track sperm movement during copulation. The results suggest that serotonergic-glutamatergic neurons play a significant role in controlling a muscular sphincter that allows sperm flow from the seminal vesicles into the ejaculatory duct. Furthermore, this data indicates this subset of neurons are necessary for sperm transfer from the male to female D. melanogaster. This novel finding provides an important basis for understanding the role of dual neurotransmitter neurons in the central and peripheral nervous systems of D. melanogaster and it will also have implications more generally for understanding the function of dual neurotransmitter neurons in other organisms, including humans.

Acknowledgements: USP - Undergraduate Scholars Program

Measuring the Electrophysiological Effects of Space Related Altered Gravity on Primary Neurons

Amelia Zannoni, Electrical & Computer Engineering; Nathan Oftedal, Electrical and Computer Engineering

Mentor(s): Anja Kunze, Electrical & Computer Engineering

Microgravity, a space related condition where gravitational forces are significantly weaker than on Earth, has modulatory effects on neuronal structure, function, and synaptic density which are all key features of neuroplasticity. However, altered gravitational environments' influence on neuroplasticity remains vastly under-studied. To gain understanding of these mechanisms, we investigated electrophysiological behaviors of embryonic rat cortical neurons (eRCN) under altered gravity environments. We conducted our experiment in two phases; the first phase, the cells experienced one condition of either high or low magnetic force field and the second phase we switched conditions. We switched magnetic field conditions to model leaving Earth’s gravity and returning vice versa, mimicking neural adaptation to microgravity and re-entry. We developed a model of

altered gravity by generating a high magnetic force field, which measured 0.563 T, and one low magnetic force field which measured 0.036 T, using neodymium 1.27 cm x 1.27 cm permanent magnets. We cultured the dissociated eRCN's on 60-electrode microelectrode arrays (MEA). After 12 days in vitro, we incubated half of the cultures with functionalized iron oxide nanoparticles (10 µg/mL), while the rest were used as control. We recorded spontaneous activity in neuronal cultures using the MEA2100 (Multi Channel Systems, Germany) after each change in magnetic field condition. The preliminary results suggest observed changes in spike rate and amplitude between conditions. Our study may provide insight into the mechanisms underlying spaceflight-induced neuroadaptations and inform strategies for controlling behavioral neuronal risks associated in long-duration space travel.

ORGANISMAL BIOLOGY

Wild Horse Overpopulation- Consequences and Environmental Effects

Tessa Eslick, Health & Human Development

Mentor(s): Sattie Fisher

The research question that will be submitted with this project covers the topic of wild horse overpopulation. More in depth, how does the overpopulation of wild horses negatively impact their environment and their overall health and well-being. This project will focus specifically on the wild horse herds that reside in Yakima Valley, Washington State. Trail camera data will be used to help observe and record equine movement, health, and the population of other native species such as deer and elk. Currently, the research is ongoing and data analysis is being completed. I found this particular research to be interesting because of my focus in studying veterinary medicine, specifically in the equine field. As an undergraduate in the organismal biology program, ecosystem health and species population are also very important as they are covered in the same scope of research.

PHYSICAL CHEMISTRY

Lower Limit PFOA Concentration and the Effect on Lipid Membranes

Jackilyn Hemphill, Chemistry & Biochemistry; Tess Sobolewski, College of Letters and Science; Robert Walker, College of letters and science

Mentor(s): Dr. Rob Walker, Chemistry & Biochemistry

Poly/Perfluorinated substances (PFAS) are a class of synthetic molecules that threaten the health of communities and wildland

environments. PFAS consist of carbon chains, usually 4 – 10 carbons in length, with fluorine atoms attached where hydrogen atoms would be in a hydrocarbon. Known as 'forever chemicals', PFAS do not break down easily in the environment and have shown

an affinity for bioaccumulating in wildlife(1). They are commonly found in clothing water proofer, food packaging and firefighting foams. PFAS have also been found to cause numerous adverse health effects due to a lack of a C-F metabolic pathways in organisms. At present, the federal limit for PFOA is 4 ppt or 10-3 nM(2). It is not widely understood how PFAS at its lower limits affect biological material. This research will examine how nanomolar concentrations of perfluorooctanoic acid (PFOA) and perfluorobutanesulfonic acid (PFBS) affect model biological membranes. It is hypothesized that PFOA is partitioning the membranes of cells and will decrease membrane stability. This research will also examine whether PFOA-PFBS mixtures exhibit a Critical Micelle Concentration (CMC) or aggregation in solution. Literature has suggested that PFAS do have a CMC, however the listed concentration varies greatly.

Acknowledgements: USP - Undergraduate Scholars Program, INBRE - IDeA Network for Biomedical Research Excellence

Morphological Optimization of Mesoporous Silica KIT-6 for Applications as an Ordered Carbon Template

Cody Morse, Chemical & Biological Engineering

Mentor(s): Nicholas Stadie, Chemistry & Biochemistry; Ian Joyce, Chemistry & Biochemistry

Mesoporous silicas are silica-based materials that exhibit finely controlled porosity that repeats over a large range. These materials have special applications as templates due to their controllable structures. Our goal is to optimize the synthesis of a unique mesoporous silica denoted as KIT-6 for applications as an ordered carbon precursor. Specifically, we aim to produces this material with a controllable spherical morphology. This was investigated by systematic modifications to a "standard" synthesis procedure credited to Ryoo et al. This synthetic procedure included the formation of micelles via the addition of copolymer Pluronic P123 in dilute acid. This was followed by the addition of n-butanol as a swelling agent and tetraethyl orthosilicate (TEOS) as a silica source. The resulting solution was aged at high temperatures to produce mesoporous KIT-6. Modification to this

procedure included partitioning of the TEOS reagent with the addition of benzyl alcohol and an addition salt (KCl) in varying amounts. The results of these synthesis were analyzed via X-ray diffraction and SEM. Overall, X-ray diffraction of products did not clearly indicate the formation of KIT-6 in any of the samples synthesized but rather suggested a possible mixture of pore arrangements present. The synthesis including the TEOS partition and benzyl alcohol addiction indicated the most optimal sample (being closest to pure KIT-6). This assumption was further supported by the SEM analysis. Although this synthesis did not result in exactly the desired material, some spherical morphology appeared to be present upon SEM analysis of the sample.

Acknowledgements: USP - Undergraduate Scholars Program

The Evolution of Anthropogenic Pollution of Bozeman Creek: Analyzing Heavy Metals in Bozeman Creek as Detected by Inductively-Coupled Plasma Mass Spectrometry

Samantha Roth, Chemistry & Biochemistry

Mentor(s): Donald Smith,

Our investigation of heavy metal contents in Bozeman Creek using inductively coupled plasma mass spectrometry (ICP-MS) gave insight to how these pollutants are accumulating over time. Heavy metals are extremely stable and do not biodegrade, thus they are very accumulative pollutants. Bozeman sources much of its potable water from snowpack that melts into Bozeman Creek, so it is vital to monitor these pollutants as they have the potential to contaminate a significant amount of water, and further they can erode and damage surrounding soil and organisms. We gathered data across various seasons ranging from February 2023 to March 2025. The samples were analyzed using ICP-MS, an industry standard for water quality testing. It is a highly sensitive method with low detection limits, and the capability to analyze samples for numerous metals simultaneously. The field samples were collected and then digested in acid. We ran and analyzed our results with Laura Dobeck, an ICP-MS specialist with the Center of Biofilms Engineering. Our results have been compiled into maps in collaboration with the GeoSpatial Core Facility as well. Our results showed significant correlation to seasonal changes, impacting the concentrations of common metals from road maintenance and vehicle traffic, including Sodium (Na), Magnesium (Mg), Potassium (K), Calcium (Ca), Vanadium (V), Tin (Sn), and Barium (Ba). We plan to extend this project for continuous monitoring of Bozeman Creek. We hope to increase the frequency of sampling to achieve a more thorough understanding of how changes in anthropogenic patterns contribute to pollution of the creek.

Acknowledgements: USP - Undergraduate Scholars Program, Empower Program

Cooperative Models for CO Adsorption on a CoMe Metal-Organic Framework

Peyton Summerhill, Chemistry & Biochemistry

Mentor(s): Nicholas Stadie, Chemistry & Biochemistry

The CoMe metal-organic framework (MOF) belongs to a class of MOFs which exhibit so-called cooperative behavior, characterized by distinctly steep steps in adsorption uptake of guest molecules. Such cooperative porous materials are especially useful for gas separation and storage due to their high capacity and tunable adsorption steps at pressures and temperatures close to ambient. In addition, CoMe exhibits high selectivity toward CO over other gases owing to a unique binding mechanism to the open Co metal sites in the MOF structure; two CO molecules can bind in succession to each Co center. To describe CO adsorption on CoMe, a new thermodynamic model was developed herein to treat cooperativity and the sequential nature of the binding mechanism. The temperature dependence of the model (T-1.5) was selected in accordance with the atomistic picture of the adsorption site: a z-oscillator (2D particle in a box with a harmonic oscillator in the third dimension). We compare this newly developed model to three other simpler models, revealing that the measured adsorption equilibria corroborate the unique chemical mechanism of adsorption proposed.

Acknowledgements: USP - Undergraduate Scholars Program, GHC Grant Award (Dr. Harlan J. Byker)

Ketone Functionalization of Aromatic Hydrocarbons for Lithium-Ion Battery Development

Emi Van Voorhees, Chemical & Biological Engineering

Mentor(s): Nick Stadie, Chemistry & Biochemistry

The demand for high-capacity and high-rate batteries is ever increasing as the world continues to transition to a fully electric economy. Carbon-based materials provide many promising opportunities due to the abundance of organic feedstocks and the high energy capacity of carbon. Previous work has shown a heat-treated form of coronene, a large polytaromatic hydrocarbon, serves as a strong anode through the lithiation of hydrogen based sites at low potentials. In this work, we investigate the mechanisms behind this capability by studying variations to the anode's synthesis and resulting performance and structure. We first created a material containing both ketone functional groups and

coronene-based hydrogen sites through the electrochemically driven oxidation then pyrolysis of coronene. This allows for the systematic investigation of the role of the functional groups on electrochemical properties. We also used variations of synthesis temperature to study the formation of the anode lattice structure. The addition of ketone groups is expected to hinder the formation of hydrogen lithiation sites, greatly increasing the proportion of intercalation and lowering performance. Increased synthesis temperature results in the complete destruction of molecular structure and formation of graphite while a significantly decreased temperature prevents the formation of the lattice required for high performance.

Acknowledgements: USP - Undergraduate Scholars Program

PHYSICS AND SPACE SCIENCE

Constraining the nature of the electron distribution in the X-ray corona of active galactic nuclei

Andrea Astorga, Physics

Mentor(s): Anne Lohfink, Physics

During the accretion process, black holes produce abundant radiation, especially in the X-ray band. A lot of this radiation is created in the corona, a region of hot electrons located at the accretion disk's center close to the black hole, where X-rays are being produced through the Compton scattering of accretion disk photons. It is believed that the powering of the corona and its emission from the X-ray continuum are important for the energy balance during the accretion process. But, there is still not much information about the nature and origin of electrons in the black hole's X-ray corona. Over the years, evidence has emerged in black hole X-ray binary systems suggesting that electrons have a hybrid nature, meaning that most of the electrons follow a thermal distribution while the minority follow a non-thermal power-law-like distribution. To date, there are no constraints on the existence of a hybrid corona in accreting supermassive black holes at the center of galaxies. In the work presented here, we placed constraints on a possible non-thermal contribution to the electron distribution by investigating the indirect effects of the enhanced hard X-ray production in the non-thermal case on the interaction of the X-ray continuum with the accretion disk in the X-ray reflection process. To achieve this, we studied the X-ray spectra from two accreting supermassive black holes. Our results are the first constraints of the nature of the electron distribution in accreting supermassive black holes.

Acknowledgements: USP - Undergraduate Scholars Program, MSGC - Montana Space Grant Consortium

A Mathematical Introduction to Spin-1/2 Lattice Systems

Trevor Carl, Physics

Mentor(s): Ryan Grady, Mathematical Sciences

Physics students spend the first two years of their undergraduate studies developing their mathematical skills in differential equations, linear algebra, and integral calculus. Often times, these skills are not put to use in quantum mechanics until the final year of their undergraduate degree. This paper aims to introduce undergraduate students to an interesting and important quantum mechanical system from an elementary mathematical perspective. This paper will communicate vital mathematical tools in quantum mechanics applied to spin-1/2 lattice systems. The result includes step-by-step examples that highlight a problem solving procedure in operator theory. To conclude, an advanced statistical method in quantum field theory (QFT) will be introduced to give context for potential graduate-level studies.

Deployment and Implementation of the SAM-III Ground Based Magnetometer to Analyze Geomagnetic Currents in the Sun-Earth System

Deven Chedalawada, Physics

Mentor(s): Rachael Filwett, Physics

Geomagnetically induced currents (GICs) are a result of disturbances in the Earth's magnetic field due to interactions with the solar wind within the Sun-Earth system. GICs have widespread effects on both man-made and naturally occurring systems and can be better understood by analyzing variations in the Earth's magnetic field during these events. Our team built, calibrated and deployed a ground-based fluxgate magnetometer, called the SAM-III, to collect data on these variations at the Earth's surface. Additionally, our team developed a data analysis system and a graphical user interface to interpret and present the collected data. The deployment of the SAM-III is the first of many ground-based instruments that will be placed across the state of Montana to measure local changes in Earth's magnetic field that are relevant to Montana's infrastructure. In this paper we will discuss in detail the building of the SAM-III, its deployment, and the implementation of its data to further understand GICs and their effects. We will also discuss further applications

of the widespread deployment of SAM-III's, including the development of a statewide space-weather educational program in Montana.

Acknowledgements: MSGC - Montana Space Grant Consortium

Estimating the Temperature Evolution of Flaring Plasmas

Christopher Entzel, Physics; Sarah Pawlowski, Physics

Mentor(s): Charles Kankelborg, Physics

The solar corona is a counterintuitive part of the sun's atmosphere, with temperatures orders of magnitude hotter than the sun's surface. The exact mechanisms behind this temperature discrepancy are not well known and are the primary focus of the "Coronal Heating Problem." New instruments, like the student-Built Ultraviolet solar Burst Observer (BUBO), seek to investigate the temperature evolution of solar flares which may give scientists some insight into these poorly understood mechanisms. BUBO is a student collaboration with the MUlti-slit Solar Explorer (MUSE), measuring short-wavelength irradiance in its three overlapping passbands (0.5-4Å, 1-8Å, and 2-16Å). The wavelength choices and designs of these passbands are nontrivial and must be modeled with x-ray data. Then, a relationship between three measured fluxes and plasma temperatures must be found. Utilizing x-ray data from the Center for X-Ray Optics and both synthetic and modeled flare spectra from the Chianti Atomic Database and the Flare Irradiance Spectral Model respectively, this relationship was found. With a valid proof-of-concept temperature estimate, future irradiance data measured by BUBO can be used to study flare temperatures at an unprecedented cadence.

Acknowledgements: MSGC - Montana Space Grant Consortium

Synthesis and Characterization of Niobium Chalcogenide Quasi-1D Tunnel Compounds

Caleb Glaze, Physics; Patrick White, Physics

Mentor(s): John Neumeier, Physics

One-dimensional compounds have become an area of focus within condensed matter physics in the last several decades, largely due to unique properties harder to find in higher dimensional compounds. We focus on niobium chalcogenides, with the chemical formula Nb 3 X 4 (X=S, Se, Te). Their one- dimensionality is defined by their electrical conductivities,

which are much higher along the needle axis than along the perpendicular axis [citation]. We use iodine vapor transport to synthesize the sulfur and selenium compounds. Measurements of magnetic susceptibility yield an interesting drop-off at low temperature (below about 50 K) at 2, 3, and 4 Tesla. These compounds are known superconductors at 3.7K and 2.3K for X=S and Se respectively [citation]. Our sulfide resistivity measurements agree with CITATION's Tc, but our resistivity measurements for X=Se yielded TC=1.7K. We suspect that the lower-than-expected TC was due to oxidation. Measurement of magneto-resistance, heat capacity and thermal expansion could more completely characterize the niobium chalcogenide tunnel compounds.

Breaking Down the Degeneracies: A Systematic Study to Determine Accurate Parameters of Globular Clusters using Photometry, Spectroscopy, and Astrometry

Sarah Heller, Physics

Mentor(s): David Nidever, Physics

Globular clusters are groups of stars bound together by gravity that share many properties, including age, metallicity (chemical content), and distance from the Sun. Clusters are essential tools for studying both stellar evolution and the gravitational potential of the Milky Way as they can be approximated as a single population, making accurate measurements of their parameters of high interest to astronomers. One of the main methods for studying clusters is fitting isochrone models to Color-Magnitude Diagrams (CMD), which plot the brightness and color for each star in the cluster. However, the exact shape of the CMD is influenced by many variables, which can lead to degeneracies where the diagrams of different clusters look identical even though their properties are vastly different. This study aims to break isochrone degeneracies by incorporating external measurements of metallicity and distance into the model fitting, reducing the chance of fitting an incorrect isochrone. We analyze 49 Milky Way globular clusters using spectrographic APOGEE data to calculate mean metallicities and astrometric Gaia data to calculate mean parallax and distance measurements. The remaining parameters are solved through fitting isochrone models to CM diagrams created from 2Mass photometric data.

Acknowledgements: USP - Undergraduate Scholars Program, MSGC - Montana Space Grant Consortium

Fabricating a Fiber-Based Polarization Entangled Photon Source for Quantum Network Research

Caleb Humber, Physics; Nathan Kuehl, Physics; Krishna Rupavatharam, Physics

Mentor(s): Krishna Rupavatharam, Physics

Quantum Communications (QC) theoretically allows for an unprecedented level of information security by leveraging the fundamental property called entanglement. Our team has successfully designed, fabricated, and tested a multi-channel fiber-based entangled photon source (EPS), which is a critical component of QC architectures. Additionally, our team was able to transport these entangled photons through kilometers of fiber and over short free-space links while maintaining a high level of entanglement fidelity. In testing, we found that our EPS can produce a Clauser Horne Shimony Holt (CHSH) inequality S value of 2.7, much greater than 2, the critical value in which we determine whether or not our source is operating in the classical or quantum regime. The quantum state tomography (QST) metrics show that the EPS system is capable of maintaining a concurrence metric on the order of 0.955 and a purity metric of 0.96, where unity is the theoretical maximum. This paper will discuss the development of a compact system capable of generating entangled photon pairs at a high rate. The presentation will also discuss new configurations, such as adding an electro-optic modulator (EOM) to encode information on the quantum signal and reducing the size and weight of our EPS to become even more mobile for entanglement transport.

Acknowledgements: Air Force Research Lab (AFRL)

Analyzing Physical Parameters with Bayesian Inference and Stochastic Differential Equations in Python

Bergen Miller, Physics

Mentor(s): Brian D'Urso, Physics

An ongoing experiment in Brian D’Urso’s Levitated Optomechanics Group at Montana State University is a novel approach to measuring the Newtonian gravitational constant. The experiment includes using magnets to levitate a micron-scale particle with underdamped harmonic oscillation in a parabolic path. Another group has used Bayesian inference to develop math methods for inferring physical parameters in an equivalent system. We seek to use their math methods to infer the force of gravity on the particle in our lab in order to measure the Newtonian gravitational constant. We use Python to study the robustness of their methodology, implementing it on our data, and find that it is has promise but requires improvement.

Acknowledgements: II-VI Foundation

Student Built Ultraviolet Burst Observer (BUBO)

Sarah Pawlowski, Physics; Chris Entzel, Physics

Mentor(s): Charles Kankelborg, Physics

BUBO is an instrument that will fly aboard the Multi-slit Solar Explorer (MUSE) mission, a NASA medium explorer class satellite set to launch in 2027. MUSE's primary objective is to investigate the mechanisms behind coronal heating and instability, such as flares and coronal mass ejections, while also providing insights into the basic plasma properties of the corona. BUBO will enhance the MUSE mission by providing rapid cadence measurements of solar flux. BUBO has six channels with passbands sensitive to extreme ultraviolet (EUV), soft X-ray (SXR), and hard X-ray (HXR). The instrument will investigate if sub-second quasi periodic pulsations are detectable at wavelengths between 0.5 and 16 angstroms, attempt to observe rapid shifts in SXR hotspots, and examine the late-phase thermal evolution of solar flares on a centi-second timescale. BUBO has been designed, and the engineering model has been assembled. Instrument testing is ongoing through spring and summer 2025, with the flight model scheduled for completion in March 2026.

Detector Design using SRIM and TRIM

North Sanderson, Physics

Mentor(s): Rachael Filwett, Physics

The energetic particles coming from activity on the sun pose a unique threat to astronauts, Earth, and its inhabitants. With a better understanding of the composition and ionic specifications of these particles, we stand to gain insight into how to mitigate their effects, design resilient infrastructure, and stay safe on Earth. We are currently in the process of developing a detector that will collect critical information about these energetic particles, including their ionic composition and the mass per charge ratio of those ions. We initially asked questions like how many individual detectors should be included in our design? How thick should each individual detector be? How will each individual ion species interact with the silicon detectors? My research focuses on answering these questions and applying my findings to the design of our detector. Through simulations and analysis utilizing the SRIM/TRIM software platform, I found it crucial that we begin testing on extraordinarily thin 40 micron silicon detectors with the objective of maximizing the amount of low energy ion data we can collect. In my pursuit of more concrete itemized results, I was led to the MSU Tempest High Performance Computing System. Through these more detailed calculations,

I have further solidified my initial penetration depth and straggling results as well as confirmed the need for a series of thin 40 micron silicon detectors.

Acknowledgements: Tempest High Performance Computing System

Mechanically Facilitating the Measurement of the Newtonian Constant of Gravitation Using Microparticles Suspended in a Magneto-Gravitational Trap.

Jay Santana, Physics

Mentor(s): Brian D'Urso, Physics; Cody Jessup, Physics

The measurement of the Newtonian constant of gravitation is achieved by a magnetogravitational trap that levitates a particle with composition of primarily graphite. The transformations in the oscillation of the particle when field masses are placed in a 20-30 cm proximity of the particle are results of gravitational attraction between the two masses. The effective displacement is related to the force imparted on one mass by another and is used to derive the Newtonian constant of gravitation. Relative definition in measurement is accomplished by the utilization of a mechanism capable of altering the position of a field mass to micron level precision. The mechanism is placed on an optical bed that is equipped with level stabilization by means of a system that actively delivers a levelness with the earth in a dynamic manner to offset the movement of the field mass.

Acknowledgements: Multiple funding sources.

Fabricating back-gated 2D heterostructure via Direct Laser Sublimation with NanoFrazor

Elijah Stuvland, Physics; Joseph Stage, Physics

Mentor(s): Nicholas Borys, Physics; Amirhossein Hasani, Physics

MonArk Quantum Foundry created the 2D Quantum Materials Pipelines (2D-QMaPs) to fabricate 2D devices as efficiently as possible. A major component of Montana's 2D-QMaP is the NanoFrazor Explore which combines Thermal Scanning Probe Lithography (tSPL) and Direct Laser Sublimation (DLS). DLS, specifically, is a new method to write custom patterns onto thermal resists. In order to optimize the DLS process, two things had to be determined. First, finding the desired power and exposure for writing patterns with the bi-layer process. A bi-layer is a common micro/nanofabrication procedure for thermal and electron-sensitive resists. DLS patterning was demonstrated with a poly(methyl

methacrylate)-co-methylacrylic acid (PMMA/MA) sacrificial bottom layer and a polyphthalamide (PPA) patterning top layer. PPA layer needs to be sublimated thoroughly. Being too shallow or too deep can affect the development and lift-off steps for the second layer, PMMA/MA. Second, ensuring that the optimal parameters chosen consistently exhibits correct development and lift-off. Establishing a reliable DLS process is advantageous to MonArk as well as other researchers as it will be another step towards efficient and optimized 2D quantum material research. In order to demonstrate optimal parameters, a proof-of-concept back-gated device comprising of encapsulated WS2 via hexagonal boron nitride has been developed and characterized to demonstrate that the integration of DLS with the tSPL process can be replicated.

A Multiwavelength Analysis of AGN and Star Formation Signatures in the Dwarf Galaxy NSA 19176

Mahpara Tasnim, Physics

Mentor(s): Amy Reines, Physics

Dwarf galaxies provide key insights into galaxy evolution, particularly in understanding the role of active galactic nuclei (AGNs) in low-mass systems. Active Galactic Nuclei are astrophysical sources powered by accretion onto supermassive black holes in galaxies, and are effective indicators of black hole population in the centers of galaxies. AGN activity is often obscured by or mistaken for star formation in dwarf galaxies, and vice versa. We present a multiwavelength analysis of the dwarf galaxy with NSA ID 19176 exhibiting nuclear emission, aiming to determine whether its spectral characteristics arise from star formation, AGN activity, or a combination of both. To achieve this, we employ multiple diagnostic techniques, including optical emission-line classification through Baldwin-Phillips-Terlevich (BPT) diagrams, mid-infrared color diagnostics using Wide-field Infrared Survey Explorer (WISE) photometry, and spectral fitting to characterize the underlying stellar population and ionizing sources. Additionally, we incorporate radio observations at 1.4 GHz and 9 GHz and assess whether the compact radio emission is indicative of AGN activity. Our analysis will provide constraints on the dominant physical processes driving the observed emission and contribute to the broader understanding of AGN feedback and star formation in low-mass galaxies. This study contributes to the ongoing efforts to refine AGN selection criteria in low-mass regimes and improve our understanding of black hole-host galaxy coevolution in the low-mass universe.

Optimizing Pressure and Temperature for High-Yield MoS2 Monolayers With Bayesian Linear Regression

Seamus Whyte, Physics

Mentor(s): Nick Borys, Physics

Molybdenum Disulfide (MoS2) has been a material of significant interest to scientists and engineers for over a decade, finding applications in high-performance dry lubricants, Field Effect Transistors (FETs), photovoltaics, and other areas. A promising application of MoS2 can be found within the field of 2D quantum materials, where its unique photonic and electronic properties are particularly pronounced in monolayer and/or thin-layer forms. However, the exfoliation process used to produce MoS2 generally results in low yields of large-area monolayer/thin-layer crystals. This limitation hinders device fabrication and integration, and restricts the potential of 2D heterostructures. The efficiency of monolayer yield during exfoliation can be heavily influenced by many factors, each of which may lead to deeper insights into the fabrication of these materials. In this study, we aim to optimize the temperature and pressure parameters in order to increase the volume of large-area MoS2 monolayer/thin-layer crystallites. We will utilize a multiple linear regression model in conjunction with a Bayesian analysis to predict the ideal range of pressure and temperature for maximizing monolayer yield via exfoliation.

A Machine Learning Approach to Minimizing Aberrations

Carver Wiegand, Physics

Mentor(s): Brian D'Urso, Physics

Studying trapped particles has become a crucial point of interest, as it enables precise measurements and controlled experiments that test fundamental physics, develop quantum technologies, and enhance our understanding of the world. One of the main issues with particle trapping, is that producing a clear image of a trapped particle, in the size range of a micron, is a complex, time-consuming task due to optical aberrations caused by light dispersion or lens geometry. This research presents a machine learning-based system that streamlines focusing by analyzing images and providing real-time adjustments. The system controls the image focus through 15 screws that are manual turned, each altering the optical path and affecting aberrations. Using a model optimized for mean squared loss (sharper quality), our AI interprets an image, suggests screw adjustments, and iteratively refines the focus. However, interactions between screws are highly nonlinear, making accurate mapping difficult and requiring a larger dataset than

expected. To address this, a secondary project was initiated to generate synthetic training data, though it remains incomplete. Preliminary results show the program effectively guides focusing and slightly accelerates optimization so far. If given enough training, the system could reach full automation and clearer quality, but due to limited training data, the AI ran into some problems. This presentation will walk you through the steps leading to the creation of both systems and the issues that arose.

Acknowledgements: USP - Undergraduate Scholars Program

PSYCHOLOGY

The Relationship between Subjective Isolation and Morality

Fiona Burkart, Psychology

Mentor(s): Peter Helm, Psychology

This project aims to explore the relationship between types of subjective isolation and morality. Study 1 (n = 400) operationalizes morality using the concept of moral disengagement (MD), which describes the process individuals engage in to avoid feeling remorse following an immoral act. We predicted that moral disengagement would be positively correlated with subjective isolation. Results found existential loneliness to be the primary correlate of MD (rather than general loneliness or existential isolation). Study 2 (data collection in process) will further test the relation between subjective isolation and morality using different operationalizations of morality, specifically dehumanization, anti-social personality traits, and perceived severity of social transgressions. We hypothesize a replication of Study 1, such that existential loneliness will still be the strongest predictor of various operationalizations of morality. Implications and future directions will be discussed.

Acknowledgements: USP - Undergraduate Scholars Program

Rapid Eye Movement Sleep Density and Overnight Processing of Trauma in American Indian Adults

Emma Howard, Microbiology & Cell Biology

Mentor(s): Cara Palmer, Psychology

Previous research has shown that the density of rapid eye movement (REM) sleep is a risk factor for a number of psychiatric disorders including post-traumatic stress disorder

(PTSD). Prior studies have focused on temporal disturbances to REM sleep, while REM density as it relates to overnight emotional processing and emotional memory has remained largely unexplored. The current investigation conducted by the MSU Sleep Research Lab is in the process of collecting intake assessments and using overnight polysomnography equipment to compare baseline sleep and physiological health to positive and negative emotional conditions. Participants of the study will complete three overnight stays in the MSU Sleep Research Lab for data collection and be randomly assigned to experience positive or negative emotional videos prior to sleep. Emotional surveys prior to and after overnight stays will be analyzed to observe possible relation to REM density during the night. Analysis will include using EEGs from scalp, eye, and chin electrodes to determine the average REM density of each REM sleep period. REM densities will then be compared to next-day emotional memory. This study aims to understand potential roots of PSTD symptoms as they relate to sleep and emotional processing in order to support further research exploring the connections between sleep, sensory and emotional processing, and memory processing- all of which will provide further understanding of how various brain regions and neural pathways are effected by traumatic stress.

Acknowledgements: USP - Undergraduate Scholars Program

Perceived Concerns and Benefits of Engineered Living Materials: A Qualitative Approach

Hannah Lavoie, Psychology; Kristen Intemann, Department of History & Philosophy; Helena Kunz, Department of Psychology

Mentor(s): Kristen Intemann, History & Philosophy

While Engineered Living Materials (ELMs) show promise in addressing a variety of problems related to sustainability and healthcare, they are likely to encounter social challenges as well (Heveran et al., 2024). Various populations have developed negative perceptions of other biotechnologies, such as genetic engineering, and cloning, but to date, no researcher has tested social perceptions related to ELMs. It is important to understand individual perceptions and concerns towards ELMs early so they can be addressed through design, development, communication and outreach. Qualitative research methods can clarify not only what reactions individuals have towards ELMs, but why they believe they are having such reactions. We conducted semi-structured interviews of college students (n = 22) to assess reactions to and concerns about ELM technology and its applications. Participants were presented with three different applications of biofilm ELMs that would require varying

degrees of direct user interaction with biofilms (bioremediating highway barriers, bioremediating roofs, and self-repairing dishes). Interviews were transcribed and coded by three different researchers and analyzed for common themes. Additionally, participant disgust sensitivity was assessed using the 27 item Disgust Scale – Revised (Haidt et al., 1994) with higher scores indicating greater propensity to be disgusted. This helps determine the extent to which concerns raised correlate with disgust sensitivity. Our quantitative results indicate that participants displayed an average level of sensitivity to disgusting things (M = 48.86, SD = 11.56) while our qualitative results suggest that participants tended to express both positive and negative reactions towards the applications. Positive reactions included the importance of sustainability, the environment, and trust in scientists. Concerns expressed included human health, the structural safety of such materials, cost, and distrust of regulators. We did not find that there were more significant concerns with more direct contact with biofilms, but rather that the concerns deemed the most significant varied based on the application.

Existential Isolaiton and Decision Making

Emogene Plagmann, Psychology

Mentor(s): Peter Helm, Psychology

This research examines the relationship between existential isolation (EI; Pinel et al., 2004, Yalom 1980), the feeling that one is alone in their subjective experience, and decision-making behaviors (prosocial vs. selfish), moderated by transparency of the behavior. We predicted that people with higher EI would make more selfish decisions, while people with lower EI will make more collaborative decisions. We also predicted that the transparency of decision will result in more prosocial behavior, though only for those high in EI. Study 1 (n = 400) found a significant interaction between EI and transparency of the behavior in predicting selfish decision making. Study 2 hopes to further examine the role of EI and transparency in decision making behaviors. The relation between EI and decision making has not yet been explored and could yield important implications for community building, group dynamics, and teams.

Acknowledgements: USP - Undergraduate Scholars Program

Effects of Mortality Salience and Tolerance of Racism on Perceptions of Racism

Aster Sabin, Psychology

Mentor(s): Peter Helm, Psychology

Reminders of mortality (MS) in White participants have previously been found to increase sympathy for White perpetrators of discrimination (Greenberg et al., 2001). Additionally, information about shifting racial demographics in the United States functions as a worldview threat and heightens death-thought accessibility for White participants in ways comparable to more traditional MS primes (Jimenez et al., 2022). Recent operationalizations of tolerance of racism (TOR; Hunt et al., 2021) assess participants' willingness to accept racism in others, regardless of personally espoused beliefs, and may moderate an MS prime or worldview threat on White participants' perception of racism in ambiguously racist acts. Specifically, we predicted that those with high TOR will perceive less racism in ambiguous scenarios following an MS prime (Study 1, n = 494) or a demographic threat prime (Study 2, n = 656) compared to a control prime and to low TOR. Study 1 found support for the hypothesis, but only when controlling for political leaning. Study 2 found a significant three-way interaction between political leaning, threat condition, and TOR such that politically right leaning participants were most impacted by the prime. Implications for future research and limitations are discussed.

Acknowledgements: USP - Undergraduate Scholars Program, Faculty startup funds

SOCIAL SCIENCES

Can Indigenous Traditional Ecological Knowledge (TEK) be effectively integrated into mainstream climate adaptation policies to enhance environmental resilience and support Indigenous-led conservation efforts?

Cassidy Alber, Political Science

Mentor(s): Paul Lachapelle, Political Science

Climate change is one of the pressing challenges the global community must face, with its effects disproportionately affecting Indigenous communities and their traditional cultures and lands. Whilst western science is working on the crisis with mitigation strategies and climate models, Indigenous people continue to practice Traditional Ecological Knowledge (TEK). TEK is a type of environmental stewardship that has had impacts in enhancing ecological resilience but is underutilized in mainstream climate policy conversations. This research investigates how TEK can be integrated successfully into climate adaptation policies. The research found that TEK provides proven climate adaptation techniques such as controlled burning and rotational farming, and Indigenous-led conservation efforts often outperform state programs, and barriers such as the marginalization of TEK and lack of

land rights hinder its integration into policy frameworks. To address these issues, the research suggests legal recognition TEK conservation methods, collaborative research models, and Indigenous inclusion in climate policy. By including TEK climate adaptation and mitigation can be more effective, benefiting both Indigenous communities and global environmental resilience.

Assessing Concern About Perceived Impacts of Climate Change Among Select Montana State University Students

Oliver Anderson, Land Resources & Environmental Sciences

Mentor(s): Paul Lapachelle, Political Science

Effective communication about climate change remains a significant challenge, with gaps in climate literacy contributing to varying levels of concern and perception across populations. Despite efforts to integrate climate education into all levels of curricula, a disconnect persists between scientific discourse and public understanding, often influenced by political ideology, media consumption, and personal experiences (Tyson et al., 2023). This study examines the perceived impacts of climate change among select Montana State University students, exploring how academic background and field of study shape climate-related concerns and perceived impact. A survey was distributed across various colleges at the university, incorporating four questions from Yale's "Six Americas Super Short Survey" (Chryst et al., 2018) to assess levels of climate concern and engagement. Results indicate that MSU students show higher concern levels than national averages, with 40.1% classified as "Alarmed" compared to the national estimate of 26.0%. Political affiliation strongly influenced climate attitudes, with Democrats skewing heavily toward "Alarmed" and "Concerned," while Republicans exhibited higher percentages of "Doubtful" and "Dismissive." Academic background also played a role, as engineering students displayed more skepticism, while students from science-based disciplines expressed greater concern. These findings highlight the importance of integrating climate literacy into higher education to foster informed decision-making and support for climate policies. The study aims to contribute to the growing body of literature on climate literacy by identifying trends in students' attitudes and knowledge.

What policies can effectively promote green roofs as a climate change mitigation and adaptation strategy in Bozeman, Montana?

Natalie Baur, Liberal Studies Degree

Mentor(s): Paul Lachapelle, Political Science

As Bozeman's population grows, its urban areas will expand, increasing resource demand and depleting green space, which will ultimately contribute to climate change and its associated repercussions. Green roofs present a viable solution, offering both climate change mitigation (reducing energy consumption, sequestering carbon, and improving air quality) and climate change adaptation (reducing the urban heat island effect, managing stormwater runoff, and enhancing biodiversity) while also supporting economic and social activity.

Thus, my guiding research question is: "What policies can effectively promote green roofs as a climate change mitigation and adaptation strategy in Bozeman, Montana?"

To conduct this research, I performed a knowledge synthesis using various sources, including peer-reviewed journal articles, local news articles, government reports, and planning documents. In evaluating potential policy solutions, mandates emerged as the most reliable approach to integrating green roofs into Bozeman's infrastructure. Sources emphasized the importance of clear communication regarding how green roofs function and their economic benefits.

Based on this research, I propose two policy recommendations. The first, the Eco-Roof Requirement, is a mandate requiring all new residential and commercial developments to install either green roofs or solar panels. The second, the Living Architecture Initiative, targets existing infrastructure by providing tax incentives for property owners to install green roofs.

Overall, existing policies from other regions can serve as models for how Bozeman can integrate green roofs into its infrastructure, contributing to both climate change mitigation and adaptation.

"Like all my friends have one": Exploring Parent-Adolescent Perspectives on Delaying Smartphone Ownership

Tiana Carney, Health & Human Development; Patty Kroemer-Spiess, Health and Human Development

Mentor(s): J. Mitchell Vaterlaus, Health & Human Development

Adolescents are gaining access to smartphones at increasingly younger ages, raising concerns about their impact on development, relationships, and mental health. While some parents provide smartphones for communication and safety, others delay access to

reduce risks associated with screen time and social pressures. However, delaying acquisition may lead to feelings of exclusion and challenges in social interactions. Parents often struggle with balancing concerns about smartphone use with external pressures from peers and other families. Despite this, public calls to delay adolescent smartphone ownership are growing. This qualitative study explores parent and adolescent experiences with delaying smartphone ownership among parent-adolescent dyads (n = 12) where the adolescent (ages 12-14) does not own a smartphone.

Acknowledgements: USP - Undergraduate Scholars Program

Advancing Undergraduate Research Through Systems of Shared Governance

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Mentor(s): Anna Tuttle, Undergraduate Research

Undergraduate research is a cornerstone of experiential education that fosters critical thinking, problem-solving skills, and professional development. At Montana State University, the Undergraduate Research Council (UGRC) has pioneered a model that leverages shared governance to enhance access, equity, and sustainability within undergraduate research programs. By engaging diverse stakeholders, the UGRC integrates the voices of undergraduates into decision-making processes that directly affect the research culture at Montana State. The UGRC serves as a formal student-led part of the shared governance framework at our university that elevates students voices to balance with other researchers. Initiatives the UGRC have tackled include standardizing the process for earning research credits, integrating peer research support, hosting an annual Research Fair, and publishing the student-run journal

Curiositas. These efforts to create streamlined access have resulted in record-breaking participation in undergraduate research programs, increasing representation from historically marginalized groups. The UGRC's model highlights strategies for fostering collaboration across institutional silos by examining barriers to participation in undergraduate research. The Council addresses resistance to organizational change and gaps in communication through inclusive and transparent practices that promote interdisciplinary collaboration. By prioritizing student agency within governance frameworks, the UGRC aims to serve as a replicable model for other institutions seeking to advance undergraduate research on a systemic level. As higher education increasingly prioritizes equity and access, the UGRC's model offers a blueprint for embedding student

voices into systemic change, ensuring the long-term sustainability of undergraduate research programs.

Acknowledgements: USP - Undergraduate Scholars Program, NSF-ARTT

Climate Litigation and Science: Lessons learned from the Massachusetts v. EPA case

Nicholas Crosby, Political Science

Mentor(s): Paul Lachapelle, Political Science

The debate around climate change is one of the most pressing issues of the 21st century, and litigation has been a key part of how the United States continues to work on addressing the problem. The 2007 case Massachusetts v. EPA was a landmark climate-related case and highlighted the tension that can arise when the fields of climate science and law collide. Utilizing relevant peer-reviewed literature on the case and other significant climate change-related rulings by the Supreme Court, I worked to develop further policy recommendations that promote a better synergy between climate science and the law.

In what ways do Montana and California's public health policies differ in addressing outdoor worker risks from wildfire smoke hazards, and what policies can be implemented to add further protections?

Paula Diaz, Microbiology & Cell Biology

Mentor(s): Paul LaChapelle, Political Science

Climate change drives intensification of wildfires, producing smoke and unhealthy air quality. Wildfire smoke exposures adversely affect human health with increased exposure times associate with increased risks. Chronic exposures create lasting health effects that can lead to chronic lung disease, heart disease, stroke, asthma, kidney damage, diabetes, anxiety, adverse birth outcomes, and systemic inflammation in otherwise healthy, young adults. More time spent outdoors by outdoor workers disproportionately exposes them to wildfire smoke hazards. Public health entities must promulgate effective policies to protect the health of outdoor workers. This research compares Montana and California’s public health policies addressing the protection of outdoor workers from wildfire smoke hazards and incorporates existing federal standards and policies to recommend further policy actions.

Enhancing Community Resilience to Wildfire in Gallatin County

Marshal Galinato, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

Fire season in the United States is increasing in length and intensity, with no data showing any meaningful decrease in the future. Small communities situated within the Wildland Urban Interface (WUI), such as many of the communities found within Gallatin County, are most at risk. As wildfire frequency and intensity increase and become less predictable in a changing climate, what policies can Gallatin County enact to allow communities to become more resilient against the indirect and direct threats of wildfire? A systematic review of existing literature was conducted surrounding community resiliency to wildland fire to highlight the most at-risk demographics and potential policy solutions to aid in increasing community resiliency throughout Gallatin County. Generally, economically disadvantaged individuals, renters, residents within WUI areas, and children and the elderly were the most negatively impacted groups by wildfire events. Communities with higher social capital were found to be the most resilient to disturbance events through higher amounts of community participation in planning/prevention pre-disturbance and higher levels of collaboration during post-disturbance recovery. To bolster community strength and perceived risk to wildfire events, the county must consider allowing rezoning to allow for mixed used and medium density building, a revision of the county community wildfire protection plan (CWPP) to consider both socioeconomic factors in its assessment as well as post-fire recovery, and changing the county educational material of defensible space to survivable space will foster a change in the perceived wildfire risk of the county and strengthen the community ties that are necessary for the success of educational initiatives and the creation of an invested fire informed population.

How has Italy addressed climate-induced migration, and what policy changes are needed to better support displaced communities?

Giulia Gandolfi, Political Science

Mentor(s): Paul Lachapelle, Political Science

Climate change is forcing many to migrate due to rising sea levels, extreme weather, and droughts, yet there is no recognized status for climate refugees, leaving them without legal protection. This research explores how Italy, with EU support, has responded to climate-induced migration and what policy changes are needed to assist these displaced communities better.

Climate change is driving population shifts, with migration as a key response. By 2050, climate migrants could reach 200 million, influenced by environmental, economic, and political factors. Italy, a major entry point to the EU, relies on reactive migration policies, limiting protection for climate-displaced individuals. Negative political framing and the lack of international recognition for climate refugees hinder proactive solutions, despite the growing awareness of the issue.

This research synthesizes existing knowledge using Google Scholar and reports from key institutions to analyze climate migration and EU policies. It identifies key themes, examines the impact of the term "refugee" on policy, and compares Italy's migration approach to other European strategies.

Acknowledgements: USP - Undergraduate Scholars Program

What is the Connection Between Youth Climate Anxiety and Youth Climate Action?

Mckenzie Jarman, Political Science

Mentor(s): Paul Lachapelle, Political Science

Mental health problems due to the climate crisis are a growing issue. With mental health disorders like anxiety and depression stemming directly from a concern for the future of the planet, action to solve climate change must occur to stop the problem at its source. Both mental health issues from climate change and climate action disproportionately impact and are created by younger generations. Young people are more concerned about their ability to thrive in coming years, and this belief translates into both action and anxiety. The link between climate concern and climate action is not regularly studied, especially in Generation Z and Millennials. In an effort to explore this connection, this study illustrates the relationship between climate anxiety and climate action in youth.

Corporate Influence on the Montana Legislature

Kiera Johnson, Liberal Studies Degree

Mentor(s): Paul Lachapelle, Political Science

The success of environmental policy is determined in many cases by the influences of lobbyists. In Montana, climate-related policies are pushed against and, in part, shaped by conservative lobbying groups such as the American Legislative Exchange Council (ALEC). This research aims to look at how groups like ALEC use their massive economic power and

influence to impact Montana environmental legislation. This poster uses secondary data to explore how these groups fight against climate change prevention and environmental protection legislation. ALEC and other similar groups use elected officials to push bills that promote environmental degradation via things such as fossil fuels, utilities, corporations, or transportation while lacking transparency with voters as to where the legislation is really coming from. Policy recommendations include investigating mechanisms that promote more transparency regarding which legislators are working with groups like ALEC and for which bills being voted on were modeled after ALEC policies. There also needs to generally be less corporate influence in politics, especially in Montana.

What can the City of Bozeman learn from other comparable local governments composting policies to reduce organic waste in landfills?

Trinity Keefer, Political Science

Mentor(s): Paul Lachapelle, Political Science

Food waste is a significant contributor to global warming, with organic matter in landfills producing methane, a potent greenhouse gas. In the United States, food waste is the most common material sent to landfills. This research explores the potential of composting as a solution to reduce organic waste in Bozeman, Montana, and addresses how the city can model its waste management policies based on successful composting initiatives from other municipalities. Drawing on the UNEP Food Waste Index, studies from the US EPA, and successful programs in cities like San Francisco, this research examines the benefits of composting for reducing methane emissions, improving soil health, and lowering waste management costs. By synthesizing successful policies and considering local needs, the study offers policy recommendations for Bozeman to implement effective composting programs. The results suggest that Bozeman could benefit from expanding its current curbside composting program and introducing public education initiatives, with the potential for future mandates as the infrastructure develops.

Exploring the Role of the Social, Political, and Economic Nexus in Advancing Climate Action in Singapore and Montana

Jackson Mundell, Land Resources & Environmental Sciences; Daniel Martin

Mentor(s): Paul Lachapelle, Political Science

The role of global partnerships in progressing climate action is rooted in comparing the social, economic, and political structures between countries. Singapore is a regional and international hub for finance, trade, and industry. In recent years, progressive policies have

helped shift the country's focus toward leadership in sustainable growth and climate action. The United States, like many other nations, could adopt aspects of Singapore's climate model to develop its own pathway towards sustainability. Through this study, researchers engaged with over 70 stakeholders—including representatives from The Nature Conservancy, the Temasek Foundation, and the Singapore Ministry of Sustainability and the Environment— to analyze Singapore's history, social and government structures, and climate policies. Back in Montana, additional data was collected on the components of statewide and local climate initiatives, including the Bozeman Climate Action Plan, to understand areas where policies could be transferred or modified to catalyze change. Here, researchers explored how the social, political, and economic nexus between Singapore and Montana impact policy formation and climate action. By comparing these ideas in Montana and Singapore, we propose a variety of pathways for Montana to advance similar projects moving forward.The role of global partnerships in progressing climate action is rooted in comparing the social, economic, and political structures between countries. Singapore is a regional and international hub for finance, trade, and industry. In recent years, progressive policies have helped shift the country's focus toward leadership in sustainable growth and climate action. The United States, like many other nations, could adopt aspects of Singapore's climate model to develop its own pathway towards sustainability. Through this study, researchers engaged with over 70 stakeholders—including representatives from The Nature Conservancy, the Temasek Foundation, and the Singapore Ministry of Sustainability and the Environment— to analyze Singapore's history, social and government structures, and climate policies. Back in Montana, additional data was collected on the components of statewide and local climate initiatives, including the Bozeman Climate Action Plan, to understand areas where policies could be transferred or modified to catalyze change. Here, researchers explored how the social, political, and economic nexus between Singapore and Montana impact policy formation and climate action. By comparing these ideas in Montana and Singapore, we propose a variety of pathways for Montana to advance similar projects moving forward.

Acknowledgements: Max Baucus Institute

Exercise in Rural Communities: A Qualitative Study Exploring Impacts of Past Experiences on Current Exercise Practices

Tasha Shaffer, Health & Human Development; Bryant O'Leary, Tasha Shaffer, Dawn Tarabochia, Food systems, Nutrition, and Kinesiology

Mentor(s): Dawn Tarabochia, Health & Human Development

As the aging population continually grows, understanding how to keep older adults engaged in exercise is of increasing importance. This is critical as exercise trends show that engagement dramatically decreases with age. Moreover, older adults are more likely to live in rural communities as compared to urban communities (Cohen & Greaney, 2023). Previous studies explored barriers related to the overall decrease in exercise engagement, yet few have focused on older adults' motivation to maintain exercise practices. The purpose of this project was to explore how past experiences with exercise influence current exercise participation among rural, older adults. Residents engaging in exercise and aged 55+ (n=42) from a western state were recruited using convenience sampling (partnership with local Extension agents and social media outlets). As part of a larger online survey, participants completed an open-ended questionnaire specific to past experiences with exercise. Participant results were analyzed using Van Manen's (1990) hermeneutical approach with three members of the research team developing themes from participant responses. Trustworthiness was established by a peer reviewer to assess the themes for accuracy. Researchers identified five themes associated with how past experiences influenced current exercise practices. These included health and wellness (18), accessible instruction/resources (17), friends and family (13), community programming (10), and youth activity (4). By understanding past experiences, outreach professionals may find more impactful early or later life supports to promote exercise across the lifespan.

Acknowledgements: EHHD travel funds

Indian Boarding School Cemeteries as an Ongoing Source of Trauma for Native Communities: an interdisciplinary approach utilizing geophysical surveys and social science methods

Marsha Small

Mentor(s): Vanessa Simonds, Health & Human Development

Abstract This research addresses the socio-economic, political, and spiritual impacts of Indian boarding school policies implemented between 1880-1940 on Native communities. Between 1800 and 1940, unknown numbers of Native children in the United States were kidnapped and stolen, placed in government or religious-run institutions. Thousands of Native children died while incarcerated at these institutions (Tsestoo'ehevose ka'eskoneho-where children are jailed). It is unknown how many remain in the boarding school cemeteries and other atrocious places. The lack of data regarding the location of children in these cemeteries requires immediate remedy; multiple Nations want to rematriate their children to their Homelands. The data also serve as evidence of the

genocidal impacts of colonization. I argue that the current laws, regulations, and policies reflect a failure to uphold the trust and treaty obligations owed to the Original Inhabitants, as outlined in treaties with the United States. The policies surrounding Indian boarding schools continue to have a harmful and lasting impact on the lives of the Original Inhabitants. The disconnections from their epistemological foundations has led to significant, harmful consequences stemming from the genocidal policies imposed by the U.S. government.

Acknowledgements: Human Development and Community Health

Is it Feasible to Replace the Colstrip Power Plant in Montana With Nuclear Power?

William Stephenson, Political Science

Mentor(s): Paul Lachapelle, Political Science

This research investigates the feasibility of replacing the Colstrip Power Plant in Montana, a coal-fired facility, with nuclear energy as part of efforts to combat climate change. Given the urgency of reducing carbon emissions, transitioning to cleaner energy sources is critical; however, the adoption of nuclear power presents significant challenges. The study examines secondary data from academic articles, government reports, and case studies of similar transitions in other regions. Key findings indicate that, although nuclear energy could contribute to decarbonization, its high costs, extended planning timeline, and public resistance to nuclear power pose substantial barriers. With construction times averaging 11 years and nuclear energy costs approximately double solar power, the transition does not align with the pressing need for quick climate action. Additionally, logistical, safety, and regulatory hurdles further complicate the transition. The research concludes that while nuclear power may offer a long-term solution, it is not a practical option for immediate climate change mitigation in Colstrip. Instead, policies supporting the expansion of solar and wind energy, utilizing existing infrastructure, are more viable to meet the region's energy needs and decarbonization goals within the short timeframe.

Japanese Community level climate policies To Ensure Just Transition for workers in Carbon-intensive Industries

Carver Tison, Political Science

Mentor(s): Paul LaChapelle, Political Science

Abstract:

The purpose of this research is to highlight that once again the working class is on the chopping block. While climate change is the most serious problem humanity has ever faced, we need to have regard for working-class individuals who rely on the fossil fuel industry to feed their families. Throughout this research, we will discuss the importance of a just transition for fossil fuel workers and communities. Next, we will discuss the secondary data collection methodology that I used. After that, we will discuss how the inclusion of a just transition for workers in climate policy vastly increases public support in fossil fuel communities. Then, we will talk about the successes and failures of three different Japanese coal mining communities in their efforts to transition away from fossil fuels.

How Should the United States Government Balance Wildfire Suppression with the Ecological Necessity of Fire-adapted ecosystems in a Warming Climate

Halaina Vashisth, Political Science

Mentor(s): Paul Lachapelle, Political Science

Fires are important to our ecosystem, whether apparent or not. The research shows the solutions surrounding wildfire suppression concerning climate change, with the frequency and severity of fires due to a warming temperature. The research synthesizes literature on wildfire management, climate adaptation strategies, and policies to propose effective solutions. The findings suggest that it is more important than ever to integrate wildfire tactics and to help ecological growth take its place. Climate change and wildfire have heavily affected our communities, making it crucial to implement integrated fire management strategies, such as prescribed burns and community-based fire strategies and management. Ecological efforts can look at restoration efforts, while public engagement through educating about fire in communities could influence great change, too. These tactics explored are more crucial than ever in this ever-growing fire climate.

Acknowledgements: USP - Undergraduate Scholars Program

Analysis of the Impact of Notable Texts Referencing Gender Roles on American Contemporary Gender Norms

Rebekah Yager, English

Mentor(s): Doug Downs, English

Christianity and its subsects have been a significant sociocultural influence on American culture – specifically in the way it has viewed men's and women's gender roles. According to Amy M. Blackstone, "gender roles are based on the different expectations that individuals, groups, and societies have of individuals based on their sex and based on each society's values and beliefs about gender." There have been plenty of written and spoken works discussing the idea of Christianity and gender roles. However, there is no overall consensus across those that I have read on what the role of gender is in both the historic and contemporary church. To better map this range of gender roles advocated in Christian cultural commentaries over time, I am building an overview of what commonplace Christian scriptures and commentaries say about gender roles. My ultimate aim is better tracing how Christian thought has contributed to gender roles in historical and contemporary America. To this end, I have analyzed texts in three categories—texts from early Christianity, texts from contemporary Christianity, and texts from popular culture that advocate certain gender roles—using a code created from said texts. This analysis allows me to study gender roles present in Christianity in order to explain common-day American gendered norms and place a more specific definition of the role of sex in the history of the Christian church.

Acknowledgements: USP - Undergraduate Scholars Program