STUDENT RESEARCH CELEBRATION

SPRING 2026

Celebrating Research and Creativity in All Academic Disciplines

Morning Session: 10am-12pm

Break: 12pm-1pm

Afternoon Session: 1pm-3pm

SUB BALLROOM

FRIDAY | MAY 1

MONTANA STATE UNIVERSITY

MONTANA STATE UNIVERSITY
Student Research Celebration
SPRING 2026

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MONTANA STATE UNIVERSITY
Undergraduate Research

Student Research Celebration

May 1, 2026

SUB Ballrooms

Agenda

Morning Session: 10:00am-12:00pm

- Welcome and Keynote address: Dr. Matthew Fields, CBE Director, Professor, Department of Microbiology and Cell Biology
- Poster presentations

Break and transition: 12:00pm-1:00pm

Afternoon Session: 1:00pm – 3:00pm

- Welcome and Keynote address: Dr. Matthew Fields, CBE Director, Professor, Department of Microbiology and Cell Biology
- Poster presentations

Student Art, SUB Exit Gallery , 10:00am – 3:00pm

Earth Flavor

Prints of Extraction

Kevin Tracy, Graduate Student, Art

Abstracts by Discipline Area

Poster Presenters by Discipline Area of Project

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AGRICULTURAL SCIENCE

Mortierella diversity in Montana and their potential agricultural applications

Brett Bartell, Plant Sciences & Plant Pathology; Alexvon Barloewen, Plant Sciences & Plant Pathology

Mentor(s): Chance Noffsinger, Plant Sciences & Plant Pathology

Mortierella is a saprotrophic genus of soil fungi that are widespread and highly diverse. Species of Mortierella are present as endophytes in plant roots and have been shown to improve plant growth, protect plants from pathogens, and increase plant available soil nutrients. Some species have been shown to solubilize phosphorus and produce phytoregulators, suggesting their potential utility as biofertilizers in agricultural systems. However, no study has assessed the diversity of Mortierella in Montana or their potential use as plant growth promoting fungi in agricultural systems across the state. This research assessed the diversity of Mortierella in plant roots and soil samples from four habitats including spruce-fir, pine, cottonwood, and meadow. Fungi were isolated from root and soil onto potato dextrose agar. Cultures with radial floret morphologies were sequenced for the fungal ITS barcode and identified using BLAST searches against type specimens, complemented by phylogenetic analysis. Each isolate was then assessed for its ability to solubilize phosphorus, produce phytoregulators, and tolerate drought in culture. Five species in the Mortierellaceae were identified from nine isolates and included Podila humilis, P. cf. horticola, M. antarctica, and two unidentified Mortierella species. Preliminary analyses indicated that two Mortierella species are able to tolerate drought conditions and none of the species assessed exhibited detectable phosphorus solubilization. Auxin assays are currently underway. This study will lay the groundwork for deploying Mortierella species as biofertilizers in Montana's agricultural systems, while reducing reliance on synthetic fertilizers and improving soil health.

Acknowledgements: USP - Undergraduate Scholars Program

Developing Value-Added Agricultural Products in Montana: A Market Research Case Study Supporting Farm Integrity and Sustainability

Harley Brittenham, Health & Human Development

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

Agricultural practices contribute significantly to U.S. greenhouse gas emissions; in dairy cheese production, up to 90% of input becomes wasted whey. Therefore, researching ways to repurpose the large amount of whey waste would effectively improve sustainability in cheese production. Recent studies have found that interest in upcycled food products can increase with conscious marketing. Consumer reports suggest that acceptability of such products is increased when consumers are informed of sourcing, ingredients, and labeling claims that build confidence in purchasing. In collaboration with a local organic dairy farm, Amaltheia Organic Dairy, LLC, and the Food Product Development Lab, a goat whey protein powder is being developed. This research aims to identify consumer interest and marketability of Amaltheia's upcycled whey powder product with respect to its nutritional, sensory, and sustainability features. An IRB protocol has been submitted to initiate human-subject research. An online survey will assess consumer perceptions, motivations, and barriers, followed by individual interviews to gather sensory feedback and in-depth opinions. A subsequent survey will evaluate packaging preferences and willingness to pay. Additionally, samples of liquid goat whey have been collected for spray dry trials. Working with three potential equipment suppliers, small portions of whey will be shipped and processed for evaluation by researchers. By evaluating both production feasibility and market demand, the project supports the development of value-added uses for whey that can reduce waste and improve environmental sustainability in cheese production. The findings may also serve as a model for small-scale, local farmers seeking to adopt value-added product development.

Acknowledgements: USP - Undergraduate Scholars Program

Effects of Substrate on Strawberry Root Growth and Stability in Hydroponics

Megan Johnson, Plant Sciences & Plant Pathology; Sarah Gilman, Plant Sciences & Plant Pathology; Brady Hayden, Plant Sciences & Plant Pathology; Hailey Jenkins, Plant Science & Plant Pathology

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

Hydroponic strawberry production is increasing in controlled environment agriculture. These systems reduce the risk of soil-borne diseases and increase overall yield, without environmental constraints. Deep water culture (DWC) immerses roots in an aqueous solution, allowing constant access to nutrients unlike other hydroponic systems; however, it increases the risk of root rot. The purpose of the study was to find which of the 4 soilless media (rockwool, coconut husks, perlite, and Lightweight Expanded Clay Aggregate (LECA)) provides the best support for growing 'Albion' strawberries in a DWC hydroponic system.

Data on plant yield was collected over 8 weeks on 64 bareroot ‘Albion’ plants grown in a DWC system across varying substrates under consistent abiotic conditions. Post experiment, plants were kiln dried to ascertain the final biomass. This experiment was conducted to determine which soilless media provides the most stable root environment to produce the greatest yield. In the absence of soil in a hydroponic system, there is a question of which individual substrate will be the most effective in growing strawberries. A substrate’s level of support in a DWC hydroponic system will directly correlate to ‘Albion’ strawberry growth and yield.

Acknowledgements: Capstone Class

Screening of Pea Breeding Lines for Resistance to Aphanomyces Root Rot

Aliyah Poxleitner, Plant Sciences & Plant Pathology; Giseli Valentini, Plant Sciences & Plant Pathology

Mentor(s): Giseli Valentini, Plant Sciences & Plant Pathology; Carmen Murphy, Plant Sciences & Plant Pathology

This project investigates whether pea (Pisum sativum) breeding lines exhibit improved resistance to Aphanomyces root rot (ARR), a major soilborne disease that severely limits pea production in Montana and worldwide. Because chemical control of Aphanomyces euteiches is largely ineffective, genetic resistance remains the most promising and sustainable management strategy. Previous research has identified pea germplasm carrying partial resistance alleles. Through conventional breeding, crosses were made to pyramid these alleles into new breeding lines. In this process, continued screening is needed to identify the lines containing the desirable alleles. To address this need, approximately 100 breeding lines will be evaluated in a controlled greenhouse experiment. Lines will be inoculated with a standardized spore suspension of A. euteiches and assessed for disease severity using a 0–5 root rot index, along with measurements of plant vigor and root health. A randomized complete block design with replicated treatments will allow for statistical comparison of genotypic responses. It is expected that lines carrying alleles from known resistant parents will demonstrate reduced ARR severity relative to susceptible checks. Findings will provide breeders with promising candidate lines for future cultivar development. Results will be discussed in the context of genetic resistance as a critical tool for sustainable pea production and long-term disease management.

Acknowledgements: USP - Undergraduate Scholars Program

Effects of Ammonium-to-Nitrate Ratios on Nitrate Accumulation in Hydroponically Grown Lettuce

Ty Sebesta, Plant Sciences & Plant Pathology; Elli Austin, Agriculture - Plant Sciences & Plant Pathology; Zachary Zander, Agriculture - Plant Sciences & Plant Pathology

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

Nitrogen is an essential macronutrient that manages plant growth, yield, and metabolic function. In hydroponic crop production systems, nitrogen is primarily supplied in the form of nitrate (NO_3^-) and ammonium (NH_4^+), and the ratio between these forms of nitrogen plays a crucial role in nutrient uptake dynamics, plant physiology, and product quality. Excessive nitrate accumulation in lettuce is a concern for both crop quality and human health, making nutrient management an important part of controlled environment production. This study evaluates how varying ratios of ammonium nitrogen (NH_4^+) to nitrate nitrogen (NO_3^-) influence nitrate accumulation in hydroponically grown lettuce leaves. Lettuce plants were cultivated in a controlled hydroponic system and supplied with nutrient solutions containing different ammonium and nitrate nitrogen ratios. Leaf tissue samples were collected at harvest for nitrate analysis. Growth parameters, including biomass and visual plant health, were also recorded to assess potential trade-offs between nitrate reduction and plant productivity. It was hypothesized that increasing the proportion of ammonium nitrogen would reduce nitrate accumulation in leaf tissues by limiting nitrate uptake and storage. The findings from this study aim to identify nutrient management strategies that minimize nitrate accumulation while maintaining optimal lettuce growth in hydroponic systems.

Plant Growth Promotion in Spring Wheat by Native Mortierella Isolates from Montana Soils

Emma Warhank, Plant Sciences & Plant Pathology

Mentor(s): Chance Noffsinger, Plant Sciences & Plant Pathology

Mortierella is a highly-diverse genus of saprotrophic soil fungi that promote growth in a variety of agricultural cropping systems. *Mortierella* species have been shown to secrete organic acids into soil that solubilize nutrients such as inorganic phosphorus, as well as synthesize plant growth regulating hormones like the auxin indole-3-acetic acid (IAA). These functional traits have been shown to promote growth in winter wheat, lettuce, and saffron, but studies have not been conducted to investigate the effect of *Mortierella* on spring wheat (Vida) development. Several species of *Mortierella* were isolated from soil and

plant roots in various Montana habitats and assayed for their ability to solubilize phosphorus and produce IAA. Each *Mortierella* species was grown with spring wheat seedlings in specialized media amended with either tricalcium phosphate or tryptophan to evaluate their capacity for phosphorus solubilization and IAA production, respectively. Each experiment was conducted for 11 days and plant root, shoot, and total dry biomass was quantified. The *Mortierella* species assessed did not exhibit detectable phosphorus solubilization and had a significant negative effect on spring wheat shoot and root length. The IAA assay is ongoing; however, isolate SFP2.1A significantly increased spring wheat shoot length relative to the control, with no effect on root length. The plant growth promoting traits observed in *Mortierella* highlight its potential to support more sustainable and cost-effective crop production systems. Additional research is needed to quantify the specific auxins produced and to assess inoculation and growth-promoting potential in soil systems.

Preliminary Analysis of the Relationship Between Temperature and Germination Rates in Montana Leafy Greens

Gabriel Weinrieb, College of Agriculture

Mentor(s): Dr. Claire Luby, Plant Sciences and Pathology, Horticulture

This research aimed to better understand the relationship between cold temperatures and germination rates of popular leafy green crops. Season extension is important to farmers in colder climates to be able to sell produce year-round. This study examined a selection of species that may be appropriate to seeding in cold temperatures. A temperature gradient table with 10 datapoints was operated between 0 and 15 degrees Celsius. This represented a gradient of soil temperatures found around spring and fall frost periods. Germination was recorded each day for 21 days for 5 species across this gradient. Species varied in the rate of germination across the temperature gradient and indicated species that may germinate well, even in cold soils. The study should be further expanded to include more crops and assessment in the field to better understand the impact of earlier seeding on yield and harvest times.

Acknowledgements: Dr. Claire Luby, Dr. Fabian Menalled, Dr. Lisa Rew, Lizzie Gill, Tom Raske

ARTS AND MUSIC

Xenharmonic Praxes: Compositional Studies in 31-EDO for Guitar

Emmett Aschim, Music

Mentor(s): Gregory Young, Music

This thesis examines the creative, theoretical, and practical implications of composing for the guitar in thirty-one-tone equal temperament (31-EDO). Although 31-EDO has a deep connection to musical tradition, its application to the contemporary guitar remains largely unexplored within modern research circles.

By combining historical contextualization with theoretical analysis, instrument modification, and compositional inquiry, this study investigates how microtonality can reshape the timbral identity, expressive range, and performative possibilities of the guitar in modern contexts.

The methodology of this research encompasses the modification of two traditional guitars. A classical guitar was configured to a fretless design, with adhesive microfrets subsequently applied to facilitate precise microtonal inflections. Complementing this, an adjustable microtonal fretboard was installed on a traditional electric guitar, allowing exploration of 31-EDO across differing instrumental contexts. These modifications resulted in a collection of compositional sketches that directly engage the 31-EDO system, illustrating both the practical challenges inherent in performing microtonal music and the expanded expressive possibilities made available through instrument modification.

In this context, praxes denotes distinct modes of praxis: historical, theoretical, physical, and compositional, through which musical knowledge is generated, collectively giving rise to a broader Xenharmonic praxes. This framework demonstrates the viability of 31-EDO as a coherent compositional environment and highlights practical pathways for composers, performers, and instrument builders seeking to expand the expressive potential of the guitar.

Acknowledgements: USP - Undergraduate Scholars Program

Ceramic Mechanical Contraption Research

Garrett Dominick, Art

Mentor(s): Jeremy Hatch, Art

I am drawn to creating complex mechanical systems with clay because of the juxtaposition between material perception and real world capability. Ceramic is commonly seen as fragile and delicate, yet when applied correctly, it exhibits remarkable strength. Firing often leads to warping, cracking, and other unpredictable changes, making the successful construction of functioning mechanical elements very difficult. I utilized a clay 3D printer to produce mechanical components which require a level of precision and repeatability that are not possible to create using any other method. I also create custom tools with a standard plastic 3D printer which aid in the creation of these clay mechanical components.

Acknowledgements: USP - Undergraduate Scholars Program

Ghosts in the Ore Country

Jonathan Lau, Film & Photography

Mentor(s): Christina Anderson, Film & Photography

The scars of industry run deep in my family. A large portion of the town where I was raised was beholden to the mines. They came and went with the job, breaking their bodies because it was the only job around. The population swelled and shrank like the tide. The West was and is a land exploited. Industries use economic growth, job creation, and the necessity of their product to enrich themselves while not caring for the permanent disfigurement of the land and people, all the while demanding more—more land, more profits, more people. This photographic series explores the industry's relationship with the land and people of the Mountain West.

Acknowledgements: USP - Undergraduate Scholars Program

Ghosts and Monsters of Montana

Sydnee Lovering, Architecture

Mentor(s): Ezgi Balkanay, Architecture; Kelly Olinger, Architecture

This essay is a 5-story anthology that explores the concept of "ghosts" and "monsters" in the Anthropocene, as defined in Arts of Living on a Damaged Planet by Anna Lowenhaupt Tsing et al., applying these ideas to the landscapes of Montana. "Ghosts" are known as species and traces of past ecological relationships that continue to form the present. "Monsters" represent forces that transform the landscape, which are often introduced by

humans. Through these 5 stories, the paper examines how ecological and historical memory inform modern environmental conditions in “Big Sky Country.” The first story told is of the American Bison as a ghost species, brought to the brink of extinction, reshaping Indigenous ways of life and the Great Plains ecosystem, leaving lasting cultural and ecological absence. The next story follows a “monster,” the Russian Olive, an introduced species that disrupts riparian areas while also revealing the complexity of human and non-human entanglements. The Berkeley Pit is a tale of a haunted industrial landscape, where extractive resourcing driven by political and economic power has left behind a toxic ecological legacy. Bats, threatened by disease and pesticide use, reveal the fragility of ecological relationships that require reciprocity from the human side, and risk the “making of a ghost” of an essential species. The final story about trout tells of both “ghost” and “monster,” reflecting tensions between native and invasive species within broader environmental degradation and conservation efforts. Together, this anthology highlights the consequences of ecological amnesia, forgetting past environmental relationships, and argues for a renewed awareness of both human and non-human histories beyond the past 200 years. By recognizing these layered pasts, this essay invites curiosity for more informed and ethical ecological futures.

Acknowledgements: Crawford Scholarship

Women Who Design

Sasha Maguire, Art

Mentor(s): William Culpepper, Art

Women Who Design is an ongoing research and editorial project that documents and celebrates women working in the creative community of Bozeman, Montana. Through in-depth interviews, visual storytelling, and editorial design, the project amplifies the voices of women whose work often shapes the visual landscape while often remaining behind the scenes. By sharing their experiences, creative processes, and career paths, Women Who Design seeks to make visible the contributions of women designers while strengthening connections within the local design ecosystem. The project currently includes a series of twelve individually designed zines, each dedicated to a featured designer and her story. These publications combine written narratives, photography, and curated work samples to create accessible and engaging documentation of each designer’s work. In addition to print publications, Women Who Design has expanded to include a dedicated website and an active Instagram presence that share designer stories and increase visibility beyond the local community. Public-facing events, including exhibitions and an upcoming open house

on May 6, to further invite community engagement and conversation around the role of women in design. Women Who Design has received recognition through university exhibitions and student awards, demonstrating the project's impact as both a research project and a design-driven platform for storytelling. By documenting these stories, the project creates a lasting archive of women's contributions to the creative field in Bozeman, while inspiring emerging designers and creating greater visibility, recognition, and representation in design.

Acknowledgements: USP - Undergraduate Scholars Program

Coastal Architecture Through the Craft of Surfing

Pierce Morley, Architecture

Mentor(s): Ezgi Balkanay, Architecture; Mike Everts, Architecture

Contemporary coastal architecture is often seen as static, object-based infrastructure designed to withstand waves, tides, and weather. In doing so, it reinforces a separation in the human–ocean relationship, emphasizing control, stability, and permanence over adaptability and engagement. This research challenges that perspective by positioning surf craft as a catalyst for reimagining how architecture can move with, respond to, and connect with coastal environments. Surfing offers an alternative model of spatial interaction, characterized by motion, timing, and ongoing negotiation with changing conditions. Riding waves transforms coastal space into a dynamic zone where structure emerges through movement, balance, and adaptation, rather than remaining static. Drawing inspiration from surf craft traditions, this research views these embodied interactions as a form of spatial intelligence that can inform coastal architecture. The study investigates how surf craft principles can inform an architectural approach based on movement, flexibility, and direct interaction with coastal systems. It considers how waves, currents, wind, and tides act as active forces shaping form, organization, and experience at the land–water interface. Using observation and iterative design, these insights are transformed into performative strategies that focus on responsiveness, material behavior, and the choreography of movement within coastal environments. The result is a redefinition of coastal architecture, not as a static object but as kinetic architecture: an evolving system shaped through continuous interaction with the ocean. Through surfing, architecture is reconceptualized as something that moves, adapts, and performs within the landscape.

Unity Matters: A Look at the Historically Proposed Closure of the School of Architecture at Montana State University

Alexander Tupper, Architecture

Mentor(s): Ezgi Balkanay, Architecture

This project examines the time between December 12th, 1986 and March 27th, 1987 when Montana State University attempted to shut down their architecture program and attempts to create a history of it. Facing large budget cuts, the president of the university at the time, William Tietz, proposed for the School of Architecture to be one of the programs slated for termination. This action brought the architecture academia and profession together to successfully save the school under the 'Architecture Matters' movement. Students organized petitions, stand-ins at various meetings, and a mock funeral for the program and education as a whole. Licensed architects and other professionals directly wrote Tietz about their displeasure with his proposal and confronted him about many potential downsides of it. In unity, these group's efforts convinced the Board of Regents to table the termination of the architecture program in exchange for an extra fee placed on top of the student's tuition. Their work placed architecture as a vital function in the landscape of higher education and showed the power of an industry working together towards a collective goal. Previous study of this history is touched on by published works such as Utzinger and In the People's Interest: A Centennial History of Montana State University, although their narratives are focused on different topics. In addition to these published works, this history was collected through archival materials housed in or hosted by the Archives and Special Collections at Montana State University Library.

Acknowledgements: Montana State University School of Architecture

Grafik Intervention Bozeman's Red Light District

Kylie Zwagerman, Art; Erika Chapin; Sasha Maguire; Connor Lane; Kylie Zwagerman

Mentor(s): William Culpepper, Art

Grafik Intervention uses extensive historical research to uncover overlooked history within the urban environment. In this project, we sought to reframe public understanding of a former downtown Brothel by projecting visuals that illuminated the building's red light district. This further emphasized the historical significance and encouraged the Bozeman Community to engage in conversations about urban change, preservation, and visibility.

Acknowledgements: Montana State Universities Special Archives, Gallatin History Museum, Bozeman Public Library, and The Extreme History Project

BIOCHEMISTRY

Synthesis, Characterization, and Reactivity of Sulfur–Rich Cobalt Complexes

Bailey Allies, Chemistry & Biochemistry; Roark O'Neill, Chemistry & Biochemistry

Mentor(s): Mike Mock, Chemistry & Biochemistry

The thioether framework of phenyltris((tert-butylthio)methyl)borate, [PuTttBu]-, is a synthetic bio-mimetic system designed to model the catalytic abilities of sulfur-containing enzymes such as nitrogenase and radical SAM enzymes. This system is tridentate with the tert-butylthiolethers ligating themselves to metals such as cobalt and iron, which allows for coordinately unsaturated metal centers. Cobalt is a transition metal that can be found naturally in metalloenzymes such as coenzyme B12 and nitrile hydratase. The co-enzyme B12 can cleave in a fashion similar to the homolytic bond cleavage of the 5'-dAdo radical of SAM enzymes. This unique organometallic reaction in biology is a prime candidate for biomimetic modeling because the corresponding intermediates are highly reactive. Reported here is the synthesis, spectroscopic characterization, molecular structure, and reactivity of several complexes of high-spin, coordinatively unsaturated organocobalt, cobalt-thiolate, and cobalt amido complexes supported by the [PuTttBu]- ligand. Reactions with carbon dioxide (CO) with the new [PuTttBu]Co(R) resulted in either the addition of the CO to the cobalt to form [PuTttBu]Co((CO)(CO-R)) or bond homolysis to form previously reported [PuTttBu]Co(CO)2. Contrasting the reactivity of the organometallic complexes, the reaction of the newly prepared [PuTttBu]Co-S-(Phenyl) complex with carbon monoxide only went to completion under photolytic conditions, furnishing [PuTttBu]Co(CO)2 and organic diphenyl disulfide after several hours of UV light exposure.

MOFs for Selective Oxidation of Methane to Methanol – Can MOFs Activate O2?

Leysa Kurtyka, Conservation Biology & Ecology

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

The selective oxidation of methane to methanol remains a major challenge in the chemical industry. The exceptional strength of the C-H bond in methane is highly resistant to activation without extreme energy inputs. Developing a catalyst that is capable of selectively activating and facilitating the oxidation of methane to methanol has been a

central goal. However, even when catalysts are selective toward methanol, they tend to overoxidize to combustion products such as carbon dioxide. The proposed work aims to investigate a new class of catalysts for this reaction - metal–organic frameworks (MOFs). Specifically, a copper-based MOF named CFA-5. This MOF was identified by our group as a strong candidate to mimic the biological methane oxidation process observed in particulate methane monooxygenase (pMMO), and is hypothesized to be capable of activating molecular oxygen to facilitate controlled methane oxidation and mitigate current industrial challenges. This work specifically addresses the question “Can MOFs activate O2?” using thermogravimetric techniques. We report data measuring the redox capabilities of CFA-46-5 over a wide range of oxidation potentials to understand the conditions required to form the reactive oxygen sites needed for methane oxidation. Furthermore, we examine the temperature range over which MOF CFA-5 is structurally stable. Interest in this system stems from the potential to develop efficient, low-temperature catalytic methane conversion that mimics biological enzymatic systems seen in nature.

Acknowledgements: EcoStart - Center for Biofilm Engineering

Exploring the Effects of Galectin-3 on Human Lung Carcinoma

Bailey Mainolfi, Chemistry & Biochemistry; Janelle Bullis, Chemistry & Biochemistry; Kyce Morgan, Chemistry & Biochemistry; Aubrey Tulloch, Chemistry & Biochemistry

Mentor(s): Mary Cloninger, Chemistry & Biochemistry

In the body, both intercellular and intracellular processes occur to carry out necessary biological functions. Multivalency is a biological recognition method that is utilized both intercellularly and intracellularly to synergistically augment weak individual binding interactions to make them strong enough that physiologically relevant responses can occur. Many cells, such as cancer cells, optimize multivalent interactions to improve their ability to aggregate and form tumors. Galectins are a class of proteins that rely heavily on the use of multivalency during many stages of cancer progression, including cellular aggregation/tumor formation. In this research, a specific galectin called galectin-3 is quantified in the A549 lung carcinoma cell line. Determining the amount of galectin-3 in the A549 cell line can infer the mechanisms and binding interactions by which this cancer cell line forms tumors. To quantify the amount of galectin-3 present in an A549 cell, laboratory methods including cancer cellular growth, SDS-PAGE for protein separation, and western blotting for protein identification are used. Calculating the amount of galectin-3 per cell also requires usage of a bicinchoninic acid assay to determine the total protein concentration in the cell. Overall, the average amount of galectin-3 in A549 cells are

analogous to the galectin-3 content found in ovarian cancer cell passages of OVCAR-3 and SKOV-3. Comparing the amount of galectin-3 in A549 cells to other cell lines allow for elucidation of the galectin-3 mediated mechanism of cancer cellular aggregation/tumor formation. This could provide potential new chemotherapeutic options in the medical field.

Acknowledgements: Tamara Joy Henderson Fund

Purification and Reconstitution of Naked Mole Rat RSAD1, a Radical SAM Protein Implicated in Alzheimer's Disease

Lydia Puckett, Chemistry & Biochemistry; Balyn Muffley, Chemistry & Biochemistry

Mentor(s): Joan Broderick, Chemistry & Biochemistry

Radical SAM enzymes use a [4Fe-4S] cluster and S-adenosyl-L-methionine (SAM) to perform radical reactions. RSAD1, or radical S-adenosyl domain 1, is a radical SAM enzyme that is found at abnormally high concentrations in the brain tissue of people with Alzheimer's disease. The structure, functions, and potential contributions of RSAD1 to Alzheimer's pathology are not yet known. To characterize RSAD1 beyond humans, the naked mole rat (nmrRSAD1) homologous protein was examined. The nmrRSAD1 gene was inserted into a plasmid through Gibson assembly and transformed into optimized E. coli cells. The cells were grown at a large scale, expressed, and lysed. The soluble lysate fraction was purified through affinity chromatography. Protein presence was analyzed using SDS-PAGE and Bradford assays. The purified nmrRSAD1 was reconstituted with iron and sulfur, and UV-Vis spectroscopy was used to assess reconstitution success. The nmrRSAD1 was purified to 2 mL of 71 μM protein, with a large elution band present on the SDS-PAGE gel about 10 kDa higher than expected. The reconstituted protein had a brown color and a final concentration of 40 μM. UV-Vis spectroscopy showed increased absorbance around 410 nm, indicating the presence of [4Fe-4S] clusters at 2.18 Fe/monomer. Future work for nmrRSAD1 will focus on optimizing reconstitution to reduce protein loss and improve iron content. Once pure and reconstituted protein has been obtained, interactions with SAM and heme can be observed with electron paramagnetic resonance (EPR) spectroscopy, and x-ray crystallography can be performed to determine its structure and potential functions.

Formation of Nickel Complexes For Use as Catalysts in Nitrogen Reduction and Oxidation

Margaret Sharp-Milgrom, Chemistry & Biochemistry; Parker Keller, Chemistry and Biochemistry; Carson Rich, Chemistry and Biochemistry

Mentor(s): Michael Mock, Chemistry & Biochemistry

One of the greatest problems facing modern life is increasing temperatures worldwide coupled with the quickly diminishing supply of fossil fuels. Nitrogen makes up 78% of the atmosphere yet is notoriously difficult to activate, being able to access it could open up a renewable and plentiful energy source. Our focus was on creating nickel complexes that could be used to perform catalytic reduction of N2 to ammonia and oxidation of NH3 to NH2. The ligands that were synthesized for these nickel complexes were also used in pursuit of Ni+1 complexes, radicals, reactions with CO and CO2. Synthesis of the Nickel complexes was performed under a nitrogen atmosphere in a glove box. First a nickel bromide complex was formed and used to perform a Grignard reaction with benzyl magnesium chloride creating a nickel benzyl complex which could be used for a variety of catalytic experiments. Nuclear magnetic resonance (NMR) analysis was used to confirm the identity of products isolated from this reaction as well as analysis of the crystal structures. These characterizations were necessary before further experimentation could be performed in pursuit of activation of nitrogen as well as Ni+1 complexes, which are not often reported in literature. The most recent developments include using light and CO2 gas addition to a nickel benzyl complex which created a bridging CO2 and using light and gas additions to isolate a Ni (I) complex.

Differential Effects of PFOA and PFBS on Alcohol Dehydrogenase Kinetics

Emma Solberg, Chemistry & Biochemistry; Will Kelly, Chemistry & Biochemistry

Mentor(s): Brian Bothner, Chemistry & Biochemistry

Per- and polyfluoroalkyl substances (PFAS) are long-lasting environmental contaminants detected in humans that can interact with proteins. However, how these compounds affect enzyme function at the molecular level is still largely unknown. This project looks at whether exposure to perfluorooctanoic acid (PFOA), a commonly detected PFAS compound, influences alcohol dehydrogenase (ADH) activity. Alcohol dehydrogenase is a metabolic enzyme that converts ethanol into acetaldehyde using NAD^+ as an essential cofactor. ADH is a useful model for studying how environmental chemicals influence enzyme function because extensive research has characterized its structure and kinetics.

ADH kinetics were measured using a UV-Vis spectroscopy assay that tracks NADH production at 340 nm as ethanol is converted to acetaldehyde. Michaelis–Menten curves were generated for ADH incubated with and without PFOA, and kinetic parameters were estimated using Lineweaver–Burk plots. Both Km and Vmax increased slightly in samples containing PFOA, although these changes were not statistically significant. Mass spectrometry was used to test whether PFOA binds to ADH. However, data quality was limited by background noise and protein loss during sample preparation. Additional experiments are being done to identify trends and improve resolution in detecting potential ADH–PFOA interactions. Current efforts have expanded to examine interactions with additional PFAS compounds, including perfluorobutanesulfonic acid (PFBS), to assess how structural differences influence enzyme activity. These findings provide a first step in understanding how PFAS may interact with metabolic enzymes at the molecular level.

Development of a Cryo-EM Standard for Single Particle Analysis

Isaac Stock, Microbiology & Cell Biology; Sterling McBee, Chemistry & Biochemistry; Prince Asamoah, Chemistry & Biochemistry; John Hardin, Chemistry & Biochemistry

Mentor(s): Martin Lawrence, Chemistry & Biochemistry

Modern Transmission Electron Microscopes are highly technical pieces of equipment requiring significant maintenance. Accordingly, protein standards are needed as positive controls to confirm these microscopes are functioning properly. The structure of DPSL from P. furiosus has been determined by the Lawrence lab at an ultra-high resolution of 1.86 angstroms on a 200 kV microscope, suggesting it could serve this role. A prerequisite, however, is it must be easily purified and stable during storage and transport. Towards this goal, we optimized a one-column purification of untagged DPSL and surveyed buffer conditions to maximize DPSL stability during long-term storage. We are currently testing the ability of DPSL subjected to long term storage to deliver an ultra-high resolution cryo-EM structure. We have prepared vitrified DPSL on grids and collected a data set at 200 kV on our local Talos Arctica. This data is currently being processed; the structure is currently at 3.13 angstrom resolution. However, while processing is not yet complete and the structure is likely to go to somewhat higher resolution, the ice thickness on these grids is not ideal. For this reason, this data is unlikely to reproduce the 1.86 angstrom structure. Nevertheless, given the thick ice, the initial data looks quite promising. Moving forward, we will recollect data with thinner vitreous ice to confirm DPSL is a convenient, ultrahigh resolution standard for cryo-EM that can be shared with cryo-EM centers around the world.

BIOMEDICAL SCIENCE

Center-of-Mass Inclination Angle and Ski Edge Angle Influence Glide Length on Rollerskis

Brandon Cabaniss, Microbiology & Cell Biology; Isaac Burgess, Food Science, Nutrition, and Kinesiology; Ethan Livingood, Food Science, Nutrition, and Kinesiology

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

Glide length is a critical determinant of cross-country skiing performance, with longer glide length consistently linked to faster V2 ski speed. On-snow studies show that mediolateral plantar-pressure balance, but not ski edge angle, is strongly correlated with glide time. However, this relationship has not been examined on rollerskis despite rollerskiing accounting for over half of yearly training volume. In addition to pressure balances, maintaining a stacked body position on the ski might be essential for longer glide lengths. Thus, the purpose of this study was to investigate the relationship between glide length and plantar-pressure balance, ski edge angle, and mediolateral center-of-mass inclination angles during rollerskiing. 29 elite biathletes (15M/14F, 24±5 years) skied on a roller ski treadmill at race intensities. Ski, pole, and whole body kinematics were collected using hybrid markerless motion capture, while forces applied to the ski were measured using plantar-pressure system insoles. Glide length (GL), mean mediolateral center-of-mass inclination angle (θML), mean asymmetry in mediolateral pressure balance as an asymmetry index (ASI), and average ski edging angle (θski) during the gliding phase were then calculated. Multiple linear regression was used to evaluate the extent to which θML, ASI, and θski predicted GL.

A multiple-regression model demonstrated that ASI, θski, and θMLaccounted for 30% of the variance in glide length ($F_{3,52} = 7.393$, $p < 0.001$); ASI was not significant ($p = 0.155$, Table 1). While ASI, not θski, is a strong predictor of GL on snow, our finding suggests this is not true on rollerskis. This may be due to the differences between gliding on snow and rollerskis. Less balanced ASI on-snow may increase ski friction and thus decrease GL. However, the same may not hold on a roller ski, as changing ski orientation does not have as large an impact on the ski's rolling speed. On a roller ski, a skier's ability to dynamically balance on the wheels, as measured by θski and θML, appears to be more influential than plantar-pressure balance. Skiers who maintain a more stacked body position and flatter ski across the gliding phase may glide further on the skiing treadmill.

Acknowledgements: USP - Undergraduate Scholars Program

Quantitative Fluorescence Imaging for Multivariate Analysis of Mitochondrial Morphology

Sam Cotton, Chemical & Biological Engineering; Hershel Nemer, Biomedical Engineering

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

Mitochondrial morphology is tightly coupled to cellular function, yet simplified classification schemes have historically constrained its characterization. In particular, a binary fusion-fission framework has dominated the field, despite growing evidence that mitochondria exhibit a far broader spectrum of structural states. Advances in computational image analysis, including tools such as ImageJ, now enable the identification of more refined morphologies. These include branched networks, elongated/tubular forms, nanotunnels, and toroidal ("donut") structures.

In this project, we applied advanced image processing approaches to more comprehensively characterize mitochondrial morphology in human neural progenitor cells. We then re-analyzed existing fluorescence imaging datasets of mitochondria from previous work in the Kunze Lab with differentiated human neurons that were exposed to varying magnetic field conditions. To move beyond qualitative or binary classifications, we implemented various quantitative metrics incorporating aspect ratio, form factor, and network connectivity. This approach enables characterization of mitochondrial populations, allowing us to refine our systematic morphology comparison between control and magnetically exposed conditions.

Our fluorescence image analysis established a broader profile of mitochondrial forms across experimental groups and provides a more differentiated foundation for probing how magnetic field gradients influence mitochondrial structural dynamics. Such dynamics are of particular interest given that shifts toward fragmented mitochondrial states are associated with impaired bioenergetics and the progression of neurodegenerative diseases.

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Validation of OpenCap-Based Estimates of Peak Knee Abduction Moments during a Drop Vertical Jump

Lucas Gaston, Mechanical & Industrial Engineering

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

Large peak external knee abduction moments (pKAbM) are associated with anterior cruciate ligament (ACL) injury risk, making their accurate measurement clinically valuable. Traditional motion capture (MoCap) systems capable of measuring knee kinetics are expensive and impractical in many clinical settings. OpenCap presents an affordable alternative, using only iOS devices to collect motion data. However, OpenCap-based estimates of pKAbM have rarely been validated against MoCap. This study aimed to assess the agreement between OpenCap and MoCap pKAbM estimates during the double limb drop vertical jump (DLDJ), a clinically meaningful movement task. Eight participants (4F/4M; 22.5±3.5yrs; 1.72± 0.08m; 69.5±14 kg; Tegner:4.57±1.27; Marx:6.25±3.69) completed five DLDJ trials recorded simultaneously by three iOS devices running OpenCap and an 8-camera Qualisys MoCap system. MoCap data were processed in Theia3D, and OpenCap kinetics were estimated using torque-driven OpenSim algorithmic differentiation simulations. Right leg pKAbM during the first 100ms after landing were normalized by height and weight and averaged for each participant. Pearson correlations and Bland-Altman plots assessed agreement between methods across 32 analyzable trials. OpenCap and MoCap pKAbM showed a moderate, nonsignificant correlation ($r = 0.68$; $p = 0.061$). A small negative mean bias (-0.00388 %BW-HT) indicated OpenCap marginally overestimates pKAbM relative to MoCap. The wide 95% confidence interval [-0.04, 0.937] reflects the limited sample size. Ongoing data collection using a 16-camera hybrid MoCap setup will increase statistical power and allow comparison against a gold-standard marker-based benchmark. In short, an iOS-based tool shows promise for affordable ACL risk screening, but more data is needed.

Acknowledgements: USP - Undergraduate Scholars Program

When Size Matters: Linking Bacterial Cell Geometry to Antibiotic Tolerance

Owen Kuhl, Chemical & Biological Engineering; Martina Du, Center for Biofilm Engineering & Department of Chemical and Biological Engineering; Campbell Putnam, Center for Biofilm Engineering & Department of Chemical and Biological Engineering

Mentor(s): Ross Carlson, Chemical & Biological Engineering

Chronic wound infections affect millions in the United States and impose annual costs of $30–50 billion. These infections are frequently associated with bacterial biofilms, which exhibit persistent antibiotic tolerance not fully explained by genetic resistance. This project investigates underexplored biophysical factors underlying this phenomenon: bacterial cell geometry, specifically the surface area-to-volume ratio (SA:V), and membrane protein crowding. Building on membrane-centric theory developed by Carlson and colleagues, we

hypothesize antibiotic tolerance is influenced by cell geometry and membrane protein crowding, where cells with high SA:V ratios are proposed to be capable of hosting more membrane associated drug efflux pumps, increasing the cell tolerance to the antibiotic.

To test this hypothesis, we use a combination of approaches to modulate the cell SA:V ratio and membrane protein hosting capacity. Different substrates control growth rate which in turn controls cell SA:V ratios which we hypothesize will influence antibiotic sensitivity. In parallel, targeted gene knockouts—generated using P1 phage transduction and the Keio gene deletion library— are being used to modify metabolic and transport pathways involved in membrane function and efflux. These methods enable an approach to understand how geometry and membrane protein crowding constrains antibiotic susceptibility. Quantitative phase-contrast microscopy combined with MicrobeJ image analysis are used to measure single-cell dimensions and compute SA:V across conditions. Antibiotic tolerance is assessed using tetracycline gradients, linking intracellular drug accumulation to membrane-limited efflux capacity. The study is ongoing, however, this framework provides a foundation for understanding how physical constraints dictate antibiotic susceptibility and inform new therapeutic strategies.

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Comparative Analysis of Regions of Nonhuman Primate Brains using Quantitative MRI

Jaxon Larson, Chemical & Biological Engineering

Mentor(s): Lori Ray, Chemical & Biological Engineering

Regional differences in brain microstructures are expected to influence molecular transport, yet the variation in effective diffusivity across functionally distinct cortical and subcortical regions remains poorly understood. This study estimates and compares effective diffusivity across select regions of the rhesus macaque brain using contrast-enhanced MRI (CE-MRI). A contrast agent was injected intrathecally, and then CE-MRI data were acquired over four hours across multiple subjects and combined into a composite brain volume to improve the estimate reliability. A physics-informed neural network (PINN) constrained by the diffusion equation is used to estimate effective diffusivity in five regions of interest: the precentral gyrus, postcentral gyrus, occipital cortex, hippocampus, and dorsolateral prefrontal cortex. Regional effective diffusivity values will be compared across the five regions of interest using a combination of statistical analysis and machine learning approaches to assess significant differences. It is hypothesized that regions with highly organized cytoarchitecture, such as the occipital cortex and postcentral gyrus, will exhibit

higher effective diffusivity compared to structurally complex regions like the dorsolateral prefrontal cortex, while the hippocampus is expected to have low diffusivity due to its deep location and structural complexity. This work aims to improve the interpretation of CE-MRI transport data and has broader implications for understanding brain waste clearance mechanisms relevant to neurodegenerative diseases such as Alzheimer's and Parkinson's.

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Electrochemical Impedance Spectroscopy (EIS) Analysis of Saliva Using IDE Fabricated Sensors for MDK Interactions in Metastatic Melanoma

Kestley Lutey, Chemical & Biological Engineering; 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. We have discovered a novel interaction between two proteins, B7-H3 and Midkine (MDK), which may provide new targets for melanoma treatments and diagnosis. MDK, a growth factor that mediates cancer growth, is highly expressed in melanoma cells and present in bodily fluids such as blood and saliva. We have undertaken preliminary saliva analysis utilizing Microfabrication and Electrochemical Impedance Spectroscopy (EIS), both of which were conducted at the Montana Microfabrication Facility (MMF) at MSU. EIS was performed with a Palm Sens 4 impedance analyzer and 8x multiplexor. Samples were initially tested against PBS controls. After preliminary testing, nanoparticles bound to MDK (NP-MDK) and Antibody (ABS) were added to the saliva. All samples were analyzed with impedance measurements. We identified that saliva has a lower impedance when compared to PBS. Upon addition of NP-MDK and ABS to saliva, the impedance values increased. These results suggest that the IDE sensors have the sensitivity to not only distinguish between saliva and protein samples such as PBS but have the potential to track protein interactions within saliva. The ability to track protein interactions in bodily fluids can provide a better understanding of biomarker interaction, such as those between MDK and B7-H3, for melanoma detection and treatment. Further research is required to evaluate the IDE limit of detection, along with the evaluation of MDK and B7-H3 interactions within saliva.

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Integrative Surgical Simulation: Comparative Assessment of the Veterinary Assessment Laparoscopic Skills (VALS) and Fundamentals of Laparoscopic Surgery (FLS)

Evangeline Newkirk, Microbiology & Cell Biology; Alex Westlund, College of Mechanical & Industrial Engineering

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

Laparoscopic surgery is a minimally invasive surgery (MIS) performed through a small incision where a camera can be inserted, enabling physicians to inspect and assess possible trauma. Laparoscopic surgery simulators that imitate this MIS procedure allow surgeons to prepare adequately, enabling them to overcome the steep learning curve of complex operations while promoting safe medical practices. However, there is a deficiency in long-term supervised laparoscopic surgery training, leaving many surgeons and clinicians without the opportunity for consistent practice. Thus, the aim of this pilot study was to quantify the differences between novice and expert performance in laparoscopic surgery simulations, with the goal of further analyzing quantifiable characteristics of laparoscopic expertise as well as exploring differences in difficulty between the FLS and VALS tests. To do this, this study utilized the FLS Trainer, which included an eight-sensor electroencephalogram cap, eye tracking bar, electromyography muscle sensors, and galvanic skin response. This study focused on the pegboard task, incorporating both the VALS and FLS test, which helped to replicate anatomical differences between humans and animals. Using novices (undergraduate and graduate students), comparisons between natural and improved training conditions, along with emotional responses to said tasks, were made, which were then used to optimize learning and testing efficiency with this training system. The results from this study revealed that there were no statistically significant differences in completion rates, duration, or any other modalities between the FLS and VALS tasks, signifying the similarities between the two and indicating that the FLS and VALS trainer systems could potentially be used interchangeably. Data from the Facial Expression Analysis (FEA) technology, however, revealed different emotional responses between the two tasks, with higher accounts of anger associated with the FLS task compared to the VALS.

Acknowledgements: USP - Undergraduate Scholars Program

Sex Differences in Osteocyte Turnover of the Bone Matrix

Colette Niglio, Center for Biofilm Engineering

Mentor(s): Chelsea Heveran, Mechanical & Industrial Engineering; Kenna Brown, Mechanical & Industrial Engineering

There are significant sex disparities regarding bone fragility, with women having a higher fracture risk in their lifetime than men. Previous research has identified sex differences in bone microarchitecture, density, and metabolism. Treatments for bone fragility typically target bone mass through the bone cells that deposit and resorb bone at its surface. However, a promising treatment for bone fragility is improving bone quality by targeting osteocytes. The osteocyte is the most abundant bone cell that resides in the perilacunar-canalicular system (LCS) of bone. Little research has been done on osteocyte sex differences. However, it was recently discovered that these cells can also remodel bone around the LCS. Osteocytes comprise 90 to 95% of bone cells and, due to their expansive nature, can significantly alter bone quality. Using confocal laser scanning microscopy and image analysis, my project analyzes femur samples from female and male rats (n = 12/sex; animal procedures IACUC-approved) injected with the fluorochrome calcein, which binds calcium, enabling visualization of osteocyte bone turnover. Calcein-labeled lacunae are analyzed in both sexes to understand the abundance and distribution of osteocyte activity at the anterior, medial, lateral, and posterior areas of femur cross-sections. The image and statistical analysis (ongoing) will be combined with strain data maps in these regions of interest to better understand LCS turnover dependence on mechanical stimuli. My project aims to define sex differences in osteocyte bone turnover, enabling more effective treatments for bone fragility.

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Relationship between Lower Extremity Joint Range of Motion and Center of Mass Vertical Displacement during Running

Lailah Rosario, Health & Human Development

Mentor(s): Megan Peach, Health & Human Development

Higher center of mass displacement (comVD) in distance runners has been related to overuse injuries. While cycle metrics (stride length and step frequency) have been established as interventions to reduce comVD, it is unclear whether manipulating lower-extremity joint range of motion (ROM) is an intervention for reducing comVD. This study aims to evaluate the relationship between lower extremity joint ROM and comVD during

running. Fifteen participants (7 F, 8 M; 23.25 ± 2.32 years, height 1.77 ± 0.08 m, mass 75.96 ± 12.99 kg, activity 326.56 ± 158.48 minutes) ran five trials along a 15 m runway while body kinematics were recorded using markerless motion capture. A 13-segment biomechanical model was used to calculate comVD and sagittal hip, knee, and ankle angles. Sagittal joint ROM and comVD were calculated during stance phase. A regression model was used to determine relationships between hip, knee, and ankle ROM and comVD. A model including ROM for hip, knee, and ankle accounted for 41.4% of the variance in comVD ($F = 16.49$, $p = <.001$). Knee and ankle ROM, but not hip ROM, were significant predictors of comVD, with increasing ROM resulting in greater comVD. An increase of a degree of sagittal knee or ankle ROM results in a 1 mm increase in comVD. Reducing knee or ankle ROM during running may be an intervention to reduce comVD. Future studies should examine interventions that target reductions in knee or ankle ROM to decrease comVD and identify adverse consequences that may result from decreasing ROM.

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Investigating Strain Distributions in Male and Female Rat Femurs Using Finite Element Analysis

Jacob Swenson, Mechanical & Industrial Engineering

Mentor(s): Chelsea Heveran, Mechanical & Industrial Engineering; Kenna Brown, Mechanical & Industrial Engineering

One in three women and one in five men over 50 will experience an osteoporotic fracture in their lifetime. Research has shown sex differences in bone tissue and cellular activity but there may also be differences in mechanical signal environment. Osteocytes, the most abundant bone cells, are load-sensitive and use mechanical loads to signal bone remodeling to keep bones healthy. However, the relationship between strain distribution and osteocyte activity remains poorly understood. We hypothesized that strain would vary non-uniformly across the femoral cortex and that female femurs would exhibit higher strain magnitudes than males. All animal procedures were approved by IACUC. Whole bone meshes including bone mineral density (BMD) for finite element (FE) analysis were generated from micro-CT scans of femurs from skeletally mature male and female Wistar rats (n = 12/sex). FE simulations applied displacements (0.05% femur length) at the femoral head to estimate midshaft forces and moments. Strain distributions were analyzed across four quadrants of the femoral cortex defined as 200 μm on either side of the loading axes calculated by principal component analysis. Statistical comparisons were made between

quadrants and sexes. No significant difference between the sexes for strain magnitudes experienced in any of the quadrants were found. For the first time we show a strain distribution map of the femur that accounts for BMD heterogeneity with resolution appropriate for co-registration with osteocyte microscopy images. Together these will provide insight into osteocyte activity with strain in healthy bone, which can be used to improve treatments of bone fragility.

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BUSINESS AND MARKETING

Integrating Cyber into Multi Domain Operations

Morgan Ericsson, Bracken Center

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

Modern military operations increasingly depend on cyberspace and digital networks to support communication, intelligence, and command functions. Although current U.S. doctrine identifies cyberspace as a key domain within Multi-Domain Operations (MDO), the operational role of cyber capabilities is not always clearly defined for military planners. This study examines how cyberspace capabilities contribute to MDO within existing doctrinal mission structures. The study analyzes U.S. military doctrine and policy documents related to cyberspace operations and MDO. The analysis evaluates cyber actions within the doctrinal mission categories of: Offensive Cyber Operations (OCO), Defensive Cyber Operations (DCO), and Department of Defense Information Network Operations (DODIN). Selected real-world applications of cyber operations are also used as case studies to determine how cyberspace capabilities support military operations. Results indicate that the doctrinal mission categories of OCO, DCO, and DODIN correspond to distinct operational functions including: cyberspace attack and exploitation, response and internal defense, and cyberspace security respectively. These findings can provide commanders with a framework for integrating cyber capabilities into MDO through aligning offensive effects with cyber disruption, defense of friendly systems, and DODIN operations with the upkeep of friendly networks. Additionally, this study clarifies the operational role of cyberspace effects within MDO, giving a structured understanding and practical guidance that support planning and joint operations.

Baseball Hits Home

Elsa Tritsch, JJCBE Center for Entrepreneurship; Kaili Chikos; Alexandra Hill

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

Major League Baseball is one of the most iconic brands in American culture, built on tradition, family, and shared memories. While baseball remains respected, our research shows that MLB is no longer culturally relevant to Gen Z. We conducted research with the goal of discovering how to re-establish MLB's cultural relevance with Gen Z. Primary research consisted of four focus groups (n=40) and two nationwide surveys (n=736), while secondary research examined internal and external forces affecting MLB. Data was analyzed to uncover Gen Z's relationship with MLB in terms of preferences, brand associations, cultural relevance, engagement, willingness to subscribe, messaging, and motivation to engage with MLB. Regression analysis, t-tests, and moderation analysis were used to analyze data, and results were leveraged to develop a strategic marketing plan for MLB. Results showed that Gen Z is less engaged with traditional sports than older generations. They attend fewer live events, watch less sports on cable TV, and show a declining interest in leagues like MLB. Gen Z is more likely to consume content through streaming. NFL is their favorite league, with MLB ranking third, and most view baseball as nostalgic and family-oriented, as 62.7% were introduced to MLB by their parents. Focus group participants indicated that a student discount and a month-to-month subscription for a single team would increase their likelihood of subscribing to MLB.TV, which was confirmed in the surveys. Finally, we found that Gen Z prefers the tagline "Baseball Hits Home" rather than MLB's current tagline "Baseball is Something Else."

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The Effects of Today's Political Environment on Rebranding

Kinley Walters, JJCBE Center for Entrepreneurship

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

In the wake of the controversy surrounding Cracker Barrel's 2025 logo redesign and the impact of political polarization on consumer response, this study examines the effects of logo redesign on rebranding through a political lens. As political polarization continues increasing (Weber et al., 2021), prior research suggests that political affiliation can influence consumer behavior and brand perceptions (Jost et al., 2008; Kim et al., 2018; Ordabayeva & Fernandes, 2018). Therefore, it is possible that reactions to Cracker Barrel's rebranding were influenced more by political ideology than by the logo design itself. In turn,

attitude toward a redesigned logo may affect purchase intention and brand loyalty. Results from the study, which features two experimental scenarios, reveal three major contributions to our understanding of brand attitudes and political influence during brand redesigns. First, the interaction of attitude toward the rebrand and political affiliation showed that Republicans, regardless of brand, took politics into account when making choices about both brands after the redesign. Second, commitment mediated the relationship between attitude toward a logo redesign and behavioral variables, but only in specific cases. Finally, marketers should consider the political leanings of their core customers when embarking on a potential brand redesign. Additionally, it is recommended that they adopt an evolutionary rebranding approach, in which small, gradual changes are introduced over time, rather than a revolutionary rebrand that involves large, sudden changes and may lead to negative consumer reactions. Republicans likely considered Cracker Barrel's rebranding evolutionary, with a negative influence on the logo and behaviors.

Acknowledgements: USP - Undergraduate Scholars Program

COMPUTER AND INFORMATION SCIENCE

Generative AI in Cybercrime: A security Analysis of Deepfakes Technologies

Morgan Brunner, Computer Science

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

Deepfakes are a form of artificial intelligence that can change videos, images, or audio to make them look or sound real. While this technology can be used for things like entertainment or education, it is also a serious risk. These risks include the spread of misinformation that can be used to trick others. To research this topic, I conducted a literature review and explored real world examples of how deepfakes are being used to harm people. I focused on cases involving businesses and cybersecurity threats. I also reviewed both the positive and negative impacts of this technology. The research showed that deepfakes can be used to scam companies by copying a CEO's voice to steal money or information. These attacks can cause financial loss and damage a company's reputation and trust. It is also evident that there are not enough laws in place to fully control this technology. Deepfake AI is a growing problem that can affect both individuals and businesses. In the future, stronger regulations and better detection tools will be important to reduce these risks.

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Quantifying Cumulative Head Impact Exposure Using Wearable Sensors

Sara Croghan, Computer Science; Nicholas Kasten, Computer Science; Dayton Wickered, Computer Science

Mentor(s): Clemente Izurieta, Computer Science

We describe a system designed to operationalize a comprehensive head impact monitoring and risk assessment system. The system, designed in collaboration with Phreno Inc., is targeted for use while skiing but is extendable to other domains. The system functions as an analytical layer to be used within Phreno's existing iOS application. Data from helmet wearable sensors is extracted by Phreno's existing sensor infrastructure and is then processed by this system to provide the user with information and data to identify high-risk exposure patterns. Central to this system is a cumulative risk exposure tracking subsystem.

The first key component of the system is a Cumulative Exposure Calculator, which accepts a user's historical head impacts and calculates a user's cumulative head impact load score across multiple time windows (7 days to 90 days) using exponential decay models. The second key component is population level statistical analysis and comparison of an individual's head impact load score and history with a broader population dataset. This is done using z-score and standard deviation. The third key component is the visualization of this data on Phreno's applications dashboard interface. This can be used to visualize trends, and personal vs. population metrics.

For each user individual Cumulative Load Scores are calculated to quantify their total head impact exposure across time periods. These scores are then associated with risk status updates (normal, elevated, high). The user-facing dashboard displays daily impact counts, severity load graphs and rolling averages for an individual, enabling the user to make data-driven decisions about continued activity and recovery periods.

The system's implementation was validated using simulated and real-world impacts collected from skiing activities.

Artificial Intelligence Generated Image (AIGI) and Image Manipulation Detection Platform

Alexander Ellingsen, Computer Science; Matthew Nagel, Computer Science

Mentor(s): Clem Izurieta, Computer Science

Digital media, especially images, are remarkably easy to manipulate. Due to recent advancements in generative artificial intelligence, the generation or alteration of photorealistic images is becoming increasingly trivial and widespread. Thus, authenticity can be difficult to verify, which makes image manipulation a useful tool for spreading disinformation. In response to this growing threat, open-source detection tools that attempt to identify either manipulated or artificially generated images (AIGI) have been developed, though no single model offers coverage of a range of manipulation techniques. This capstone project presents a web platform that leverages a variety of AIGI detection models and forensic image manipulation detection frameworks to combat disinformation. By using models that differ in their methods for detecting AIGI or image manipulation, we ensure coverage of a number of techniques. A user can upload a suspicious image to our platform via a web app, which is then analyzed by the selected set of models. The model's outputs are aggregated into a custom report that provides a likelihood score of whether the image was created by artificial intelligence or altered otherwise. This, as well as any other generated visuals, explanations, or metrics required to support that conclusion, is displayed to the user via the web interface and is available for export if desired. This project shows how existing models can be implemented as a more comprehensive, accessible tool for analysis of image authenticity, with potential further applications in disinformation prevention and digital forensics.

Gust Front Detection Web App

Coleton Flesner, Computer Science; Robert Mcabee, Computer Science; Eoghan Perkins, Computer Science; William Elder, Computer Science

Mentor(s): Clemente Izurieta, Computer Science

A gust front is a powerful wall of wind generated by storm cells, when cool downdraft air rapidly descends and spreads outward along the surface of the Earth. A gust front rapidly cascading across a landscape experiencing a forest fire can endanger the lives of wildland firefighters responding to the incident, by creating a sudden change in the direction of the spread of the fire.

The aim of this project is to develop a web interface for the Neuro-Fuzzy Gust Front Detection Algorithm (NFGDA), a system that uses computer vision models to detect the presence and direction of gust fronts by processing live weather data. Currently, NFGDA must be executed locally, limiting its operational use. The proposed system provides a web interface that allows the algorithm to be executed remotely while presenting detection results through an intuitive web-map.

The system is being developed by Montana State University in collaboration with the United States Forest Service Fire Lab based in Missoula, Montana. The resulting system is operationalized as a fully-functional modern web-app, awaiting installation on USFS servers before deployment, in time for fire season.

Acknowledgements: United States Forest Service

Unified Schema Intelligence Engine

Maksym Makarchuk, Computer Science; Alex Ellingsen, Computer Science; Oscar Oropeza, Computer Science

Mentor(s): Ann Reinhold, Computer Science

Healthcare organizations maintain medical records electronically using different database vendors and schema designs. Semantically vendors may name fields differently, yet the information contained in the fields is identical. For example, a person's id may be tagged as person_id, prsnid, or patient_identifier. This makes record transfer between facilities challenging. These inconsistencies require data engineers to manually map hundreds of tables and columns for each new client. This manual process is time-consuming, error-prone, and not scalable for large healthcare data ecosystems.

In this project, we propose a machine learning–assisted pipeline to standardize client schemas into unified set of target tables. The pipeline is encapsulated by a system that combines large language models (LLMs) and statistical similarity techniques to classify and map incoming columns. LLMs infer the most appropriate target table, while string similarity measures compare column names against a library of known fields. Statistical profiling analyzes column data to calculate the median and standard deviation. These descriptive metrics are compared with distributions from known columns, and a weighted distance score is calculated to evaluate similarity.

The output from the pipeline is a standardized source-to-target mapping along with confidence scores that quantify the reliability of each column assignment. These mappings can be used to automatically generate ETL templates for integrating new client datasets.

Our approach aims to significantly reduce the time required to onboarding new data sources and improve transparency for analytics and records transfer.

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A Comparative Analysis of Political Bias in the Sourcing of Consumer-facing Large Language Models

Connor McLean, Business Management and Computer Science

Mentor(s): Jason Clark, MSU Library

AI chat bots are increasingly replacing traditional information gateways, so the need to determine any potential biases in these models is also increasing. This study provides a bias rating for 13 different open-source and proprietary large language models based on the sources they cite in response to news-based queries. Using Python-based batch querying, we submitted a news query dataset spanning 36 unique queries designed to emulate news questions with 100 iterations across three temperature ranges (0.1, 0.5 and 1.0) to each model while directing it to ground its responses using news websites as sources. This process yielded a dataset of 140,400 responses. We compared each source cited to AllSides' pre-classified political bias rating of news sources from left to right-leaning to establish the bias of each model based on the predominant leaning of their citations. Preliminary findings revealed that the majority of sources cited are center or center-left. Additionally, there was minimal difference between the open-source models and proprietary models tested. The resulting rating can be used to audit and correct potential bias present in any of the models tested. This would allow the increasing number of people who rely on AI to evaluate the models they use and account for any inadvertent or unknown biases present. Future research should include a historical analysis to establish longitudinal change of these models political leaning.

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A Quantitative Comparison of Hypermedia and the Model-Context-Protocol as Agentic Tool Architectures

Will Mitchell, Computer Science; Carson Gross, Computer Science; Zachariah Kraven, Computer Science; Stuart Kennedy, Computer Science; Matthew Revelle

Mentor(s): Carson Gross, Computer Science

As Large Language Models (LLMs) increasingly perform autonomous tasks, standardized protocols for agentic tool use are essential. This paper presents the first controlled, multi-vendor empirical comparison between Anthropic's RPC-style Model Context Protocol (MCP) and hypermedia (HTML and Markdown) as tool-use architectures. Using a custom framework over a synthetic train scheduling domain, we evaluated five state-of-the-art models on tasks of increasing complexity to measure token consumption, API call volume, and task success rates. Our quantitative results demonstrate that MCP is generally more token-efficient than hypermedia formats. This efficiency gap stems primarily from hypermedia's progressive discovery model rather than HTML's inherent verbosity; the necessity for multiple API calls geometrically compounds token consumption within the standard ReAct agentic loop. However, hypermedia proved significantly more robust across model variations. Two of the tested models struggled to conform to MCP's JSON-RPC requirements but successfully navigated the hypermedia interfaces. Furthermore, some models actively leveraged HTML affordances, such as form options, to bypass discovery steps and optimize their workflows. We conclude that while RPC-style protocols like MCP are currently more efficient for concatenative agent loops, hypermedia offers critical advantages in dynamic discoverability, late binding, and system resilience. Future adaptations, such as flattened hypermedia interfaces or plan-then-execute agent paradigms, may mitigate this overhead while preserving hypermedia's flexibility.

Acknowledgements: USP - Undergraduate Scholars Program

Bad Data, Real Consequences: Monitoring and Detecting Silent Failures in Healthcare Data Systems

Jada Zorn, Computer Science; Owen Cool, Data Science; Jordan Unzaga, Data Science; Kurtis Brennan, Data Science

Mentor(s): Ann Marie Reinhold, Computer Science; Clemente Izurieta, Computer Science

When a patient moves between hospitals or clinics, their healthcare records must follow. Unfortunately, transferring these records across health organizations is incredibly complex because different healthcare organizations store data in incompatible ways. For example, a patient’s name could be stored under “patientName”, “patient_name”, or even “memberName” depending on the system. These inconsistencies create significant challenges when records need to be transferred between organizations at scale. Central to this process is an ETL (extract-transform-load) pipeline, an automated workflow that extracts data from one location, transforms it by filtering, cleaning, and restructuring it into a consistent format, then loads it to its destination. When millions of records move through

these pipelines, failures and anomalies can result in inaccurate or missing patient data, with real consequences for care. To improve visibility in this process, our team developed a dashboard that presents pipeline statistics, trends, and tabular data in an accessible visual format. The prototype enables data engineers to monitor successes and failures, filter process outcomes, and better understand the causes of errors throughout the pipeline. By clarifying ETL behavior, the dashboard supports more accurate and efficient transfer of medical records between healthcare organizations, helping ensure patient data is reliable, consistent, and actionable for better care.

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EARTH AND ENVIRONMENTAL SCIENCE

Habitat Suitability Changes for the North American Bison

Jasper Blanchett, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Land Resources & Environmental Sciences

Climate Change poses an encroaching threat to the livable habitat available for North American Bison. Fossil records of bison can be traced back 40,000 years, when the atmosphere was 6 C cooler. From the previous fossils, it is estimated that bison body mass declines 41 kg per 1 C increase (Martin et al., 2018). The bison mass lost model can be combined with current climate prediction models to estimate the possible economic and geographic losses associated with various climate scenarios. Based on the RCP 8.5 climate scenario (zero climate intervention), feasible bison habitat is expected to shift 2,200 km northwest by 2100, leaving much of the contiguous US unsuitable for bison production (Shupinski et al., 2026). Results suggest that North-Central Montana is one of the few places within the lower 48 that will retain a suitable habitat for the North American Bison in 2100. However, in January 2026, the BLM revoked 63,000 acres of grazing permits given to the bison stewardship company; American Prairie. This decision was made on the basis that bison do not qualify as “livestock” under the Tayler Grazing Act (TGA) of 1934 (Cochenour et al., 2026). Although wild bison are technically found in the United States in national parks, state parks and protected reservations, they are not at liberty to migrate freely and are reliant on human management decisions. Both factors (exclusion from the TGA as livestock but the inability to migrate freely) leave bison in a state of limbo, teetering towards extinction. This research recommends that the TGA be rewritten to include bison as “livestock” to keep the animal thriving within the contiguous United States

Vote for Water: Why water policy is our most pressing challenge, and how to combat it

Isaac Buttery, Political Science

Mentor(s): Paul Lachapelle, Political Science

60 years is a conservative estimate for how long we have until persistent low to no snow winters become the new normal in the Western United States. Adaptation is critical, particularly as the West grows and water demand continues to rise. Upgrading inefficient infrastructure, committing to water-wise agriculture and landscaping, and most importantly, voting for water. The US needs legislators and politicians who are willing to implement strong water conservation policies that are backed by negative consequences. According to the Sao Paulo report, this is the most effective way to implement drought resistance policies. Furthermore, weather and water research stations should be moved to higher altitudes to more accurately predict the droughts that these policies will seek to combat. Backed by fines or tax penalties, these policies will help adapt to our changing future and further our knowledge of the problems we are rising to face.

Climate Financing Won't Stop Terrorism: But It Sure Can Prevent It

Gracie Caldwell, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

Political instability is strongly correlated with the presence of major international terrorist organizations. Factors such as war, famine, and government corruption- among other socioeconomic triggers- create conditions in which extremist groups can emerge and consolidate power. Environmental degradation driven by climate change appears to introduce a threshold effect in state fragility. In less severely affected environments, effective climate action is associated with increased political stability. However, in more heavily degraded contexts, government intervention and preparedness have no observable impact on stability. This divergence may reflect situations in which terrorist or criminal organizations have already provided state functions as a means of recruitment, or where government responses are perceived as insufficient. Based on this framework, countries with relatively lower climate vulnerability but high political instability may represent critical intervention points. Future research should aim to identify this "turning point", the stage at which environmental action no longer produces stabilizing effects. Pinpointing this threshold could help guide targeted diplomatic and development investments to prevent the emergence and entrenchment of terrorist organizations.

Economic Impacts of Drought and Extreme Heat on Montana Agriculture

Aspen Carlson, Political Science

Mentor(s): Paul Lachepelle, Political Science

Agriculture is a central component of Montana's economy and rural identity, but increasing climate variability poses growing risks to crop production. In 2024, drought and extreme heat caused significant agricultural losses across the United States. Montana experienced particularly severe impacts, with approximately $429 million in crop losses affecting major crops such as wheat, forage, and peas. These losses highlight the vulnerability of agricultural systems to changing environmental conditions. This project examines how climate-related crop losses may affect the long-term sustainability of local agriculture and food systems in Montana. Using publicly available reporting and agricultural loss data, this research analyzes the economic consequences of drought and heat events and considers their broader implications for local farms and regional food security. Preliminary findings suggest that smaller and mid-sized farms may be disproportionately affected by climate-related losses due to limited financial resources and infrastructure compared to large agricultural operations. As climate pressures increase, these challenges may accelerate agricultural consolidation and reduce the availability of locally produced food. Supporting local agriculture through drought-resilience programs, agricultural policy initiatives, and community food procurement systems may help mitigate these impacts and protect the long-term sustainability of Montana's agricultural economy.

Sustainable issues with Montana State University's Parking Systems

Maia Coe, Liberal Studies Degree

Mentor(s): Paul Lachapelle, Political Science

Montana State University (MSU) has a goal of Net 0 by 2030, yet its current greenhouse gas reporting excludes Scope 3 emissions, including those from commuting and campus parking. MSU's parking system operates through a lottery-based permit structure with limited availability, prioritizing access for higher-paying users while providing minimal incentives for low or zero-carbon transportation options such as EV, biking, public transit, or carpooling. As a result, commuting and parking on campus remain major contributors to campus emissions and reinforce inequities among students, faculty, and staff.

A Warming West: The Climate Crisis and the Decline of the Mule Deer Population

Chloe Cook, Political Science

Mentor(s): Paul Lachapelle, Earth Sciences

Over the past 30 years, mule deer populations in Montana have declined by more than 50% due to increasing environmental pressures and human development, resulting in ecosystem imbalance, biodiversity loss, and cultural impacts. While mule deer populations have historically fluctuated with severe winters and drought, recent data has continued to show an inconsistent downward trend. In response, the Montana Fish and Wildlife Commission implemented significant hunting regulation changes for the 2026–2027 seasons, including reduced nonresident tags and resident bag limits, which fails to address long-term large-scale habitat protection and land use delegation. An alternate proposal argues that long-term recovery requires a shift away from reliance on hunting regulations and a focus on habitat protection and strategic land-use management. Key strategies include protecting critical habitats, limiting and planning development, expanding conservation partnerships, and increasing public involvement. Management decisions will be guided by scientific data and input from diverse stakeholders, including biologists, hunters, landowners, and tribal governments. Funding will continue through the American System of Conservation Funding, supplemented by additional donation-based partnerships. The desired outcome is to stabilize and rebuild mule deer populations while promoting a sustainable balance between wildlife and human land use. This approach advances equity, equality, and environmental justice by ensuring inclusive, science-based conservation that benefits diverse communities and stakeholders.

Acknowledgements: USP - Undergraduate Scholars Program

Data Centers: Not Only Costly for You, but for the Environment, Too.

Ronan Edison, Political Science

Mentor(s): Paul Lachapelle, Political Science

Data center spending and construction are rising every year. Analyzing the costs and effects of data centers seems more pertinent than ever. Given that data centers are unlikely to disappear anytime soon, it seems important to make them more energy-efficient and environmentally friendly. Studies in recent years have shown that alternative data center practices can produce energy savings. Not only are data centers environmentally detrimental, but data center spending is correlated with increased electricity costs for residential and all sectors. Sources have shown with confidence that “new energy

infrastructure for data centers contributed to price increases in at least one region (the Mid-Atlantic)" (Walker & Goldsmith, 2026). If data centers really do contribute to higher electrical costs, Americans should expect that energy rates will steadily increase as data center spending continues. Data center investments, construction, and energy consumption all pose a potential threat to the environment and private Americans bottom line.

Threat of Oil and Gas in Montana

Sayge Felker, Political Science

Mentor(s): Paul Lachapelle, Political Science

This research presentation details the harm that occurs from oil and gas facilities to nearby residents. Living within a half mile of a facility exposes people to elevated levels of toxic pollution and health impacts. Currently, 14,084 Montana residents are living within the threat radius. This threat is in violation of Montana citizens rights under the Montana constitution to a clean and healthful environment under Article II and the states requirement to maintain and improve a clean and healthful environment under Article IX. The Montana DEQ is in the process of developing the Big Sky Emissions Roadmap and has citied that this act is meant to achieve emissions reduction through innovation, not regulation. However, this threat is violating citizens inalienable rights and in direct violation of the constitution. This direct violation needs to be addressed and requires stricter regulation of oil and gas facilities in Montana.

Impacts of snowpack drought in Montana

John Fitzgibbon, Political Science

Mentor(s): Paul Lachapelle, Political Science

Montana and much of the western United States are experiencing a severe snow drought this year, with snowpack levels across many Montana basins far below normal. Current data shows that the snow water equivalent (SWE) is ranging from 15 to 25% below the median for this time of year (National Integrated Drought Information System, 2026). In some areas, levels are approaching record lows, and approximately 46% of SNOTEL stations are reporting snow drought conditions, defined as SWE at or below the 20th percentile (NIDIS, 2026). Because mountain snowpack serves as a natural reservoir, storing water through the winter and releasing it gradually in the spring and summer, reduced

snowpack directly impacts the timing and availability of water. The effects of snow drought are already visible in southwest Montana, mainly around Bozeman. Lower snowpack has led to reduced streamflows in rivers such as the Gallatin (Muckway, A. 2024), which can stress ecosystems and limit water availability for agriculture and municipal use. In addition, earlier snowmelt, longer dry periods, and reduced water availability create significant stress on agriculture, fisheries, and surrounding ecosystems. These dry conditions also contribute to an increased chance of more frequent and severe wildfires, creating risks to both natural landscapes and human health. During my research the importance of early warning systems, enhanced monitoring, and clear communication of changing conditions came up frequently when considering what we can do to prepare for these seasons of drought. Tools like the National Weather Service alerts, state water dashboards, and NRCS snow survey data provide real-time information that can support decision-making. Access to accurate and up-to-date information helps communities stay ahead of snow drought conditions and make more informed decisions. I understand I am 30 words over I will fix this for my final draft.

Can Performance-Based Regulation Fix Montana's Energy Problem?

Ava Gross, Liberal Studies Degree

Mentor(s): Paul Lachapelle, Political Science

NorthWestern Energy is the dominant investor-owned utility in Montana. The company operates under a cost-of-service (COS) regulatory model that rewards capital investment, like large construction projects, over efficiency, clean energy, and consumer savings. This research examines how this COS structure actually drives over investment in fossil fuel infrastructure, raises customer bills, and prevents Montana from reaching its climate goals, ultimately making it structurally incompatible with the state's promise of a clean and healthy environment. I recommend that the Montana Public Service Commission adopt performance-based regulation (PBR) tools. This framework would tie a portion of NorthWestern's profits to outcomes such as emissions reductions, affordability, and renewable integration. Further recommendations include making the approval for large projects contingent on Northwestern's completion of full-resource alternative analyses to prove that they considered alternatives, expanding affordability protections for low-income customers, and improving public transparency and accessibility in rate cases through plain-language summaries and enabling online participation. The proposed regulatory framework is one in which utilities profit only when the community benefits.

Bark Beetles, Wildfires, and the Air We Breathe at MSU

Maya Hanlon, Political Science

Mentor(s): Paul Lachapelle, Political Science

Climate change is increasing bark beetle outbreaks across western forests, leading to widespread tree mortality and compounding wildfire risk. Bark beetles damage trees by disrupting nutrient flow and introducing fungi, and warmer, drier conditions make forests more vulnerable to infestation. This research draws on a 2025 study by Chen et al., which models how different climate scenarios and forest management strategies affect beetle-driven tree mortality and ecosystem services such as carbon sequestration, water retention, and timber production. The study projects annual tree biomass loss due to bark beetles from 2020 to 2100 under six scenarios, combining three climate conditions (historical, warmer/wetter, and hotter/drier) with two management approaches: business-as-usual and enhanced management. The results show that while climate conditions influence outcomes, enhanced management strategies, such as increased biomass removal and prescribed fire, consistently reduce tree mortality compared to business-as-usual practices. These reductions also correspond to avoided economic losses in ecosystem services, estimated between $20,000 and $800,000 annually. This research connects these findings to local impacts in Bozeman, Montana, where increasing wildfire activity and smoke exposure affect public health, including on the Montana State University campus. It highlights the need for institutional responses, such as improved indoor air filtration and monitoring, to better protect students and staff. Overall, the findings emphasize that proactive environmental management and local adaptation strategies are both critical in addressing the cascading effects of climate change.

The Importance of Land Trusts on Open Space

Kyle Hase, Agricultural Economics & Economics

Mentor(s): Paul Lachapelle

Open space across Montana has always faced pressures from housing developments, administrative policy changes, and private land acquisitions. In Gallatin County alone, over 67,000 acres of open space have been converted to housing since 2000, while proposed changes to the federal roadless rule threaten millions of additional acres of Forest Service land statewide. Through a synthesis of existing research and news reporting, this study examines the effectiveness of land trusts as a mechanism for preserving open space for public use. Findings indicate that land trusts play a significant role in permanently

protecting land from future development through the strategic use of conservation easements. The Gallatin Valley Land Trust serves as a key case study, having conserved 75,000 acres since its founding in 1990. Recent actions include placing the final stretch of the Bridger Ridge Trail under easement and permanently conserving 190 acres of generational agricultural land near South Cottonwood Creek. The results suggest that land trust organizations, operating through both public and private funding, offer an effective and durable solution to open space loss in Montana and the broader Mountain West.

Phenological Response of Vegetation to Drought Termination in the Shortgrass Steppe Ecosystem

Isaac Jensen, Land Resources & Environmental Sciences; William Weinberg

Mentor(s): Andrew Felton, Land Resources & Environmental Sciences

Annual productivity of plants is greatly influenced by the amount and timing of precipitation, and water-limited ecosystems are especially sensitive to rainfall dynamics. Future shifts in climate are likely to affect the water cycle by causing extreme drought and rainfall events (IPCC, 2024; Post et al., 2021). As a result, any future changes in precipitation patterns may have significant effects on plant communities such as those of the shortgrass prairie (Ojima et al., 2021). This project aims to investigate potential relationships between precipitation variability and the phenology of vegetation following periods of drought in the shortgrass prairie region of North America's Great Plains. Two grassland experiments located in northern Colorado have generated data related to plant phenological responses to variation in the timing and quantity of precipitation. This data will be used to test correlations between precipitation variability and community composition, plant biomass, and plant greenness over time. Pairwise relationships between these variables will then be scaled up to create a model predicting community composition across the shortgrass step ecosystem using Landsat imagery as well as ArcGIS Pro and ENVI software. Findings from this project will help researchers more accurately predict the impact of climate change on drylands ecosystems, which will be crucial for establishing more effective land management and conservation practices as extreme climate events become more common.

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The End of the Caribou?

Benjamin Langer, History & Philosophy

Mentor(s): Paul Lachapelle, Political Science

Climate change - Amplifies disease by pressuring cervid habitats and different environments resulting in higher spread of disease. Diseases like C.W.D are rapidly spreading amongst cervid populations according to annual reports (See figure 1). Evidence suggests that climate change influences CWD due to the increased global temperatures, more extreme weather events (wildfires, drought, harsh winters), and applies pressure to the environments of cervid populations leading to isolated populations that can be fully afflicted by C.W.D. Chronic Wasting Disease- Poses a threat not only to the populations it has already affected but to those it has not reached, particularly the Caribou. A growing concern amongst biologists consider that the consequences of CWD transferring to Caribou would be detrimental to the Northern Cervid populations. Outcomes?- As of todays' standard, of practice The Method of culling or eradication, according to the Ecological Society of America, has proven to be the only effective solution for dismantling the disease in some populations of cervids. Other-wise the disease is 100% fatal. As trends of Cervids continue to move northwest along with them will be disease. Reducing climate change and its effects on existing cervid habitats are essential to eliminate this threat caribou face in the near future. Tribes of the Northern Territory's that rely annually on Cervid harvests are facing food security risk as well. (Arctic Research Foundation 2018)

Acknowledgements: USP - Undergraduate Scholars Program

Adaptive Reuse

Kylie Macdonald, Education

Mentor(s): Paul Lachapelle, Earth Sciences

Adaptive reuse, also known as brownfielding, is the practice of repurposing abandoned or underused buildings and land instead of constructing new developments. While current policies offer incentives such as tax credits and grants, these programs are optional and do not prioritize reuse over building on undeveloped land. This project examines the environmental and economic benefits of adaptive reuse and considers whether it should be required before new development is approved. Research shows that demolition and new construction produce significantly higher carbon emissions due to material production, transportation, and energy-intensive building processes. Studies from the Carbon Leadership Forum suggest that adaptive reuse can reduce carbon emissions by

approximately 50–75 percent compared to new construction. In addition to environmental benefits, reuse can also reduce costs by limiting material use, minimizing infrastructure expansion, and decreasing site preparation. Despite these advantages, many redevelopment programs focus primarily on historic preservation rather than all underused spaces, leaving many viable properties unused. This poster argues that adaptive reuse should be treated as a priority in development decisions. Mandating the reuse of vacant or abandoned spaces before allowing construction on undeveloped land could reduce emissions, lower costs, and promote more sustainable land use. Overall, adaptive reuse represents a practical strategy for balancing development with environmental responsibility.

Implications of a Snowless World

Helena Mazzarella, Land Resources & Environmental Sciences; Jasper Blanchett, Land Resources & Environmental Sciences; Anneka Thompson, Land Resources & Environmental Sciences

Mentor(s): Tony Hartshorn, Land Resources & Environmental Sciences

Snowpack is incredibly important for water resources, tourism and the economy, and wildfire prevention in many snow dependent systems. Increasing yearly average temperatures have a direct correlation with decreased snowpack. Bozeman's water supply heavily depends on snowmelt from Hyalite Canyon and the Bridger Mountain Range, and there are certain management techniques that can affect the timing of melting and the amount of snowfall. Changes in Bozeman’s water supply has vast implications for much of the United States due do Montana’s location at the top of the Missouri watershed. Snowpack characteristics such as total accumulation, snowpack duration, melt time, and shifts from snow to rain are inextricably linked to environmental, agricultural, and community health. As increased temperatures have been linked to anthropogenic activity, is there a way we can change our fingerprint to protect our snowpack? This project explores implications of snowpack management techniques, public perception of snowpack importance, and actionable changes to help keep mountain environments as reliable water storage systems.

Acknowledgements: LRES Department

How can adaptive fishing regulations mitigate the impacts of climate change on Arctic Grayling and cold-water fisheries in Southwest Montana?

Timothy McLain, Political Science

Mentor(s): Paul Lachapelle, Political Science

Cold-water fisheries in Southwestern Montana have been experiencing rapid declines in trout and grayling populations due to rising stream temperatures, reduced discharge, and cumulative environmental stress. Southwestern Montana also hosts the last fluvial Arctic Grayling population in the contiguous United States, found in the Big Hole River. Historical monitoring demonstrates that, specifically, the Big Hold, Beaverhead, and Jefferson Rivers, as well as the state as a whole, are experiencing temperatures that routinely exceed the 70-degree Fahrenheit threshold, which leads to increased metabolic stress, hypoxia, and elevated mortality risk for native salmonoids and fluvial grayling. Long-term population assessments indicate sharp declines in trout recruitment and severely depressed Arctic Grayling populations. A synthesis of peer-reviewed and grey literature identified convergent trends and consilience in hydrology, physiology, and effective management strategies, revealing that current conditions and management strategies are both detrimental to the long-term success of native fish populations and inadequate at addressing and mitigating such persistent conditions. Evidence suggests that adaptive management strategies for Montanas threatened cold-water fisheries, such as mandatory river closures when water temperatures exceed 70 degrees, narrower windows for hoot owl regulations, mandates of barbless hook only fishing, and the continuance of seasonal spawning closures are necessary for the continuance of these fisheries even in their currently degraded state, and must be implemented to return to a healthy state. Firmly implementing these strategies can help to sustain native populations while preserving the ecological, cultural, and economic value of Montana's cold-water fisheries.

A County-Level Wildfire Mitigation Strategy for Gallatin County, Montana

Jesse Meyer, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle,

Gallatin County faces intensifying wildfire risk driven by declining snowpack, longer fire seasons, and residential development expanding into wildland-urban interface areas. As climate conditions amplify fire behavior across the western United States, suppression-only approaches are no longer enough to protect communities, ecosystems, or firefighters.

This research is based on a synthesis of peer-reviewed literature, government reports, and local planning documents to source evidence-based mitigation strategies for Gallatin County. The U.S. Forest Service is already proposing a 7,905-acre fuel treatment project

within the Bozeman Fireshed, which is ranked among the 250 highest-risk in the nation; yet county-level action on planning and preparedness has not kept pace.

Three strategies are recommended. First, Gallatin County should coordinate with Montana DNRC and local fire districts to extend fuel reduction beyond federal forest boundaries; mechanical thinning combined with prescribed fire reduces wildfire severity by up to 72% compared to untreated areas (Davis et al., 2024). Second, the county should integrate wildfire risk mapping into subdivision review, attaching mitigation conditions to future development approval, an approach supported by Montana planning law, though constrained by statutory limitations neighboring states have begun to address. Third, targeted expansion of Ready Gallatin through Firewise USA certification and updated WUI evacuation planning would strengthen community resilience.

Together, these strategies can reduce fire intensity, lower suppression costs, improve firefighter safety, and ensure growth in Gallatin County happens in a fire-adapted manner.

Maintaining a Comfortable Environment

Owen Minton, Mechanical & Industrial Engineering

Mentor(s): Paul Lachapelle, Political Science

As global temperatures rise, air conditioning has become essential for indoor comfort and productivity, driving a massive surge in global energy demand. Developers around the world lack sufficient motivation to buy efficient units, and currently opt for the least efficient air conditioners available on the market, worsening the magnitude of energy consumption beyond what is necessary. In Montana, the environment and outdoors are one of the most prominent features of the local culture. To preserve the environment, we need to be more diligent when regulating what will harm it. By synthesizing global energy demand and emissions projections from Our World in Data, this research evaluates the environmental cost of inefficient cooling and proposes localized policy interventions. The City of Bozeman should raise the efficiency standard of HVAC systems, ensuring that we do not ruin the survivability of our climate while still maintaining indoor comfort. ASHRAE Standard 189.1 provides a regulatory framework for local governments to mandate sustainable practices in: commercial buildings, industrial buildings, or high-rise residences. The City of Bozeman should adopt ASHRAE Standard 189.1 and ensure that developing businesses practice sustainability in their construction as the city continues to grow. This standard will ensure industrial and commercial buildings are sustainable from construction to operation, encompassing broader environmental issues such as water consumption and ensuring applications of renewables.

Determining the Accuracy of Buffer-Based Lime Requirement Estimations for Montana Soils

Rowyn Morehouse, Land Resources & Environmental Sciences

Mentor(s): Joao Souza, Land Resources & Environmental Sciences

The Current Western State Soil Laboratory methods suggest the use of the Shoemaker-McClean-Pratt (SMP) buffer to determine lime rate requirements for acidified soils. However, the SMP buffer creates hazardous waste that is difficult to dispose of, and was developed in southeastern states like North Carolina. Southeastern states' soils are chemically very different from arid Montana soils, making it unlikely that SMP provides an accurate estimation of lime requirements.

By conducting a lime incubation experiment to determine lime rates, I will create a regression curve that I can compare the accuracy of 4 different buffer tests against. Thus, determining the most efficient buffer test for Montanan soil labs. The lime incubation was conducted by taking 5 acidified soils from across Montana. The soils were then incubated with 5 lime treatment rates (0, 1, 3, 6, 15 tons per hectare effective calcium carbonate equivalent. Each treatment was replicated 3 times. Pots were incubated at field capacity for about 90 days. This incubation provides an empirical reference for the lime requirement of the soils, allowing for direct comparison with buffer-based predictions.

Each soil will be tested using 5 buffer-based methods (SMP, Sikora, Woodruff, Modified Mehlich, Adams-Evans). Protocols for each buffer will be followed on an individual basis. Buffer method predictions will be compared to incubation- derived lime requirements to assess accuracy

This work aims to determine whether a more precise, less hazardous buffer test can replace SMP in regional soil laboratories. Improved LR estimation would support more cost-effective lime recommendations for Montana farmers and contribute to better long-term soil health management across the state.

Acknowledgements: USP - Undergraduate Scholars Program, Roseanne Wallander

Gallatin River: Current Pollution and How to fix it

Samuel Nay, Political Science

Mentor(s): Paul Lachapelle, Political Science

The Gallatin River, one of the most pristine trout rivers in the continental United States, has been experiencing significant changes in water composition and temperature, resulting in an invasive algae bloom. This algae bloom first emerged in 2018, when warm water and elevated N+N levels created optimal conditions for its growth in the Gallatin (Gardner & Buban, 2024). In the following years, many studies have been performed to assess the effects of pollution on the Gallatin, as well as the algae's effects on fishing, through aquatic insect life. Through these studies, we have learned that the current rates of N+N levels seem to be attributable to sewage leakage from various sources around the town of Big Sky, leaching their way into the water through the West Fork of the Gallatin River, where the algae bloom is most prevalent today (Meyer, 2023). We have also learned from these studies that the impact both raising water temperatures and increasing N+N levels are having on the Gallatin is not irreversible, with the most vulnerable of aquatic insects indicating that species rehabilitation is attainable (Birrell & Frakes, 2025). While these reports have indicated that fishermen should be optimistic because aquatic insect populations within the Gallatin are relatively healthy now, with no current indication of species decline, they do not indicate that these aquatic insects will be able to withstand more pollution of their environment (Birrell & Frakes, 2025). Birrell, J. H., & Frakes, J. I. (2025, July).

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How Extinction Distorts Our Understanding of Trait Evolution

Carden Nerem, Earth Sciences; Sunay Bhatt, Earth Sciences; Emi Bender, Earth Sciences

Mentor(s): Chris Organ, Earth Sciences

Studies of adaptation and evolution commonly employ phylogenetic comparative methods. However, comparative datasets use exclusively extant species data, despite evidence that incorporating fossil data yields better results. Despite the prevalence of this bias, its effects on recent methods that model rate variation in trait evolution have not been

systematically evaluated. This project aims to assess the impact that extinction has on our inferences of rate variation among traits by simulating phylogenetic trees and trait data under a uniform Brownian Motion model, where evolutionary parameters are known and controlled, and then analyzing these datasets in BayesTraits under two conditions: total-data and extant-only, where fossil species are removed. Also, we will compare results to two mammalian datasets from the literature, an Afrotheria and a Rhinoceros. By comparing the results of these analyses, we look to assess whether a systematic bias exists and to quantify the effect that extinction plays on estimation rate variation for trait evolution. The insights gained from this investigation will advance the development of statistical strategies that account for persistent extant bias in comparative data.

Acknowledgements: USP - Undergraduate Scholars Program

The role of vegetation phenology in grassland vulnerability to extreme drought

Blake Nestor, Land Resources & Environmental Sciences; William Weinberg, Land Rehabilitation and Environmental Science

Mentor(s): Andrew Felton, Land Resources & Environmental Sciences

Growing evidence suggests that in years of extreme drought, patterns of increased Carbon Dioxide uptake emerge during the cooler border seasons, with decreased Carbon Dioxide uptake during the drier summers. Carbon dioxide is often used as a proxy for ecosystem health, and is therefore important for understanding phenological dynamics. To better understand the vegetation phenology's role in shaping grassland vulnerability to extreme drought in the Northern Great plains, large-scale remote sensing observations are synthesized to create usable data for the region. Data collected included precipitation and temperature climate data, as well as gross primary productivity (GPP) and net primary productivity products (NPP) from MODIS. The data was synthesized through a twenty-three year period from 2000 to 2023. Preliminary results indicate a difference between drought year's GPP (for spring, summer and fall) and the average year's GPP. The results indicate a trend in compensation of border seasons.

Acknowledgements: USP - Undergraduate Scholars Program

A Data-Driven Model for Dry Snow Metamorphosis

Jerry Nye, Physics

Mentor(s): Robyn Gotz, Earth Sciences

For decades, the mysteries of persistent weak layer avalanches have plagued backcountry recreationalists and mountain communities. However, with modern modeling and snow pit stratigraphy techniques, it is possible to build a data-driven model that could predict when and where in a snow pack a weak layer is going to form. Using the large-scale data collection from NASA's SnowEx 2020 and 2023 Intensive Observation Periods, we attempted to overcome the inherently chaotic nature of snow and develop models that can take any snow pit and predict how it will change. This data was processed as a one-dimensional system and modeled using linear ODEs. Alternative methods for extracting information from this data include training a neural network on the data to uncover unseen trends. Successful implementation of this model would allow recreational users to input snow pit data and receive a prediction for what layers will round and facet over the coming days, and better be able to plan higher consequence objectives.

How is Climate Change Increasing Wildfire Risk in Montana?

Charley Palm, Political Science

Mentor(s): Paul Lachapelle, Political Science

Montana is experiencing higher temperatures, longer fire seasons, and more frequent drought conditions. These environmental shifts have resulted in a rise in the size and intensity of wildfires. This poses a threat to Montana's ecosystems, public health, and local economies. My research synthesis explores how climate change is influencing wildfire in Montana, as well as policy solutions to mitigate wildfire risks. This is from a culmination of peer-reviewed literature and government reports on wildfire trends, climate data, and land management practices. Findings indicate that rising temperatures, earlier snowmelt, and fuel accumulation from historical fire suppression are all elements that have intensified wildfire conditions. Mitigation efforts through policy could include expansion of prescribed burns and improving land-use regulations. This research concludes that proactive policy can significantly improve Montana's capacity to adapt and mitigate long-term impacts, despite the continuation of climate change's impact on wildfire conditions.

The Impact of Climate Change on Bee Populations and How Policy Can Help

Siena Quesada, Political Science

Mentor(s): Paul Lachapelle, Political Science

When examining the impacts of climate change, insects are often overlooked. However, pollinators, specifically bees, are a critical component to the production of food for humans. Climate change is becoming a greater threat to most bee populations. This is mostly due to land-use factors which impact the ability of Bees to adapt to climate change (Ganuza et al., 1, 2022). As well as increased temperatures/heat due to climate change. A risk that comes from climate change is increased temperatures affecting flight patterns. Flight pattern changes are causing more colonies to fail. (Rajagopalan et al., 1, 2024). Montana State University's campus can work with students to create policy solutions for this problem. On campus, there can be efforts small or large that help conserve the local bees of Bozeman. We can continue to fund research of bees on campus, place more beehives on the main campus, and work with the Gallatin Pollinator Initiative (GPI). The GPI provides free seeds with plants that feed pollinators and increase their chance of survival. If climate change drastically impacts bees, humans will feel their effects. Creating change and policy can help put measures in place to conserve bees and other pollinators.

Wildfire Risk

Abigail Ruddell, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

Researchers and planners may use GIS technology to map wildfire risk in Gallatin County. By combining environmental and spatial data, GIS technology can use factors such as vegetation type, slope, elevation, temperature, precipitation, humidity, wind speed, and how close the fire may be to roads or buildings. This information allows for pre-fire planning and helps researchers identify where wildfires are most likely to start and how quickly they might spread. Wildfires are an increasing threat to ecosystems and environments. Over the past decade, both the frequency and size of these events have increased and are projected to continue rising over the next three decades. Recent estimates from First Street Technology, Inc. indicate that 98% of properties in Gallatin County may face wildfire risk within the next 30 years. (First Street Technology, Inc, 2026) Using GIS models allows for a better understanding of these risk levels in accessible formats such as color grading, numerical grading, or proportional symbols. This makes it easier for decision-making agencies to develop mitigation and response strategies. Recent research has taken into account factors beyond the typical physical and environmental risk factors. Socioeconomic factors such as education, housing conditions, and demographic characteristics are now being considered as factors in both exposure and recovery

capacity (Lambrou & Kolden, 2023). This new perspective offers more insight into understanding the lasting impacts of wildfires.

Montana's Nutrient Standards Rollback: Implications for Water Quality and Ecosystem Health

Macy Schmidt, Land Resources & Environmental Sciences

Mentor(s): Paul Lapachelle, Political Science

In October 2025, Montana legislature approved House Bill 664 with the support of Montana DEQ and the EPA. This bill repealed numeric nutrient standards for Montana rivers, giving agricultural industries and wastewater treatment plants more latitude when it comes to discharging contaminated wastewater into Montana's rivers and streams. In place of the long-standing numeric standards, a more subjective narrative standard will be adopted. The passing of this bill will deepen the potential for further nutrient pollution of Montana rivers and streams. As nutrients such as nitrogen and phosphorus are introduced in excess to aquatic systems, processes like nitrification increase both in frequency and severity, leading to harmful ecological disruptions such as algal blooms. These processes alter nutrient cycling and restrict oxygen in the water, causing decreased water quality and impaired food and habitat structures for aquatic organisms. The purpose of pollution standards is to mitigate the amount of added nitrogen and phosphorus on aquatic ecosystems. Numeric standards have been successful in this as they are well researched, clearly established, and explicit in their expectations. Narrative standards, on the other hand, leave more room for interpretation, and do not set a clear precedent for environmental expectations. This shift in pollution standards has the potential to lead to a myriad of issues, ranging from habitat degradation for aquatic organisms to decreased drinking water quality and economic costs for local communities. Ultimately, this policy shift highlights the need for strong, clearly defined pollution standards to better uphold environmental protections in Montana legislature.

Assessing durophagy in the amphicyonid Daphoenictis from the Pipestone Springs Locality, Montana, USA

Ryanne Stoddard, Earth Sciences; Donald Lofgren, John Scannella, MSU Earth Science

Mentor(s): John Scannella, Earth Sciences

The middle Chadronian Pipestone Springs locality of the Renova Formation in Jefferson County, Montana, preserves a diverse assemblage of mammals, including marsupials, rodents, and carnivorans. Carnivora reported from the area include members of the Amphicyonidae, a family of “bear-dog” carnivores known from middle to late Eocene (42-5.3mya) deposits in North America, Eurasia, Asia, and Africa. In 1994, a left mandible with lower molars m1-2 of a carnivoran (Museum of the Rockies [MOR] specimen 1304) was discovered at the Pipestone Springs Locality. Examination of the m1-2 and comparisons with the carnivoran literature indicate that MOR 1304 represents the first confirmed specimen of the amphicyonid Daphoenictis from the locality. Previous descriptions of Daphoenictis suggest that the linearly aligned talonid of the m1 and blunt protoconid and talonid of the m2 were used for durophagy (bone-crushing behavior). However, the “cat-like” linear alignment of the elevated cusps on both molars suggests a specialized shearing action which contradicts the interpretation of bone-processing behavior and complicates interpretations of feeding ecology in this taxon. To further evaluate functional morphology, MOR 1304 was microCT scanned to analyze root morphology and potential microwear. The findings of this analysis may provide new insights into amphicyonid functional morphology and enhance our knowledge of Eocene carnivoran diversity and adaptive strategies.

Acknowledgements: USP - Undergraduate Scholars Program

Facilitating a Responsible Renewable Energy Transition

Anneka Thompson, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

As climate change accelerates and the need for emission reduction increases, scientists, policymakers, and the public are calling for a rapid transition to renewable energy sources. Yet renewable energy sources require critical metals and minerals such as copper, nickel, lithium, and cobalt for electric vehicles, solar panels, wind turbines, and grid-scale battery storage. Current reserves and operational mines are insufficient to meet the scale of a global energy transition (Fu et al., 2025), and demand for key minerals is projected to increase, making new mineral extraction effectively unavoidable to meet decarbonization goals. However, mining poses significant threats to ecosystems, biodiversity, water systems, human health, and Indigenous communities (UNEP, 2024). New mining initiatives must occur equitably and responsibly in order to truly create a clean energy source (NASEM, 2024). This review examines the policies, regulations, and techniques necessary to facilitate a responsible energy transition without sacrificing social and ecological integrity. Topics covered include circularity practices, community engagement and benefit

frameworks, and environmental safeguards. Together, these approaches offer a pathway toward a mineral supply chain that is not only sufficient for decarbonization, but equitable and environmentally sound.

Unexpected microbial uniformity in Rocky Mountain soils

Anneka Thompson, Land Resources & Environmental Sciences

Mentor(s): Anthony Hartshorn, Land Resources & Environmental Sciences

Soils are hubs of microbial abundance and diversity driving critical ecosystem processes, and shifts in microbial community composition are closely linked to changes in soil health and ecosystem functions. Soil properties such as pH and organic matter are well-established drivers of community composition, consistent with the principle that the local environment selects for microbial community structure. Underlying rock type, or "parent material," largely shapes these soil characteristics, yet its relationship to soil microbial communities remains poorly understood. This raises questions about whether community composition varies predictably across soil types and whether indicator taxa exist for specific parent materials. This study builds on Sugden's (2015) master's thesis characterizing the effect of parent material on soil physical and chemical properties across a lithosequence of five forest soils near Langohr Campground in Hyalite Canyon, MT, providing a natural pH gradient. Samples were collected from four of Sugden's sites and MSU's Post Farm, representing five parent materials: Archean gneiss, Flathead sandstone, Wolsey shale, Absaroka volcanics, and loess. PCR sequencing of 16S rRNA gene amplicon sequencing was used to characterize community composition across sample site and soil horizon. Sample site accounted for 28% of variation, horizon for 9%, and 62% remained unexplained. The volcanic soil appeared to have the most microbial specificity, while the claystone soil exhibited the least. The phylum Verrucomicrobiota and the order Solirubacterales appeared most indicative of soil type. Overall, community composition was far more similar across sampling site than expected, indicating that other factors are driving microbial differences among these soils.

Acknowledgements: USP - Undergraduate Scholars Program

Your Closet is Killing the Planet

Leah Tinjum, Bracken Center

Mentor(s): Paul Lachapelle,

Fast fashion has reshaped the clothing industry by prioritizing speed, low cost, and rapidly changing trends. The term, popularized by The New York Times in the 1990s, reflects a production model in which companies like Zara or H&M can move designs from the drawing board to store shelves in as little as fifteen days. While this model satisfies consumer demand, it has significant environmental consequences. Fast fashion accounts for approximately 10% of global carbon emissions and places a heavy strain on water and energy resources. Environmental harm continues after purchase, as washing synthetic garments releases an estimated 500,000 tons of microfibers into the oceans annually, equivalent to 50 billion plastic bottles. As consumer culture grows, emissions from the fashion industry are projected to rise, reinforcing a cycle of overproduction and waste. This research examines the environmental impacts of fast fashion and explores sustainable alternatives, including "slow fashion," which promotes higher-quality, longer-lasting clothing, and circular systems that encourage reuse through thrift stores and online resale platforms. Ultimately, reducing the industry's harmful effects requires both systemic changes and shifts in consumer behavior toward buying less and extending garment lifecycles.

Co-evolution of Brood Size and Parenting in Reptiles and Birds

Andrew Victorino, Earth Sciences

Mentor(s): Chris Orga, Earth Sciences

This project investigates the evolutionary trade-off between offspring number (clutch size) and parental investment within the group Sauropsida—encompassing reptiles, birds, and their extinct relatives. While avian dinosaurs (birds) have extensive parental care, non-avian reptiles display a spectrum of behaviors from neglect to complex nest-guarding. The fossil record offers only rare snapshots of these behaviors in extinct dinosaurs, making broad conclusions difficult. To address this, I am performing a mathematical analysis to find a measurable connection between physical reproductive traits and behavior.

Using comprehensive global archives like ReptTraits and BIRDBASE, I have compiled a database of over 18,000 living species to analyze clutch size, body mass, and parental care. I am employing Bayesian phylogenetic modeling to test the hypothesis that a reduction in relative clutch size is a reliable predictor of complex parental care, after accounting for millions of years of shared evolutionary history.

The resulting numerical model will be applied to extinct groups, such as non-avian theropod dinosaurs, to infer the likelihood of specific behaviors based on fossilized clutch sizes. This research aims to move beyond descriptive comparisons, providing a robust,

odds-based framework for reconstructing reproductive behavior in dinosaurs and understanding the evolutionary origins of the complex social behaviors seen in modern birds.

Acknowledgements: USP - Undergraduate Scholars Program

Range Expansion, Disease Risk, ad Forest Mortality in a Warming Climate

Madison Wellman, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

Rising temperatures associated with climate change are facilitating the northward expansion and extended life cycles of migratory insect species in Montana[12]. This educational infographic examines the ecological and public health implications of two underrecognized invasive species: the blacklegged tick (Ixodes scapularis) and the mountain pine beetle (Dendroctonus ponderosae).

First identified in Montana in late 2024[3], the blacklegged tick is a primary vector of Lyme disease, posing increasing risks to both human and animal populations. Even at low densities, this species has significant epidemiological implications due to its ability to transmit pathogens that can lead to chronic and debilitating illness[4].

Simultaneously, the mountain pine beetle continues to expand its range and reproductive window under warmer conditions, intensifying forest disturbance across millions of acres. By boring into tree bark to reproduce, these beetles disrupt phloem transport, leading to widespread tree mortality. This large-scale forest loss reduces wildlife habitat, alters hydrological processes, and increases susceptibility to severe wildfires[5].

Current management strategies include surveillance, monitoring, and public education for tick-borne diseases[6], alongside silvicultural treatments, pheromone applications, and insecticide use for beetle control[7]. However, these responses are largely reactive. This work emphasizes the need for proactive, accessible public education focused on species identification, prevention strategies, and ecological awareness. Increasing public engagement is critical to mitigating the cascading environmental and health impacts associated with climate-driven species expansion in Montana.

Plant Species in the McDermitt Caldera and Their Relationship to Soil Geochemistry Through Remote Sensing

Skylar Wildman, Department of Earth Sciences

Mentor(s): Dr. Anna Schweiger, Department of Land Resources and Environmental Sciences, and Dr. Madison Myers, Department of Earth Sciences

This study investigates the relationship between plant species geochemistry and soil composition in the McDermitt Caldera region of Nevada and Oregon, an area known for its high concentrations of lithium and other heavy metals. Remote sensing techniques such as imaging spectroscopy, including data from the Earth Surface Mineral Dust Source Investigation (EMIT), provide large-scale geochemical mapping but are limited by mixed pixels that contain vegetation, soil, and rock. Previous research suggests that Great Basin sagebrush (Artemisia tridentata) may reflect the elemental composition of the soils in which it grows. This study evaluates whether Great Basin Sagebrush and Rubber Rabbitbrush (Ericameria Nauseosa) can serve as indicators of soil geochemistry in the McDermitt Caldera. Plant samples from the McDermitt Caldera were cataloged, processed, and analyzed using spectral measurements and Partial Least Squares Regression (PLSR) models, with chemical validation conducted through laboratory analysis. Relationships between plant, soil, and rock chemistry were assessed using statistical modeling in R. Wider applications from this research involve enhanced understanding of plant-soil geochemical interactions and the use of vegetation in remote sensing for mapping mineral resources.

Acknowledgements: USP - Undergraduate Scholars Program, Drs. Schweiger and Myers

ECOLOGY

The Distribution of Bison Wallows in the Mixed Grass Prairie of North-Central Montana

Leif Brandsness, Ecology; Claire Bresnan, Ecology; Hila Shamon, Smithsonian's National Zoo and Conservation Biology Institute; John Olson, Ecology; Jesse Boulerice

Mentor(s): Scott Creel, Ecology

As ecosystem engineers, plains bison (Bison bison bison) shape their environment and increase overall landscape heterogeneity through intensive grazing and wallowing. Wallowing is when bison roll on their backs and sides, creating bare depressed patches of soil. The subsequent wallows have been shown to provide habitat for many organisms including insects, amphibians, and flowering plants. Despite their importance to

landscape heterogeneity, it is not well understood what factors influence wallow distribution across landscapes where bison are present. Our study took place in two fenced bison pastures in north-central Montana managed by American Prairie, an NGO restoration of bison to private nature reserves. We collected drone imagery from 45 randomly selected 500x500 meter plots across the two management units. We annotated the imagery in ArcGIS Pro to identify locations and characteristics of wallowing sites. The drone imagery was then used to calculate bison wallow density. We analyzed the relationships between wallow density, environmental characteristics, and bison movement behavior. The environmental characteristics included presence or absence of other mammal species, slope, and land cover. We estimated bison intensity of use with occurrence distributions generated using the CTMM package in R from movement data from over 100 GPS ear tagged bison. These results improve our understanding of where wallows are distributed across the landscape. By uncovering the relationships between bison wallows, environmental characteristics, and bison behavior, we can better predict where and to what extent bison reintroductions will impact landscape heterogeneity.

Acknowledgements: USP - Undergraduate Scholars Program

Examining significance of human disturbance on nest selection in Great Gray Owls (Strix nebulosa) in Southwest Montana using an RSF Model

Tori Flath, Ecology

Mentor(s): Justine Becker, Ecology; Arcata Leavitt, Ecology

Great Gray Owls (Strix nebulosa) are one of the most understudied raptor species in North America. In Montana, there is currently no peer-reviewed research about the species, and many aspects of the species' ecology are not well understood. In this study, we aimed to quantify the effect of human landscape disturbances (roads, trails, recreation sites) on Great Gray Owl nest selection in southwest Montana. We used ten known nest sites with breeding attempts in the last five years that were identified by wildlife managers in southwest Montana. We then used a resource selection function to compare the human disturbance covariates between the used nest sites and randomly generated available points. We used a forward stepwise model selection approach to determine which combination of human disturbance variables best explained the observed data. We found that Great Gray Owls selected for nest sites in areas with higher trail density but found no support for an effect of roads or recreation sites on nest site selection. Latent habitat covariates such as trail construction creating gentler slopes with mixed open/forested areas, or the small sample size could have contributed to the observed results. The

positive relationship with trail density could also be attributed to owl nests being more likely to be found near trails than in less accessible areas. Future research using a larger sample size and exploring the effects of intensity of trail use would be valuable to further evaluate the effects of human disturbance on nest selection.

Acknowledgements: McNair Scholars Program

Spatiotemporal variation of plant phenology and forage quality and their effects on elk migration in the Greater Yellowstone Ecosystem

Brooke Fonnesbeck, Danielle Ulrich, Emelia Morgan, Department of Ecology

Mentor(s): Danielle Ulrich, Department of Ecology

The seasonal migration of ungulates often follows peak vegetation growth throughout a region; however, with climate change affecting season durations, the different timing of peak vegetation may influence migration paths over time. To better understand how forage quality can influence migration, we asked the questions: (1). How does Chlorophyll A content vary seasonally? (2). How does Chlorophyll A content vary across an elevational gradient? The study area, the Paradise Valley region of the Greater Yellowstone Ecosystem, was broken into classes based on elevation, average start of season growth rate, and previous elk migratory movement, including early (1,231-2,134m), middle (2,134-2,438m), and late (2,438-3,453m). We then sampled from these groups in predetermined locations during June-September. Quadrant sampling methods were used to collect vegetative samples, which were subsequently prepared for Chlorophyll A analysis. Forage quality was determined using a spectrophotometer. Chlorophyll A concentration significantly greened-up throughout the course of the growth season ($p = 0.0116$). There was a month-elevation interaction driven by the middle elevation class ($p= 0.0003$), as well as a late-season peak. Our findings were consistent with the presence of delayed peak green-up, as the largest difference in Chlorophyll concentration occurs between June and September ($p= 0.0095$). With this, we can evaluate the behaviors of migrating elk. Elk may prefer to first forage on early elevations as the Chlorophyll content becomes stable early, then there may be a pull to follow the green-up into middle elevations. By building effective methods in vegetation mapping, we will better understand ungulate migration patterns and how to manage migrating populations in an ever-changing landscape.

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Distance Sampling to Estimate Bozeman's Urban Deer Density

Makayla Gilbert, Ecology

Mentor(s): Justine Becker, Ecology

Recently the frequency of deer-vehicle collisions has increased within Bozeman, Montana. A high white-tailed deer (Odocoileus virginianus) population has become hard to ignore in southeast Bozeman, contributing to the concerns of Chronic Wasting Disease's recent appearance within city limits. 10 samples have returned positive since its initial detection in December 2025. These factors have prompted the City of Bozeman to request a population estimate of the white-tailed deer within Bozeman's city limits. While distance sampling is a common sampling method to estimate deer densities, there are limited studies measuring deer densities with this method in urban environments. In part of developing a new management plan for this urban population, we mimicked Helena, Montana's distance sampling protocol of conducting counts along road transects. On December 11th and 12th, two trucks covered 13 road transects of varying lengths during the last three hours of daylight. The transects were divided equally between the two trucks, then herd size, distance to the herd center, and the initial angle of detection were measured from observers within the trucks. This information was then put through an analysis in RStudio to estimate urban deer density. The results of this methodology suggest a need for longer/more road transects or hierarchal modeling to account for the uncertainty produced from a couple very large herd detections. Regardless, a very large deer density was observed, and the resulting estimates and methodology are expected to contribute to an upcoming urban deer management plan.

Acknowledgements: Montana Fish, Wildlife & Parks

Taphonomic and morphological evidence for a mixed-species cave-roosting bat community in the Early Pleistocene of eastern China

Vetotas Han, Earth Sciences

Mentor(s): Christopher Organ, Earth Sciences

An Early Pleistocene bat assemblage from a hilltop cave in Xiaoxian, Anhui Province, eastern China, provides unique evidence for the taxonomic composition and ecological structure of a fossil cave-roosting community in Asia. Comprising two bat taxa referable to Rhinolophidae and Vespertilionidae and including mandibular, dental, pedal, and ungual elements, this assemblage offers a rare opportunity to directly investigate the link between bat taxonomy, functional morphology, and roosting ecology in an early cave environment,

given the highly limited Quaternary bat record in Asia. Taphonomic observations suggest that the bat remains accumulated within the cave rather than being transported there from elsewhere, and there is no strong evidence that predation was the main cause of their accumulation. The two taxa were recovered from the same sedimentary setting and exhibit broadly similar taphonomic patterns, suggesting they were deposited at roughly the same time and may represent a mixed-species cave-roosting association. The presence of both rhinolophid and vespertilionid bats in the same layer implies that these animals occupied the cave environment. However, the morphological differences also hint at a level of ecological differentiation. The differences in mandible and dental structures might have been due to dietary differences, while the differences in pedal and ungual bones might have been due to differences in substrate use or roosting sites in the cave. The Xiaoxian assemblage thus expands the sparse Early Pleistocene bat record of eastern China and provides rare insight into the functional and ecological organization of a fossil mixed-species bat community.

Acknowledgements: USP - Undergraduate Scholars Program

Endophytic and Exophytic Foliar Microbiomes of Sugar Maples

Coral Mercer, Ecology; Madelyn Zack; Fen M Sago, LRES; Matthew Kapthrop, LRES

Mentor(s): Qian Wang, Microbiology & Immunology; Anna Schweiger, Land Resources & Environmental Sciences

Sugar maple (Acer saccharum), a dominant canopy species in eastern North American forests, is undergoing widespread decline, highlighting the need to better understand the biological drivers of tree health and productivity. Emerging evidence indicates that sugar maple health is shaped by interactions among roots, rhizospheric soil microbiota, and foliar microbial communities that influence nutrient acquisition, pathogen resistance, and carbon allocation. This study investigates whether sap quantity and quality are associated with specific microbial communities by characterizing the endophytic and exophytic foliar microbiomes of sugar maple and linking these data to leaf chemistry, structural traits, and health metrics. During the 2025 growing season, 102 leaf samples were collected from 17 sugar maple trees at the MSU Forest Innovation Center in Escanaba, Michigan. A novel methodology was developed to separate endophytic and exophytic leaf-associated microbiomes. Microbial DNA was extracted and analyzed using 16S rRNA Illumina sequencing, with downstream community analyses conducted in Mothur and R. Results showed that endophytic and exophytic microbial communities were compositionally distinct, that exophytic communities exhibited greater alpha diversity than endophytic

communities, and that endophytic microbiomes displayed strong tree-specific patterns in beta diversity. Integrating microbiome profiles with foliar chemistry and spectral data will improve understanding of plant-microbe-environment interactions and their contributions to tree health and sap production. We hypothesize that healthier trees harbor more stable and functionally beneficial microbial communities, promoting enhanced defense, tissue maintenance, and carbohydrate allocation, ultimately contributing to higher sap sugar content. This work will support the development of a predictive framework for sugar maple stand management to identify more productive and resilient trees, thereby enhancing economic returns and promoting sustainable forest management.

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Optimizing Sharp-Tailed Grouse Reintroduction: Habitat Matching and Post-Release Nest Survival

Abigail Tullius, Ecology; Kristina Gunderson, Montana Fish, Wildlife & Parks; Mikel Newberg, Montana Fish, Wildlife & Parks; Ty Smucker, Montana Fish, Wildlife & Parks; Beau Larkin, MPG Ranch

Mentor(s): Lance McNew, Animal & Range Sciences; Laura Dykstra, Animal & Range Sciences

Grouse reintroduction outcomes depend on the nest survival of translocated birds. Identifying whether nest site conditions or source-site adaptations have a stronger influence on nest survival is critical for informing reintroduction management. One strategy for reintroductions is selecting source populations exposed to similar habitats as the restoration site, so that translocated animals are better adapted to release site conditions. To guide reintroduction planning, we quantified how local habitat conditions, source-site environments, and similarity between source and release sites determine nest survival of translocated sharp-tailed grouse in western Montana. We expected that daily nest survival would be positively associated with 1) increased visual obstruction and concealment at nests, and 2) increased similarity between the nest habitat and source lek habitat. We translocated grouse from 43 leks in central and eastern Montana to three restoration sites in western Montana and monitored 126 nests from 106 females during 2023–2025. We recorded nest fate and assessed vegetation cover and height around nests. We quantified land cover, canopy height, distance to roads, and rangeland productivity within 2 km of nests and associated source leks, then calculated an index of habitat similarity. Areas surrounding source leks differed in whether grassland or shrubland was the dominant

vegetation type, and in the proportion of anthropogenic and agricultural land use. Restoration sites also ranged from more developed to more rural and dominated by private cattle ranches. If source-site adaptations affect nest survival, then reintroductions should prioritize capturing birds at source leks most similar in habitat to the restoration sites.

EDUCATION

Decolonizing and Indigenizing Short-Term Education Abroad: A Scoping Review

Grace Epperson, Sociology and Anthropology; Sky Wernik; Education

Mentor(s): Sweeney Windchief, Education

Although research on social justice-oriented approaches to education abroad has increased in recent years, there is minimal research on international programs that are culturally grounded in an Indigenous paradigm. To this end, we have conducted a scoping review to map out the current landscape of literature on decolonizing and Indigenizing short-term education abroad programs. Unlike a systematic review, which identifies, evaluates, and synthesizes evidence on a specific research question, a scoping review is better suited to broadly identify and describe key characteristics of evidence on a given topic, concept, or issue. This scoping review enables us to 1) understand the breadth and depth of the literature on critical approaches to short-term education abroad, 2) illuminate gaps and opportunities for future research, and 3) inform a basis for program improvement. We hope to encourage education abroad practitioners and participants to critically examine their own motivations for studying abroad and develop strategies for mitigating the reproduction of colonizing practices within Indigenous communities.

Acknowledgements: USP - Undergraduate Scholars Program, Mary Anne Hansen

From Campus to Conference: Preservice Teachers Taking the Stage with Purpose and Play

Rayna Gehring, Health & Human Development; Dexter Tedesco, FSNK; Brindly LaGrange, FSNK; McKenzie Walker, FSNK

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

This poster highlights a transformative professional learning experience in which preservice Health Enhancement teachers traveled to Saratoga, Wyoming to present at the WAHPERD

state conference. This experience provided an authentic opportunity for students to move beyond the university setting and engage directly with practicing professionals in the field. Preservice teachers collaboratively designed and delivered interactive, standards-aligned sessions featuring activities such as yoga, Theraband Slingshots, and the Hawaiian Handshake. These activities emphasized creativity, engagement, and inclusivity, while allowing students to apply pedagogical knowledge in a real-world context. Preparation for the conference required intentional planning, practice, and professional collaboration, mirroring expectations of in-service educators. The poster shares reflections and outcomes from this experience, including increased confidence, enhanced professional identity, and a deeper understanding of effective teaching practices. Students not only demonstrated content knowledge and instructional skill, but also presented themselves with a high level of professionalism—communicating clearly, engaging participants, and adapting in the moment. Findings suggest that immersive, field-based experiences such as conference presentations can play a critical role in bridging theory to practice, supporting preservice teachers in seeing themselves as capable and confident professionals prior to entering the classroom.

Acknowledgements: College of EHHD Research Travel Fund

A Theory-First Approach to Modeling the Colorado Learning Attitudes About Science Survey Using Expectancy-Value

Owen Gibbs, Physics

Mentor(s): Jayson Nissen, Physics

The learning attitudes with which introductory physics students enter introductory physics courses predict not just with their performance in the course but their likelihood of becoming a professional physicist. Researchers and educators often use the Colorado Learning Attitudes about Science Survey (CLASS) to assess these attitudes. Including the original model, five different models exist for analyzing the CLASS data. In this paper, we take a theory-first approach analyzing CLASS responses using two latent factors based on Expectancy-Value Theory (EVT). Using a sample 6576 students collected with the LASSO platform, we compared our EVT model to four of the other models using Confirmatory Factor Analysis (CFA) and reliability. Whereas the other four models either had low fit statistics or low reliability on at least one factor, the EVT model results were acceptable on the post test. Applying EVT to the CLASS allows us to identify theoretically grounded interventions with causal impacts to use in physics courses to improve students attitudes about learning physics.

Acknowledgements: USP - Undergraduate Scholars Program

Exploring the Influence of a Career Based Academy on Potential Agricultural Educators

Evan Heupel, Department of Agricultural and Technology Education

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

eDucATE: Building Montana's Agricultural Educators Evan Heupel, Department of Agricultural and Technology Education. Mentor: Emily Sewell, Department of Agricultural & Technology Education. With the world's population continually on the rise and less agricultural ground, it is more important than ever that we have a sustainable agricultural workforce. To achieve this, it is necessary to ensure proper learning and training through agricultural education, which continues to suffer from a lack of qualified individuals (Eck & Edwards, 2019; Smith et. at., 2024). The primary objective of eDucATE is to provide a 3-day immersive experience to prospective agricultural educators to give a jump start on their future and supply them with the tools they need to be successful in obtaining a degree in and starting a career in secondary agricultural education and extension programs. 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 the participants' attitude toward a college major and career in agricultural education, 2) Determine the influences on participants' intentions to pursue a college major and career in agricultural education, 3) Determine the influence of experience on participants intentions to pursue a college major and career in agricultural education, 4) Describe the impact of eDucATE on participants' intentions to pursue a college major and career in agricultural education. Satisfaction and influence of 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. Data from 2024 will be presented with applications for adjustments we have made for the upcoming academy and study.

Acknowledgements: USP - Undergraduate Scholars Program

Special Education Policy Research: Advisory Programs

Noah Oakes, Sociology and Anthropology

Mentor(s): Leslie Rogers, Education

As the understanding of learning differences in students continues to advance, it has become increasingly important to ensure that best practices in curriculum are being implemented in special education programs. The use of policy advisory boards is an effective way to ensure that special education programs are operated in accordance with the needs of the institution of higher education (IHE) as well as the surrounding community. This study explores best practices in the formation, operation, composition, and activity of special education policy advisory boards (SEPAB). A literature review was conducted to create an initial basis of information on the formation and operation of SEPABs. During this review, it became evident that literature concerning policy advisory boards is scarce, especially literature concerning SEPABs. Based on the current lack of comprehensive literature about SEPABs, a qualitative study was designed to triangulate data from several IHEs on best practices when forming and operating SEPABs. The study design is currently being applied through qualitative data collection, which will then be analyzed. Interviews are being conducted with directors of SEPABs. Data from these interviews are being collected on the context specific to the IHE, how and why the SEPABs were formed, their member composition, sustainability practices, and barriers to obtain a generalized set of guidelines. Grounded Theory will be utilized to analyze the data for themes.

Launch, Engage, Inspire: High-Energy Strategies that Stick in Physical Education

Ellen Olson, Health & Human Development; Peter Townsend, FSNK; Jack Erlander, FSNK; Hannah Thill, FSNK

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

This poster highlights an engaging instructional session delivered by preservice Health Enhancement teachers at the SHAPE Utah conference in Salt Lake City. Presenters facilitated a large-group session with over 75 participants, demonstrating innovative activities including Theraband Slingshots and Stomper Foot Cannons. Designed to promote engagement, creativity, and physical activity, these activities provided participants with practical strategies that can be immediately implemented in K–12 physical education settings. The session emphasized student motivation, inclusive participation, and the use of nontraditional equipment to enhance learning experiences. A key outcome of this experience was the meaningful interaction between preservice teachers and current physical educators. The high level of engagement from in-service

teachers reinforced the relevance and applicability of the content, while also validating the preservice teachers' preparation and delivery. Presenters demonstrated confidence, adaptability, and professionalism while facilitating a large and active audience. This poster shares insights into how hands-on, high-energy activities can support effective teaching practices while also highlighting the value of authentic professional experiences in preparing preservice teachers to lead, engage, and inspire in diverse educational settings.

Acknowledgements: College of EHHD travel research fund

How Using CBPR for a Research Project Led to Meaningful Research: An Inclusive Outdoor Community & Safe Outdoor Spaces for BIPOC College Students

Mey Palomino, Modern Languages & Literatures; Aydemar Guerrero, College of Engineering; Alma Montoya, College of Engineering

Mentor(s): Mayra del Carmen, Psychology; Desiree Taylor, Education

The primary objective of this research is to implement a community-based participatory research (CBPR) approach, encouraging Montana State University (MSU) undergraduate student researchers to develop an outdoor recreation program that enables participants from the university community to engage in safe outdoor activities. Prior research identified a positive correlation between university students' sense of belonging and academic retention, with outdoor recreation as an endeavor that fosters a more enjoyable college experience. However, scholars also acknowledge a lack of diversity in outdoor recreation spaces.

This initiative is significant because it bridges the gap between Black, Indigenous, and People of Color (BIPOC) students at MSU, who are underrepresented in outdoor spaces, and encourages them to participate in outdoor recreational activities. MSU is a highly regarded institution for outdoor sports and recreation. It is crucial to ensure all campus members have equitable access and participation. These experiences may also have a generational impact on the students who participate by introducing the activities to their communities.

The research involved the active participation of MSU undergraduate students and a faculty mentor to create a Community Advisory Board (CAB). Throughout the 2024-2025 academic year, the group planned and executed events that fostered a more inclusive environment for outdoor recreation while engaging other members of the student community. The CAB directly collaborated with community partners who were experts in their respective

outdoor recreation activities. The collaborative research strengthened the research team's commitment to fostering an inclusive environment for all members at MSU.

Acknowledgements: USP - Undergraduate Scholars Program, McNair Scholars Program, College of Letters and Science - Liberal Studies Program

Moving Minds and Bodies: Creative Approaches to Engagement in Physical Education

Charles Peake, Health & Human Development; Gavin Boudet, FSNK; Rob Luceno, FSNK; Easton Hatleberg, FSNK

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

This poster showcases a dynamic session presented by preservice teachers at the SHAPE Utah conference in Salt Lake City, where over 75 participants engaged in innovative, movement-based learning activities. The session featured a variety of creative strategies, including yoga, Chopstick Ninja, States and Capitals, and Hawaiian Fitness Handshakes. Each activity was intentionally designed to integrate physical movement with cognitive engagement, supporting whole-child learning while aligning with national standards. Preservice teachers demonstrated the ability to design and implement inclusive, engaging lessons that promote both physical activity and academic connections. The large audience provided an authentic teaching environment, allowing presenters to practice classroom management, clear communication, and instructional adaptability in real time. This poster highlights how integrating creativity, cross-curricular connections, and movement can enhance student engagement and learning outcomes. Additionally, it reflects the professional growth of preservice teachers as they confidently facilitated sessions, responded to participant needs, and experienced the impact of their instruction on practicing educators.

Acknowledgements: College of EHHD travel and research fund

Beyond the Classroom: The Power of Travel, Connection, and Professional Growth

Oliver Woodford, Health & Human Development; Tanner Hart FSNK; Luke Gaines, FSNK; Treyten Pester, FSNK

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

This poster explores the broader impact of conference travel on preservice teacher development through participation in the SHAPE Utah conference in Salt Lake City.

Traveling as a cohort provided opportunities for students to build meaningful connections, strengthen relationships, and develop a sense of community within their professional program. Beyond presenting, preservice teachers engaged in professional learning by attending sessions, interacting with experienced educators, and gaining exposure to new ideas and practices within the field. These experiences contributed to a deeper understanding of the profession and reinforced the importance of lifelong learning. Presenting to large audiences allowed students to step into professional roles, gaining confidence as their voices were heard and valued by practicing teachers. This validation played a critical role in shaping their professional identity and reinforcing their readiness to enter the field.

This poster emphasizes how immersive experiences—such as conference travel, collaborative learning, and professional engagement—support the development of confident, connected, and reflective educators prepared to contribute meaningfully to their profession.

Acknowledgements: College of EHHD Travel and research fun

Bridging the Gap In Quantum Education from Beginner to Advanced Resources

Rebekah Yager, Computer Science

Mentor(s): Suzi Taylor,

Quantum computing is rapidly emerging as a transformative field, yet significant gaps remain in accessible educational resources for learners transitioning from introductory lessons to advanced study. This project addresses the critical need for intermediate-level quantum education by developing a structured, self-paced online course designed for students and educators with limited prior experience. Building on findings from the 2025 Quantum Summer Academy at Montana State University's Science Math Resource Center (SMRC), this work identifies a consistent barrier for learning. While beginner-friendly materials and advanced academic resources are widely available, there is a lack of content that effectively bridges the conceptual and technical divide between them. Expected outcomes include improved accessibility to quantum education, increased learner confidence in approaching advanced materials, and a scalable model for workforce development in emerging technologies. This project contributes to ongoing efforts to expand quantum literacy and strengthen the educational pipeline in Montana.

Acknowledgements: USP - Undergraduate Scholars Program

Culturally Responsive Teaching: Perspectives of International Mathematics Graduate Teaching Assistants

Bernard Yeboah, Mathematical Sciences

Mentor(s): Elizabeth Arnold, Mathematical Sciences; Megan Wickstrom, Mathematical Sciences

This study examines how international graduate teaching assistants (ITAs) in mathematics, with their valuable cultural perspectives, implement culturally responsive teaching (CRT) in U.S. undergraduate mathematics courses. Using semi-structured interviews and classroom observations, the study examines how ITAs implement the essential components of CRT, as defined by Gay (2002), while confronting cultural and institutional challenges. Findings revealed that ITAs build inclusive learning communities and negotiate mathematics registers with their students to improve accessibility. The study highlights the pivotal role of culture in teacher professional development, igniting discussion to enhance support for ITAs and promote equity in mathematics education.

ENGINEERING AND TECHNOLOGY

Spatial Acoustic Analysis

Ryan Adolph, Computer Science; Michael Oswald, College of Engineering; Micaylyn Parker, College of Engineering

Mentor(s): Clem Izurieta, Computer Science

Spatial awareness and signal profiling are increasingly critical in both defense and civilian applications. This project explores the design and implementation of a modular, real-time audio sensing and processing system to determine the direction and possible identity of an acoustic profile using a Raspberry Pi platform. This system will use a common audio interface and multichannel microphone signal chain via USB connection as well as physical connection to an operator pc to provide rapid cycling of audio information and useful processing in an adaptive environment. This system will cycle through rapid sequences of audio acquisition, decomposition, beamforming, and FFT reduction to rapidly provide parsable spatial information based on the available microphone array. The microphone array in this application is intended to be adaptable to what the user has available. To accomplish this, the system will be set up to accept continuous signal from any audio interface. To reduce the file size of these directional outputs, they will be processed by a Fast Fourier Transform (FFT) pipeline to extract frequency domain

characteristics, stored as a text file on the Raspberry Pi, and waits for the operators PC to download the file. The operator's PC will then compare and contrast frequencies it has stored, being audio or radio frequencies to produce a profile displayed on a basic application run on the operators computer showing the current signals profile. This system demonstrates a lightweight, modular, extensible framework for acoustic sensing suitable for deployment in resource-constrained and dynamic environments.

Fluorescence Microscopy Platform for Real-Time Monitoring of DNA Amplification via Integrated Thermal Regulation

Christian Aitchison, Electrical & Computer Engineering; Henry Hamp, Electrical Engineering; Alexandra Houseworth, Electrical Engineering

Mentor(s): Dr. David Dickensheets, Electrical & Computer Engineering; Dr. Stephanie McCalla, Chemistry & Biochemistry

Quantitative Polymerase Chain Reaction (qPCR) requires precise, rapid thermal cycling coupled with sensitive optical detection to monitor DNA amplification in real-time. This research details the design and implementation of an integrated fluorescence microscopy system featuring an active temperature-regulated sample stage. The system utilizes a Peltier-based thermoelectric cooler coupled to an aluminum stage to provide stable thermal modulation. Temperature feedback is achieved using a high-precision Resistance Temperature Detector (RTD), ensuring high-resolution monitoring and sub-degree accuracy throughout the experimental period. A custom-developed MATLAB application serves as the primary control and acquisition interface. An Arduino-based controller implements a PID control algorithm to maintain temperature setpoint stability while simultaneously managing high-resolution imaging. The imaging hardware consists of the Lumenera Infinity 8-8M camera and custom optics, which are synchronized with the thermal control system to allow for automated time-lapse studies under varying temperature profiles. This integration allows for the correlation of morphological changes with precise thermal states. Experimental results indicate that the system maintains a stable temperature range suitable for diverse applications with minimal steady-state error. The optical system achieves excellent light transmission and field of view while eliminating the effects of field curvature and astigmatism. This integrated platform provides a robust, cost-effective solution for observing temperature-dependent phenomena in real-time for Polymerase Chain Reaction (PCR) experiments in DNA amplification. By combining high-resolution digital imaging with precise environmental control, this system facilitates a more comprehensive understanding of gene sequencing.

Acknowledgements: Dr. Stephanie McCalla

Isolation of Unique Microbial Species from Multidomain Biofilms on Military Vehicles

Kalena Awram, Chemical & Biological Engineering; Kylie Bodle, Chemical and Biological Engineering; Ghazal Vahidi, Chemical and Biological Engineering

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

This research focused on the isolation and cultivation of microorganisms from biofilms on military vehicle surfaces, with the future goal of developing representative “field biofilms” for coating testing. Military vehicles are frequently exposed to extreme environmental conditions and prolonged periods of time without maintenance, thereby enabling multi-domain biofilms to form on coated vehicle surfaces. These biofilms, composed of diverse microorganisms embedded in extracellular polymeric substances, can increase coating degradation and harbor harmful pathogens. Understanding their composition is therefore critical for testing coating durability and developing maintenance strategies.

The primary objective of this research was to isolate unique bacterial and fungal species from biofilm samples collected from military vehicles. This was achieved using samples collected from the outside of military vehicles at Marine Corps Base Camp Lejeune. Samples were inoculated onto different types of agar with different nutritional compositions to cultivate as many species as possible. Specifically, R2A agar, antifungal R2A, Potato Dextrose Agar, and pH 3 Sabouraud Dextrose Agar were used. Cultures were then incubated at 30℃ and at 30% humidity until individual colonies were observed. Individual colonies with unique morphologies were transferred to new plates until plates contained only identical colonies, indicative of a pure culture.

Over 28 bacteria, 65 fungi, and 127 species of unknown domain were isolated from four samples, indictive of highly successful species recovery. Pure cultures were preserved in glycerol at -80℃ for long term storage. Isolated species will be further examined by amplifying fungal- or bacterial-specific genes via polymerase chain reaction. This will enable domain-level characterization of each isolate and future taxonomic identification via gene sequencing.

Acknowledgements: USP - Undergraduate Scholars Program

Microfluidics Design and Fabrication for Robust Medical Diagnostics

Addison Bahr, Chemical & Biological Engineering

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

Millions of people are infected with Human Papillomavirus (HPV) every year, which creates a need for cost-effective and non-invasive testing, like microfluidic diagnostics. HPV is identifiable through blood samples using sensitive microfluidics devices, as HPV nucleic acid strands (mRNA) can be found in the bloodstream. Cyclic Olefin Copolymer (COC) is a practical material for microfluidic diagnostics, because it is strong, easily manufacturable, compatible with sensitive reactions like PCR, and low-cost. This project has focused on the successful fabrication, bonding, and filling of a proposed COC chip to detect low-concentration nucleic acids. COC beads are melted into plaques, which are then flattened and milled to produce chip features, including over 1,000 microfluidic reaction wells, each capable of holding single molecules. Inlet holes are drilled through the back of the chip and a layer of flexdymTM (SBES polymer) is applied to the back of the chip. The desired reaction is scraped into the wells on the front of the chip. A glass slide is adhered to the top of the COC chip, sealing the reaction. Low viscosity oil fills in the remainder of the chip through the inlet holes to isolate reaction wells. The flexdymTM covering the inlet holes is resealed with heat. A custom device controls the temperature within the chip, which can initiate a DNA amplification reaction for downstream HPV detection. With the current chip design, thousands of reactions can occur at once, allowing for rapid detection of HPV mRNA strands with just a blood draw, reducing the need for invasive testing techniques, such as pap smears.

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

Measurement of Wildfire Derived Organic Carbon in Burned Watersheds Using an In-stream Optical Sensor

Levi Bala, Environmental Engineering; Kristina Bonnet, Civil Engineering, Environmental Engineering; Amanda Hohner, Civil Engineering, Environmental Engineering

Mentor(s): Amanda Hohner, Civil Engineering; Kristina Bonnet, Civil Engineering

Wildfire is a common threat and concern to communities of the mountain west. Wildfire derived organic carbon from burned forest biomass and soils can leach and travel with runoff, entering streams and watersheds. Heightened carbon concentrations in these waters can pose challenges to drinking water treatment facilities of communities supplied

by this water. To track the effects of wildfire on a watershed and better inform and prepare treatment facilities for impacts on source water quality, we used the Spectrolyser in-situ sensor to collect measurements of turbidity, total organic carbon (TOC) and UV – spectra. The sensor was deployed at two locations: the Gallatin River near Gallatin Gateway, and within the Bozeman Water Treatment Plant (BWTP) intake tank. The deployment at the Gallatin River lasted two weeks and posed various challenges including installation in the riverbed, sensor malfunction, and debris interference. The sensor deployment at the BWTP intake tank has been ongoing since July 2025 and has provided an accessible, controlled environment to fine tune sensor software and examine the effects of fluctuating seasonal water conditions using sensor data. The data has been useful in determining desirable water conditions for best sensor performance. This preliminary troubleshooting has been insightful, and we hope to deploy the sensor within a burned watershed during this spring's runoff season. In November 2025, we surveyed a burned watershed in the Tobacco Root mountains, sampling burned soils and streams, and scouting potential sensor installation sites. The findings from this survey will help shape our deployment plans this spring.

Modeling Brain Solute Transport to Improve Understanding of Neurodegenerative Disease Development

Maya Carlson, Chemical & Biological Engineering

Mentor(s): Jeff Heys, Chemical & Biological Engineering

Understanding transport in brain tissue is critical for improving drug delivery strategies and characterizing neurodegenerative disease progression. Accurately quantifying diffusion and advection in vivo remains a significant challenge. This project investigates transport of MRI contrast agents in the brain to estimate effective diffusion behavior and assess directional transport dynamics. The primary research question is how transport varies across spatial dimensions and whether a physics-informed framework can reliably extract physiologically meaningful parameters.To address this, a physics-informed neural network (PINN) was implemented to model one-dimensional advection–diffusion along selected spatial axes of 4D MRI data. Preprocessing scripts were developed to extract concentration profiles along the x, y, and z directions over time. The governing partial differential equation was approximated by a neural network to estimate transport parameters while enforcing physical consistency. Visualization techniques, including time–space heatmaps, wireframe plots, and temporal concentration curves, were used to analyze transport behavior.Preliminary results indicate anisotropic transport behavior, with variation in diffusion characteristics across spatial directions. The model successfully captures

concentration evolution over time and provides stable parameter estimates that are comparable in magnitude to known diffusivity values of Gadobutrol, supporting physical plausibility.These findings demonstrate the potential of combining medical imaging with physics-informed machine learning to quantify brain transport processes. This approach may improve understanding of drug delivery mechanisms and pathological transport alterations, with future work focused on extending the model to first two-dimensional, then three-dimensional analysis and a continuation of refining parameter estimation.

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Experimental Comparison of Fundamentals of Laparoscopic Surgery (FLS) and Veterinary Assessment Laparoscopic Skills (VALS) Using EEG and EMG

Mason Clark, Chemistry & Biochemistry; Evangeline Newkirk, Microbiology & Cell Biology

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

Laparoscopic surgery is a complex procedure that requires technical dexterity, spatial reasoning, movement pre-planning, and hand-eye coordination. Physicians require a safe, standardized environment to refine these skills before patient care. The Fundamentals of Laparoscopic Surgery (FLS) trainer is the gold-standard for laparoscopic simulation training, while the Veterinary Assessment Laparoscopic Skills (VALS) trainer offers a larger size and different position compared to FLS. This study uses a mixed-methods approach to quantify differences in novice and expert performance in laparoscopic surgery simulations. Additionally, the difficulty and efficiency of these training tools were compared against each other to assess differences in performance and learning. In this experiment, novices were randomly assigned to complete an FLS task or a VALS task while multimodal data was collected, including EEG and EMG data. This data was selected to better understand cognitive workload and how expertise develops in novices across cognitive, physiological, and motor domains. Experimental data for 11 participants have been collected, with a goal of 19 participants in the future. Comparing the FLS and VALS trainers offers insight into the challenges and benefits of simulations and how they can be applied in different contexts.

Acknowledgements: USP - Undergraduate Scholars Program, BioReD Murdock Foundation

***Biomechanics of the Kangaroo Rat Foot: A Study on Digitization and Articulation for Improving Robot Foot Interactions with Complex Terrain*.**

Jasmine DeVlieg, Mechanical & Industrial Engineering; Meredith Christensen, Civil 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. This work investigates the biomechanics of kangaroo rat (k-rat) feet to better understand the advantages of digitization and articulation in foot-ground interactions.

K-rats have inspired several individual foot designs of varying number of toes and toe joints. Three simplified, approximately 6x-scale leg models were designed and fabricated using 3D printing, incorporating rolling contact joints to mimic biological articulation. These models are being evaluated using a vertical linear actuator system to measure input forces and corresponding ground reaction forces to test the model's force damping capabilities. To further examine these models, tests will be conducted with small obstacles placed beneath the toes, simulating uneven ground. We hypothesize that increased digitization and joint articulation will improve force distribution and the foot's adaptability to irregular terrain, shown by a reduction in peak ground reaction forces. Ultimately, we theorize that incorporating articulated feet structures into legged robots may improve their performance in complex environments.

Acknowledgements: USP - Undergraduate Scholars Program

Effects of Interfaces on Sub-Optical Stress Transfer Efficiency in Heterogeneous Polymers

Ian Flynn, Mechanical & Industrial Engineering

Mentor(s): Lewis Cox, Mechanical & Industrial Engineering

The interface between materials with differing mechanical properties affects how stress transfers at and around the interface at sub-optical levels in heterogenous materials. Stresses are known to concentrate at and around these interfaces. Despite ongoing efforts, this effect at a sub-optical length scale remains mainly inferred by models and experimentally unvalidated. This is due to historical limits on gaining full field stress maps at these sub-optical scales. This project aims to examine the effects of these interfaces at a sub-optical level using recent advancements in gaining full-field strain maps with Digital Image Correlation (DIC) using Atomic Force Microscope (AFM) images. By relating DIC-built strain maps generated from tapping mode topography images to correlated modulus maps

obtained using Fast Force -Displacement imaging, full-field stress maps at heterogenous interfaces can be developed. These sub-optical stress maps will be compared macro- and meso-scale DIC data collected using a GoPro and an optical microscope. The material tested was Two Stage Reactive Polymers (TSRPS) to accurately control the spatial variation of mechanical polymers at a micro scale resolution. The expected deliverables are sub-optical full-field stress maps collected at differently shaped interfaces between soft and stiff materials, macro scale DIC strain maps, as well as connections between the geometry of the interface and stress transfer efficiency across the interface. This can help inform future research as well as help make improvements in current models used to infer stress transfer across heterogenous interfaces on a sub-optical level.

Acknowledgements: USP - Undergraduate Scholars Program

The Effects of Noble Metal Catalysts on the Conversion of 5-Hydroxymethylfurfural to Furan-2,5-dicarboxylic Acid

Zachary Fredericks, Chemical & Biological Engineering

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

As the consumption of plastics continues to rise, the widespread use of fossil fuel–derived materials such as polyethylene terephthalate (PET) has become increasingly concerning due to its environmental impact, prompting interest in sustainable alternatives like polyethylene furanoate (PEF). PEF can be produced from biomass-derived sugars and offers superior properties compared to PET. However, challenges remain in the conversion of 5-hydroxymethylfurfural (HMF) to 2,5-furandicarboxylic acid (FDCA), a key monomer in PEF production. This reaction step requires high temperatures, expensive noble metal catalysts, and is further complicated by the low solubility of FDCA.

To solve these issues, this research focuses on optimizing noble metal catalysts, their supports, and the reaction solvent system to achieve high FDCA yields and higher FDCA concentrations. Reactions are run in a PARR batch reactor around 590 psi and 90 ˚C with a combination of catalysts and solvents. Of these reactions, platinum supported on activated carbon has shown promising results, with yields around 70%. Other noble metals, including ruthenium, palladium, and rhodium, are being evaluated to determine whether they can achieve comparable or improved performance. In addition, all catalysts are tested across multiple solvents, including dimethyl sulfoxide, sulfolene, and gamma-valerolactone, which previous research identified as promising, high solubility solvents. Alternative catalyst supports, such as aluminum oxide, are also being investigated to further enhance yields. Future work will entail developing Artificial Neural Networks that

can predict which solvents, catalysts, and supports, ultimately advancing the development of sustainable plastics.

Acknowledgements: USP - Undergraduate Scholars Program

Comparing enzyme oxidative decarboxylase to iron-zeolites

Anna Gates, Chemical & Biological Engineering

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

Standard biodiesel production results in a combustible fuel of high viscosity and high oxygen density. For broader application to temperature sensitive combustion systems such as aviation engines, this oxygen must be removed. The enzyme, oxidative decarboxylase, can use iron active sites to decarboxylate lipids found in biodiesel to create high performance fuel additive olefins. However, this enzyme does not remain useful in industry settings as it denatures at temperature and pH extremes. To overcome this limitation, it is of interest to isolate an inorganic 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. Aided by computational analysis, the zeolite ferrierite has been identified as structurally similar to the enzyme oxidative decarboxylase. Utilizing solid state ion exchange and impregnation processes, iron sites have been templated within the zeolite structure to create uniform and highly dispersed Fe(II) active sites that match those found in oxidative decarboxylase. The synthesized iron zeolite catalysts have been characterized via UV-Vis, X-ray diffraction, electron microscopy, and Mossbauer spectroscopy. In a second phase, we will attempt oxidative decarboxylation of industry relevant biolipids. In summary, we are directing efforts to find an industry compatible Fe-zeolite catalyst inspired by the already successful, yet industry incompatible oxidative decarboxylase. Such a catalytic discovery would be transformative in global efforts to generate renewable liquid fuels from oily biomass.

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Numerical Modeling of a Flat-Plate Micro-channel Oscillating Heat Pipe in Zero Gravity Applications

James Jackson, Mechanical & Industrial Engineering

Mentor(s): Erick Johnson, Mechanical & Industrial Engineering

As electronic devices continue to become smaller and more power dense, the need for compact and efficient thermal management systems grows. Oscillating heat pipes (OHPs) are a passive cooling technology that transfers heat through self-excited oscillations without requiring additional power or moving parts. Recent advances in manufacturing, such as laser powder bed fusion (LPBF) 3D printing, have expanded the design possibilities for flat-plate OHPs by enabling new material choices and surface characteristics. However, despite experimental progress, the complex thermal-fluid physics governing OHP operation remains poorly understood. Current literature has given comparatively less attention to the effects of surface roughness and thin liquid films on OHP performance.

This work focuses on verifying that commercial computational fluid dynamics (CFD) tools can accurately resolve multiphase interfaces and reproduce oscillatory slug flow in OHP channels without introducing excessive numerical error. Preliminary results show that simulations of OHP fluid dynamics without conjugate solid heat transfer can reproduce oscillatory flow but allow unphysical temperature growth in the system. This result indicates that inclusion of a solid region is necessary to capture realistic thermal behavior and establishes a baseline for future model development.

Building on this baseline, future work will compare 2D and 3D simulations to experimental data and examine how thin liquid film formation and channel surface roughness influence heat transfer and slug flow dynamics. By complementing experimental work with detailed numerical predictions of thermal-fluid behavior, this research aims to clarify how liquid films and surface roughness influence OHP performance and to inform the design of future experiments.

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Flying Object Detection Utilizing a Wingbeat Modulation Lidar System

Lars Johnson, Electrical & Computer Engineering; Henry Hamp, Electrical & Computer Engineering

Mentor(s): Riley Logan, Electrical & Computer Engineering

Lidar technology has seen rapid advancement in recent years across a wide range of applications, from self-driving cars to MSU-patented methods for detecting flying insects. Previous wing-beat modulation lidar systems at MSU have demonstrated the ability to identify flying objects like UAVs and insects through the analysis of time-oscillating return signals. However, these systems have relied on large, costly equipment with limited

mobility and practicality in real-world settings. This project aimed to address these limitations by assembling, characterizing, and testing a compact, affordable lidar system capable of wing-beat modulation detection across a variety of airborne targets. The system utilizes a 1550-nm laser, chosen for its strong reflectance from biological targets such as insect wings. An avalanche photodiode serves as the detector, enabling sensitivity at greater distances. Characterization of the project showed the beam divergence to be 0.0767 degrees and the field of view to be 1.7 degrees. Measurements have been successfully performed on a chopper fan, accurately estimating rotation speed (frequency) at multiple distances. A digitizer was also integrated into the system to improve detection efficiency and signal quality. Looking ahead, the wing-beat modulation algorithm will be integrated with the digitizer to classify targets, including UAVs and insects, and determine their range. Once implemented, field deployments and testing will be conducted to characterize the system's detection range and evaluate its performance across target types. This project shows promising early results for a modernized and miniaturized wing-beat modulation lidar.

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Smart Tap System: Sensor-Integrated Tree Tap for Biofilm Detection in Sap Collection

August Kreiter, Mechanical & Industrial Engineering

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

The quality of maple syrup is based on the purity of sap, which is influenced by the growth of microbes during collection. A high microbial concentration darkens the syrup during processing and, if high enough, negatively impacts flavor, reducing the economic value. These biofilms also adhere to collection tubes, causing long-term contamination issues that cannot be reversed with cleaning. This project proposed the development of a Smart Tap System, a sensor-integrated maple tree tap designed to detect microbial concentrations while withstanding the outdoor conditions experienced during the sap harvesting season (January to March). Built upon and improved from existing prototypes, the current design incorporates a mount designed for swappable printed circuit boards (PCBs) and features a weather-resistant housing. The project was divided into four phases: finalizing the tap and housing design, laboratory testing, field deployment, and design refinement for manufacturability. Laboratory testing included vacuum flow leak testing and freeze–thaw cycling in an environmental chamber. Field testing was conducted between March and April of the 2026 maple season to collect sap data and evaluate the performance of the Smart Tap. The results helped identify potential areas of the system

that needed to be redesigned to improve reliability and repeatability. The Smart Tap System provides producers with real-time biofilm monitoring data in sap flow to prevent spoilage, improve syrup quality, and increase the economic value of harvests.

Acknowledgements: USP - Undergraduate Scholars Program

Quantifying Uncertainties in Airborne Hyperspectral Imagery

Adin Matthes, Electrical & Computer Engineering; Erica Venkatesulu, Electrical & Computer Engineering; Joseph Shaw, Electrical & Computer Engineering

Mentor(s): Riley Logan, Electrical & Computer Engineering

Researchers utilizing airborne hyperspectral imaging systems for a variety of remote sensing applications have recognized inconsistencies in data products collected in the field. The inconsistencies, manifesting as non-physical reflectance data, result in images that can be difficult to interpret, or, in some cases, rendered unusable. The observed effects may arise from a variety of factors, including temperature-dependent instrument response, erroneous automated processes in equipment control software, variable illumination angles, and environmental conditions. The objective of this research is to isolate and evaluate each factor to characterize and correct the observed issues when the systems are operated in the field. Laboratory-based experiments will be conducted using a controllable light source to isolate the effects of software products, illumination angles, and sensor temperature for two hyperspectral imaging systems spanning 400 – 1700 nm. Results will include reflectance data calculated using multiple software products, measurements as a function of illumination angle, and thermal analysis to observe changes in data as a function of temperature. Successfully isolating and identifying the source of the erroneous data products will allow for more accurate data collection during future field deployments.

Acknowledgements: USP - Undergraduate Scholars Program

Nuclear Energy: The Momentum Montana Needs

Cyan Mooney, Chemical & Biological Engineering

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

Montana is undergoing a rapid energy and workforce transition, underscored by the passage of Montana House Bill 623 in May 2025, which authorizes nuclear waste

management facilities and signals a major shift toward supporting nuclear energy infrastructure. This momentum, paired with rising student interest and statewide demand for reliable, low carbon power, highlights the need for nuclear energy academic programs that can meet emerging workforce requirements and establish a long term academic pathway in nuclear engineering. To evaluate this opportunity, the project conducted curriculum mapping, workforce and energy analyses, stakeholder interviews, and national benchmarking, supported by collaboration with Montana Technological University and Idaho National Laboratory. In addition to this analysis, the project developed two instructional resources: a Student Guide to Nuclear Energy Resources for outreach and recruitment, and a set of Example Nuclear Energy Related Problems designed to help MSU faculty integrate nuclear concepts into existing courses. Findings reveal that while MSU offers strong nuclear relevant coursework, it lacks cohesion and key content areas necessary for a formal program. Coordinated planning with Montana Tech and INL confirms that a unified nuclear energy certificate program for engineering majors, targeted for Fall 2026, is both feasible and well supported, positioning Montana to build the workforce needed for advanced nuclear technologies and laying the foundation for a statewide nuclear education pipeline.

Acknowledgements: USP - Undergraduate Scholars Program

Detecting Neuroplasticity Following Anterior Cruciate Ligament Reconstruction Surgery Using Functional Near-Infrared Spectroscopy

Ella Podgorney, Chemical & Biological Engineering; Alexandra Lynch

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

Detecting neuroplastic changes following functional injury provides critical insight into the brain's adaptive mechanisms and an athlete's readiness to safely return to sport. While functional magnetic resonance imaging (fMRI) is considered the gold standard for measuring cortical activity, its susceptibility to motion artifacts limits its applicability in sport-specific and dynamic tasks. Functional near-infrared spectroscopy (fNIRS) offers a more portable and motion-tolerant alternative. This study evaluated the ability of fNIRS to detect cortical activation patterns by replicating a prior fMRI-based study comparing individuals who had undergone anterior cruciate ligament reconstruction (ACLR) with healthy controls. It was hypothesized that fNIRS-derived cortical activity patterns would parallel those observed in fMRI studies. Six ACLR participants (4F/1M, 20.83+/-2.14 yrs, 174.5+/-6.66 cm, 74.32+/-10.65 kg) and 18 healthy controls (9F/9M, 20.5+/-1.62 yrs, 175.36+/-7.81 cm, 77.24+/-12.77 kg) completed a 5-minute block of seated knee flexion

and extension tasks interspersed with rest periods while cortical hemodynamic responses were recorded using fNIRS. Data were processed and analyzed using a MATLAB-based pipeline (Brain AnalyzIR Toolbox). No statistically significant differences in cortical activation were observed between groups ($p > 0.05$). These findings may be attributed to the small sample size and variability in attentional engagement during the task across participants. Future research should include larger cohorts and more controlled experimental conditions to improve statistical power and reduce variability.

Acknowledgements: USP - Undergraduate Scholars Program

Selection of Tackifiers for Engineering Biodegradable Hydromulch

Westley Roberts, Mechanical & Industrial Engineering; Ella House, Mechanical Engineering

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

Low-density polyethylene (LDPE) sheets are large plastic films widely used in agriculture as mulch, but are discarded after each growing season, contributing to long-term soil contamination and environmental degradation. Hydromulches offer a biodegradable alternative, but their performance depends heavily on the use of effective tackifiers that provide mechanical strength, durability, and resistance to environmental stresses. This study evaluates a range of hydromulch formulations to identify tackifiers and fiber compositions that produce the strongest and most consistent material properties for real-world application.

Hydromulch sheets were produced by mixing water, paper fiber, hemp hurds, and selected tackifiers, then drying the slurry under controlled conditions. Each formulation was tested for density, water holding capacity, tensile strength, puncture resistance, and rain-fastness. Multiple batches of each formulation were produced to assess repeatability and to quantify variability across sheets with identical compositions.

Results indicate that xanthan gum consistently outperformed other tackifiers across mechanical and water-related tests. Formulations containing lower percentages of hemp hurds also demonstrated superior strength and durability. However, variability was observed across sheets of the same formulation, with high coefficients of variation in several properties. Preliminary evidence suggests that sheet thickness contributes to this variability, although slurry inhomogeneity may also play a significant role.

These findings highlight xanthan gum as a promising tackifier for further development and suggest that improved thickness control may enhance repeatability. Ongoing work focuses

on identifying the sources of variability across identical formulations and conducting rain-fastness testing to evaluate field durability and performance under simulated rainfall.

Acknowledgements: USP - Undergraduate Scholars Program

Fabrication Process Development for Nanolayers

Owen Saltzman, Electrical & Computer Engineering

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

Deep ultraviolet (DUV) wavelengths (100–300 nm) are of particular interest to NASA for solar observation. Developing optical devices in this wavelength range is a challenge, as most materials are highly absorptive. Thus, NASA has identified “High-Throughput UV Bandpass Standalone and Detector-Integrated Filters and Bandpass Selection” devices as a technology gap [1]. Bandpass filters can be made using stacks of thin films, while materials, aluminum and magnesium fluoride are desirable for their semitransparency in the DUV. Fabrication processes must be developed before designing a complete DUV filter. This project investigated the deposition and characterization of magnesium fluoride and aluminum nanolayers with thicknesses in the range 20–50 nm. The nanolayers were deposited using an Angstrom EvoVac. Physical profilometry and ellipsometry were then used to characterize the nanolayer thickness, however these techniques provided limited data when measuring stacks of two or more nanolayers. Auger Nano Probe techniques were investigated to measure these multilayer stacks, yielding thickness and material composition data. Additionally, devices were imaged using field emission scanning electron microscopy (FESEM) to visualize nanolayer structures. The collected data was used to quantify the accuracy of the Angstrom EvoVac at thicknesses of 20 nm and 50 nm. Future projects will utilize the collected data to produce device simulations considering fabrication tolerances. [WN1.1]The resulting device simulations in conjunction with well-documented fabrication processes will be used to pursue the testing of DUV filters, helping to fill NASA’s technology gap. References:

[1] Nasa, "Technology Gaps," [Online]. Available: https://science.nasa.gov/astrophysics/programs/astrophysics-division-technology/technology-gaps. [Accessed 3 March 2026].

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Tumbleweed Robot

Mikael Savage, Mechanical & Industrial Engineering; Korbyn Witt, Mechanical & Industrial Engineering

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

Mobile robots that can travel efficiently across outdoor terrain have important potential in applications such as agriculture, environmental monitoring, and extraterrestrial exploration. Rolling spherical robots are especially promising because their geometry helps them traverse obstacles while also enabling passive locomotion using environmental energy such as wind or gravity. However, many existing self-propelled spherical robots rely on shifting an internal ballast mass to alter the center of mass and induce rolling, which can limit precision and controllability. To address this challenge, a hybrid sphere-legged robot was developed that can move passively by rolling with the wind, similar to a natural tumbleweed, while also deploying legs for active, controlled locomotion. The robot is designed to remain as lightweight as possible to support passive wind-driven motion and is therefore primarily 3D printed. Its spherical structure incorporates four quarter-circle sail elements that help capture wind while maintaining the tumbleweed-inspired form. In active mode, fold-out legs enable spider-like walking and controlled maneuvers. Orientation data is used to improve locomotion control and assist transitions between rolling and walking behaviors. A custom app serves as the main control hub for testing motor function, viewing live orientation data, and sending movement commands such as walking or rotating. This project demonstrates a hybrid mobility strategy that combines passive environmental transport with active robotic locomotion.

Acknowledgements: USP - Undergraduate Scholars Program

SnowMaker

Claudia Schneider, Civil Engineering

Mentor(s): Samuel Verplanck, Civil Engineering

The main objective of this research was to modify an existing snowmaker in the Subzero lab to maximize yield producing high-quality snow. This is the second SnowMaker that the Subzero lab has had, and a few other similar machines exist in other labs in the world. This specific SnowMaker has failed to produce a substantial amount of snow in the recent past despite demand in the lab for snow during the summer months. For this study, the operating parameters were changed each week for five weeks. These parameters included the nucleation material of the machine and the fan speed setting. Qualitative and

quantitative measurements were taken each week, including amount of snow produced, shape and size of snow crystals produced, and temperature data of the machine. This was done for the ultimate goal of creating operating instructions for ideal performance as well as modification suggestions for the machine. Overall, the results showed that a changed nucleation material and method of snow removal produced the highest volume of snow. In the future, the way that the machine is operated will be changed. Additionally, when the next version of this machine is built, there are many design suggestions to be implemented.

Acknowledgements: USP - Undergraduate Scholars Program

Water Ice Phase Detection with Near-Infrared Spectroscopy

Aemon Sena, Mathematical Sciences; Hans Courrier

Mentor(s): Kevin Hammonds, Civil Engineering

Using imaging spectroscopy in near-infrared (NIR) wavelengths to detect and identify properties of ice, water, and snow is well studied in remote sensing contexts. This project looks to adapt remote sensing techniques to investigate and quantify frost nucleation and growth on the microscopic scale on horizontal substrates. Here, NIR spectroscopy can help to derive objective metrics for anti-frosting or icing coatings and allow faster scan cadences. This project proposed to develop two algorithms for use on NIR data. The first: a low-fidelity phase detection algorithm to predict the bulk phase of a pixel in NIR reflectance spectra using a three-band ratio scheme. The second: a higher fidelity algorithm to estimate the concentrations of frost and water in an NIR pixel using the entire bandpass with matched filter techniques. This second algorithm utilizes more spectral data and can therefore be used to derive more precise information about ice and water content in a pixel. Results from the phase detection model have demonstrated that NIR, in combination with a three-band ratio algorithm, has promise in detecting bulk phase in homogenous cases. Additionally, preliminary results of the matched filter algorithm suggest it can be used to derive the depth of frost and condensation. Future work could use similar matched filter or band ratio algorithms, in combination with NIR imaging spectroscopy, to derive morphological information about the ice crystals and condensation that form.

Acknowledgements: USP - Undergraduate Scholars Program

The Snowman Spherical Advantage: Evaluating Heat Transfer Enhancements of Micro-Structured Surfaces in Metallic 3D-Printed Microfluidic Devices

Boone Steinberg, Chemical & Biological Engineering; Yaofa Li, Mechanical Engineering; Erick Johnson, Mechanical Engineering; James Jackson, Mechanical Engineering

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

Abstract This study investigated micro-structured surfaces formed within laser powder bed fusion (LPBF) metallic microfluidic channels. Three distinct printing conditions examined: AISI 316 stainless steel with 20 μm resolution, AISI 316 stainless steel with 40 μm resolution, and titanium with 30 μm resolution. Surface morphologies were characterized using scanning electron microscopy (SEM) followed by quantitative image analysis. The analysis revealed that the size, density, and spatial orientation of surface spherical microstructures were strongly dependent on the selected material and print parameters. Across all samples, particle diameters exhibited comparable distributions, predominantly ranging from 10 to 40 μm. However, the titanium sample demonstrated significantly higher surface coverage, with approximately 23% of the surface occupied by spherical features, compared to approximately 12% coverage observed for both stainless-steel conditions. SEM observations also revealed a tendency for spheres to stack vertically, forming composite “snowman” geometries. The extracted surface morphology data were subsequently used to construct an initial heat transfer model within COMSOL Multiphysics®. A surface geometry was generated that randomly distributed spherical features consistent with the experimentally observed size distributions, coverage fractions, and stacking behavior. Numerical simulations considered single-phase laminar flow with air as working fluid. Ongoing simulations will determine the extent to which the spherical and stacked “snowman” microstructures influence heat transfer performance within the microfluidic channel, demonstrating the potential of additively manufactured surface features to enhance thermal transport. Figure 1. Steady state air through a microchannel with the structed surface on the bottom. Temperature gradients show the effects of heat transfer. Figure 2. Microstructures in the snowman microstructures have an impact on the fluid flow within the domain. Figure 3. Imaging processing software takes the SEM image and traces the spherical surface morphology.

Acknowledgements: USP - Undergraduate Scholars Program

Validation of OpenCap Kinetic Estimation During the Single Leg Vertical Jump Task

Sophia Stemler, Mechanical & Industrial Engineering; Alexandra Lynch, Mechanical Engineering

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

Assessing knee extension moment (KEM) can identify deficiencies after anterior cruciate ligament reconstruction (ACLR). However, data collection typically requires costly lab-based motion capture (MoCap), though OpenCap provides an affordable alternative using iOS devices. OpenCap kinematics are comparable to MoCap, though differences in kinetics remain unexplored. This study addresses that knowledge gap by comparing OpenCap and MoCap kinetics in the single-leg vertical jump (SLVJ). We hypothesized that OpenCap+simulation KEM estimates would strongly correlate with MoCap. Eight participants (4F/4M, 22.5±3.5yrs, 1.72±0.08m, 69.5±14kg) completed 3 SLVJ on their right leg. Trials were simultaneously collected with OpenCap and MoCap. MoCap kinetics were estimated in Visual3D. OpenCap kinetics were estimated with an OpenSimAD torque-driven simulation. Peak KEM (pKEM) values for propulsion and landing were normalized and averaged. A significant strong correlation was found between MoCap and OpenCap pKEM estimates in landing ($r=0.875$, $p=0.004$), while no significant correlation was found in propulsion ($r=0.435$, $p=0.282$). These findings may support the use of OpenCap+simulation to identify KEM asymmetries following ACLR, though underlying limitations in OpenCap kinetic estimation are evident. The importance of an accurate alternative to MoCap for clinical settings motivates further investigation. Future work should address other dynamic tasks and kinetic measures not investigated in this study.

Acknowledgements: USP - Undergraduate Scholars Program, M.J. Murdock Trust

Biomimetic Catalysts for Urea Hydrolysis: Investigating Ni-Zeolite Catalysts as an Alternative to Urease

Max Sterbis, Chemical & Biological Engineering; Imre Karaman, Chemical and Biological Engineering

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

Urea hydrolysis facilitates in situ precipitation of calcium carbonate, useful in fracture sealing and wellbore stabilization applications. Urease is the biological catalyst that makes this reaction possible, where a dinuclear Ni(II) active site initiates the process. But under thermal stress often encountered in subsurface geological environments, urease rapidly loses catalytic functionality. This work investigates thermally robust nickel exchanged zeolite catalysts (specifically, Ni-mordenite and Ni-ferrierite) where the guiding question asks are nickel active sites in zeolites capable of mimicking the function of urease? Minibatch reactors were charged with water, urea, and a catalyst, capped tight, and placed in a sand bath for two hours to evaluate reactivity at 80–150 °C. We compared 1, 2.5, and 5 wt.% Ni/zeolite catalysts against urease and uncatalyzed control samples. Urea conversion

was quantified using the colorimetric Jung assay calibrated against known urea standards, enabling direct comparison of catalytic performance. Preliminary results show differentiation between catalyst types and show that Ni-zeolites maintain activity under conditions where urease becomes thermally inactivated. It was also noted that autothermal decomposition of urea was minimal under the studied conditions (autogenous pressure) in the minibatch reactors. These findings suggest that in high temperature scenarios, synthetic analogs could potentially replace urease, facilitating urea hydrolysis. Additional studies are required to evaluate cementation rates and transport properties prior to deployment. The studied Ni-zeolite catalysts provide a unique opportunity to rapidly compare synthetic materials against benchmark enzymatic activity under myriad reaction conditions.

Acknowledgements: USP - Undergraduate Scholars Program

Examining Characteristics of Ice Cylinders with Perturbations and Other Irregular Cross Sections in Transverse Flow

Quaid Wetch, Mechanical & Industrial Engineering

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

Understanding how icebergs melt in ocean environments requires examining the flow of water around their surfaces. Although icebergs move slowly, their large size and complex geometries make direct observation difficult, so laboratory experiments must be conducted at a smaller scale. To simulate these conditions, ice cylinders with controlled surface perturbations were created to approximate the roughness of natural iceberg surfaces. The cylinders were formed using a silicone mold and subsequently pressed through a warmed ¼-inch aluminum plate, producing a slightly reduced diameter and a distinct surface seam that acts as a perturbation. Various other shapes were also tested in order to examine different geometries. This perturbation plays a critical role in the experiment because it allows controlled investigation of flow separation around the cylinder and other shapes. In previous experiments, separated flow generated a vortex structure in the wake of the cylinder, reducing the local melt rate of the ice. By introducing a defined perturbation—analogous to the seam on a baseball used to influence airflow—the separation point of the flow can be forced to occur at a predictable location. This enables systematic observation of how flow separation affects both the hydrodynamic behavior around the cylinder and the resulting melt rate of the ice.

Acknowledgements: USP - Undergraduate Scholars Program

Quantifying Flow Structures around Rowing Blades and their Effect on Propulsion

Caleb Young, Mechanical & Industrial Engineering; Ward Cerek Mechanical and Industrial Engineering

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

Rowing is a highly competitive sport that depends on precise blade interaction with the water, and the smallest differences can have large implications on performance. A newly introduced blade attachment, the RANDALLfoil, is hypothesized to improve stroke efficiency and limit blade slip, which is the rearward blade displacement that decreases efficiency through each stroke. While initial force measurement tests suggest the RANDALL foil produces higher propulsion, few studies have connected these to the fluid interaction around the blade. This study investigates the hydrodynamic efficiency improvements by quantifying flow structures on rowing blades, both with the RANDALLfoil and without. To test this, particle image velocimetry(PIV), and 6 axis force-torque measurements were performed at 1:4 scale of true rowing blade speed. These were done with 3-D printed blade models that were mounted to linear stages in a quiescent water tank. The PIV used in this experiment helped illuminate the neutrally buoyant tracer particles with a thin laser sheet that included multiple lasers. Images were then captured beneath the tank and stitched together across multiple fields of view and analyzed in MATLAB. The vorticity and circulation output from the PIV test testing, as well as the force comparison between each of the rowing blades, are an effective method to confirm whether the RANDALLfoil improves rowing stroke efficiency. Testing revealed increased circulation in the leading edge vortex (LEV) of the RANDALLfoil blade and higher force values throughout blade motion, corroborating that this attachment improves rowing propulsion and limits slip during the drive phase.

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HEALTH AND HUMAN DEVELOPMENT

Nourishing the Future: Enhancing Iron Intake in Tribal and Head Start Preschools

Livia Cole

Mentor(s): Shelly Hogan, NicoleKrueger

Iron deficiency, one of the most prevalent childhood nutrition issues, can impair cognitive development, growth, and school readiness. Children in rural and Indigenous communities

are disproportionately affected due to limited access to affordable, nutrient-dense foods and reduced dietary variety. This project partnered with Fort Belknap Head Start and One Community in Health (OCIH) to develop realistic, culturally relevant strategies to improve iron intake among preschool-aged children. A community-engaged, feasibility-focused approach guided this work. Working with Head Start leadership, the OCIH team identified key nutrition priorities, limited menu variety, rising obesity concerns, and persistent iron deficiency. Current Head Start menus and food sourcing limitations were reviewed, and iron-rich, batch-friendly snack recipes were developed to align with US Foods systems. Educational materials for children, families, and staff were also created, along with a staged implementation plan that included cost estimates and simple evaluation strategies. Findings showed strong engagement from Head Start leadership and a clear need for more variety and practical support for cafeteria staff. Several iron-rich snacks and draft menus were successfully developed and designed for large-scale preparation. Budget scenarios support both pilot testing and future expansion. This project highlights the value of community-driven, practical solutions to address early childhood nutrition disparities. By centering Indigenous leadership and focusing on what is feasible, this work offers a sustainable approach to improving iron intake during a critical stage of development. Future efforts will focus on pilot testing, expanding family engagement, and evaluating program impact.

Acknowledgements: USP - Undergraduate Scholars Program

Integrating Behavioral Health into the Northern Cheyenne School Based Health Center

Madison Doney, Nursing

Mentor(s): Laura Larsson, Nursing

Indigenous youth experience disproportionately high rates of mental health concerns, including anxiety, depression, and substance use disorders. The literature identifies historical trauma, geographic isolation, and limited access to holistic behavioral health services as contributing factors. School-based health centers utilizing multi-tiered systems of support offer a promising strategy to reduce barriers to care. The purpose of this project was to expand access to behavioral health screening, examine tiered systems of support, and establish a streamlined referral process for mental health interventions. Interviews with public health professionals, primary care and psychiatric providers, school-based care coordinators, and social workers informed the development of a three-tiered care map spanning universal education and screening, targeted early intervention and skill-building using single session interventions, and referral to specialized treatment when

indicated. Cross-agency collaboration resulted in recommended revisions to school-based consent forms to eliminate duplicative consent requirements. Additionally, monthly interdisciplinary meetings involving educators and clinicians across all tiers of care were established. The care map is prepared for implementation pending approval of revisions to the parental consent process.

I was not Wonder Woman and required help": Black, Latina, and White Women's Recovery from the COVID-19 Pandemic

Harry Foster, Health & Human Development; Cole Pierce, Health & Human Development

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

The pandemic disproportionately impacted women, and specifically Black and Latina women. There is limited research on long-term pandemic recovery experiences, particularly among underrepresented racial groups. Understanding the pandemic's lasting effects on people's experiences is essential for identifying and delivering appropriate professional support in the recovery process. The current exploratory mixed-methods study was designed to study Black, Latina, and White women's (N = 133) experiences with pandemic recovery. Quantitative results indicated that Latina women were more likely to report ongoing recovery ($p = .017$) compared to Black and White women, highlighting disparities and support needs. Four themes were identified through coding reliability thematic analysis, and participants discussed assessing risk, their physical lives, agency in the community, and fear and meaning-making in the context of pandemic recovery.

Acknowledgements: INBRE - IDeA Network for Biomedical Research Excellence

A Model of Intergenerational Trauma and Resilience Among American Indian Family Members Affected by a Loved One's Substance Use

Fiona Grubin, Health & Human Development

Mentor(s): Monica Skewes, Psychology

Research shows the disproportionate burden of substance use disorders (SUDs) on American Indian/Alaska Native (AI/AN) populations, a significant health inequity stemming from historical and ongoing colonization. Among AI/ANs, substance use is a form of coping with complex intergenerational trauma. Failure to account for the role of colonial trauma in SUDs would disregard the systems of oppression and subsequent stress driving substance

use and other health problems in Native communities. The Indigenist Stress-Coping Model (ISCM) offers a useful framework for understanding the role of colonialism in the etiology of SUDs among AI/ANs. The ISCM also communicates the importance of cultural buffers, including family and community, as powerful factors that can interrupt the pathway between colonial trauma and SUDs. Beyond the effects on individuals, SUDs have wide-reaching impacts on AI/AN communities and families. Affected family members (AFMs) are relatives who are impacted by a loved one's SUD and experience their own stress-related health challenges such as depression, anxiety, grief, and severe emotional distress. While family plays a foundational role in health and well-being for AI/ANs, colonization has ruptured family and community relationships, interrupting intergenerational transmission of knowledge and culture. Despite the pivotal role of family in SUDs among AI/ANs, there exists a dearth of research investigating the health and experiences of AI/AN AFMs. Research with AFMs from other populations underscores the importance of exploring AFM health and providing support, not only because AFMs are well-placed to promote recovery of their loved one with SUD, but also because AFMs deserve support in their own right. The Stress-Strain-Coping-Support Model (SSCSM) is a guiding framework that conceptualizes the pathway by which stress of a loved one's SUD leads to subsequent strain on AFM health, positing that social support and coping resources are two key factors that may disrupt this pathway. To further research on AI/AN AFM health, we propose the Indigenist-Stress-Strain-Coping-Support Model (ISSCSM), a blend of the ISCM and SSCSM that recognizes intergenerational trauma as a determinant of health and extends a theoretical understanding of how SUDs impact AFM health. Two key protective factors, social support and cultural buffers, have synergistic potential to impact both the individual with SUD and their AFM by moderating the pathways from trauma to SUDs and from SUD-related stress and strain to AFM health. Our proposed theoretical model will guide future research on AI/AN AFM health and well-being.

Skate-X Bindings Increase Forefoot Pressure During Skate Skiing

William Haig, Film & Photography

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

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In skate skiing, the binding pivot plays a central role, as in speed skating [1]. A commercial binding, Skate-X (SX), changes the hinge position, creating positive physiological changes

[2]. The influence on biomechanics of skiing remains unknown. This study compares plantar pressure differences between SX and traditional NNN binding.

On a motorized treadmill set to 14.5 kph at a 5% grade, an elite biathlete performed two five-minute trials each with NNN and SX bindings. Sampled at 120 Hz, average plantar pressure and time-in-phase for the forefoot, midfoot, and hindfoot across three phases: gliding, preloading, and pushing were obtained. A 2 x 2 repeated measures ANOVA evaluated average pressure differences and paired t-tests evaluated time spent gliding, preloading, and pushing.

There were significant binding x region interactions for the gliding ($F_{1,40} = 47.3$, $p < .001$), preloading ($F_{1,40} = 44.2$, $p < .001$), and pushing ($F_{1,40} = 36.2$, $p < .001$) phases. In the gliding and preloading phases, the SX binding increased pressure under the forefoot while decreasing pressure under the rearfoot (Figure 2). Glide time was not different between bindings ($p = .242$, $d = .186$). Preload time was longer ($p = .037$, $d = .337$) and push time was shorter ($p = .012$, $d = .412$). DISCUSSION The SX binding increases forefoot loading and reduces rearfoot loading across all phases, indicating a more forward body position. The longer preload and shorter push phases suggest more time is spent positioning the body over the ski, with the resulting forward position enabling more rapid force production during push-off.

The SX binding shifts plantar pressure in a way that appears advantageous for skiing mechanics. Additional research can determine if changes improve competition performance.

1. Houdijk, H. et al. (2002). J Applied Biomech. 18, 292-205. 2. Bolger, C.M. et al. (2016). PLoS ONE. 11(5), e01

A Framework for Evaluating Cultural Fit: Developing a Rating Tool for Pacific Islander Health Promotion Interventions

Madison Hewitt, Health & Human Development; Toni Ott, University of Utah

Mentor(s): Paul Estabrooks,

The phrase “culturally tailored” is often applied loosely in health programs intended for Native Hawaiian/Pacific Islander (NH/PI) communities, making it difficult to determine the depth and comprehensiveness of community adaptations. This project aimed to provide a set of concepts to address and describe cultural tailoring of interventions for NHPIs and create a reliable tool to assess its presence within health promotion interventions.

Drawing on literature, community insight, and personal experience, we identified five key domains of Pacific Island cultural adaptation: family and community values, faith integration, cultural activities and practices, traditional food and nutrition, and visual and language representation. The Hewitt-Ott Scale for Pacific Island-Based Cultural Adaptation was developed with 16 items scored 0 ("not addressed"), 1 ("partially addressed"), or 2 ("fully addressed"). To evaluate preliminary validity, two lifestyle interventions from the EMBRACE trial—one culturally tailored ("Ocean") and one not ("Mountain")— were independently coded by two raters using the scale.

Based on two coders, the "Ocean" intervention was visually superior to the "Mountain" intervention in (1) family and community values (average=1.03 vs 0.22), cultural activities and practices (average=0.92 vs 0.00), traditional food and nutrition (average=0.59 vs 0.17), and visual and language representation (average=1.29 vs 0.17). Faith-based integration did not differ between the interventions (average=0.79 Ocean vs 0.67 Mountain). When considered separately, the culturally tailored group, Ocean, received an initial rating of 4.61/10 possible points, where the comparison group, Mountain, received 1.22/10. We also compared ratings between two coders and found a correlation of r=0.89, representing a good inter-rater reliability.

The Hewitt-Ott Scale successfully differentiated culturally tailored interventions from generic ones, showing promise as a valid and reliable measure for evaluating cultural adaptation in Pacific Islander health promotion programs. Future applications across broader interventions and community contexts can enhance understanding of cultural tailoring's role in program effectiveness.

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Therapeutic Use of Hydrocortisone in Neonates: Outcomes and Trends

Carly Jensen, Microbiology & Cell Biology; Megan Ogle, University of Washington School of Medicine; Tim Sonnenberg, University of Washington School of Medicine; Chelsea Lockyear, Duke University Hospital Department of Pediatrics; Danny Benjamin, Duke Clinical Research Institute

Mentor(s): Danny Benjamin, Microbiology & Immunology; Jovanka Voyich, Microbiology & Immunology

Hydrocortisone (HC) is increasingly used off-label in neonatal intensive care units to treat bronchopulmonary dysplasia (BPD) in preterm infants. However, clinical practices remain

variable regarding treatment timing. This study characterized national trends in HC use from 2010–2022 and evaluated outcomes associated with early versus late administration.

We conducted a retrospective cohort study of 76,617 extremely preterm infants from 323 U.S. NICUs using the Pediatrix BabySteps Clinical Data Warehouse. Infants were categorized into three groups: no HC, early HC (dose ≤7 days of life), and late HC (dose ≥8 days). Demographic variables and clinical outcomes were compared using chi-square testing and nonparametric trend analysis.

Among the cohort, 4,438 received early HC and 4,008 received late HC. Treated infants had lower gestational ages and birthweights. BPD rates were 20% for untreated, 34% for early HC, and 62% for late HC groups. HC-treated infants also showed higher rates of necrotizing enterocolitis and intraventricular hemorrhage. While early HC use rose significantly over the study period, late HC use remained stable, and early treatment durations were generally shorter.

Increasing early HC use may reflect growing clinical confidence in its role in reducing BPD. However, substantial differences in baseline risk between groups emphasize the need for prospective studies that control for birthweight and gestational age to determine the independent effects of HC treatment.

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Language Disparities and Their Impact on Healthcare Access Among Latino Populations in the Gallatin Valley

Hayden Kaufman Schiller

Mentor(s): Sally Moyce

The Latino community in the Gallatin Valley is linguistically diverse, with individuals speaking Spanish, English, and a range of indigenous languages. While Spanish is dominant among many Latinos, recent immigrants may have limited proficiency in both English and Spanish, creating complex language barriers that affect healthcare access and outcomes. Limited English proficiency is associated with lower rates of preventative care, reduced health literacy, and greater mistrust in healthcare systems. Within the Latino community, Spanish-dominant individuals may not understand the linguistic needs of indigenous language speakers, causing internal communication challenges and social exclusion. Language barriers hinder effective communication and contribute to systemic inequities, including misdiagnoses and reduced patient satisfaction. Fear of discrimination or misunderstanding can also discourage individuals from seeking care. For this project, I

collaborated with the Proyecto SALUD research team to enhance health screening forms by assessing patients' proficiency in English and Spanish across speaking, reading, and writing, as well as the languages spoken at home, work, and in the community. Data collected is stored in REDCap, and we will analyze variables like language proficiency and languages spoken in different situations to examine their influence on healthcare experiences. Preliminary findings highlight that language disparities extend beyond English, with variations in Spanish fluency and indigenous language use, which impact patient understanding, satisfaction, and care. To address these gaps, we hope to implement a program for first responders to learn basic Spanish, promoting more effective care. Recognizing linguistic diversity is essential for improving health equity and patient outcomes.

Acknowledgements: USP - Undergraduate Scholars Program

Exploring the Energy Cost of Steady-State Motorized Treadmill Climbing Between Males and Females

Mia Lund, Health & Human Development; Dana Melton, Health & Human Development; Tianrun Aaron Chun, Health & Human Development

Mentor(s): Daniel Heil, Health & Human Development

Body mass is widely recognized as a primary determinant of climbing energy expenditure. Our previous study examined body mass (MB) scaling and metabolic rates during motorized treadmill (MT) climbing (Heil 2020). Although sex differences were not a primary focus, female climbers (n=4) expended relatively more energy than male climbers (n=16). PURPOSE: This study examined whether energy expenditure during MT climbing differs by sex. METHODS: Preliminary data from five males (Mean±SD: 20±1.2 yrs; 179.4±7.5 cm; 71.2±7.6 kg; 22.1±1.5 kg/m2 BMI) and five females (19±1.2 yrs; 163.2±7.5cm; 60±7.6 kg; 22.5±1.5 kg/m2 BMI) are included. Climbers completed 5 minutes of steady-state MT climbing under three grade/speed combinations (SG1: +8º at 4.5 m/min; SG2: +8º at 6.0 m/min; SG3: 0º at 6.0 m/min) and two routes per condition: Easy Route (ER, 22 hand holds), and Hard Route (HR, 18 hand holds). Climbers were randomly assigned a counterbalanced order of testing conditions. Steady-state energy expenditure (VO2, ml/kg/min) was determined by averaging the last 2 minutes per condition. VO2 was analyzed using 3-factor (Sex x Condition x Route) repeated measures ANOVA (α=0.01). RESULTS: No significant differences were found by sex ($p = 0.785$; 7.2 vs 7.5 ml/kg/min for females vs. males) or sex interactions($p=0.033$-0.765). Significant differences were found by condition ($p <0.001$). CONCLUSIONS: Preliminary findings suggest sex is not a

significant determinant of steady-state MT climbing energy cost. Higher energy expenditure in females from prior observations may reflect small size (n=4) and will be re-evaluated upon completion of data collection (n=20; 10 males, 10 females).

Traditional Masculinity Norms and Latino Men; A Scoping Review

Samuel Marshman, Microbiology & Cell Biology

Mentor(s): Sally Moyce,

Beyond systemic barriers, many Latino men are reluctant to seek mental healthcare due to certain stigmas surrounding machismo, or the masculinity ideology in Latino culture that stresses stoicism, emotional repressiveness, strength, and self-dependability. This cultural norm may further exacerbate mental illness. To understand this concept and how it impacts Latinos' mental health and their likelihood of accessing care, a scoping review of literature from the past 10 years was conducted. Key words included: (Latino OR Hispanic OR Latinx) AND (masculinity OR machismo OR caballerismo OR "masculinity norms") AND ("mental health" OR depression OR anxiety) AND ("help seeking" OR "access to care" OR "mental health services") to search Web of Science and PubMed databases. Articles meeting inclusion criteria were imported to Covidence to streamline the production of the scoping review. Articles that were relevant to the research question were included, and articles that did not fit the patient population or intervention were excluded. We identified 14 studies that will be analyzed for common themes and will be presented at the Undergraduate Scholars Presentation.

Acknowledgements: USP - Undergraduate Scholars Program

Mental Health Status of a Sample of Latino Immigrant Men In The Gallatin Valley

Samuel Marshman, Microbiology & Cell Biology

Mentor(s): Sally Moyce,

Latino immigrant men in the United States, and more specifically in Gallatin County, MT, face unique challenges in accessing mental health care, including language barriers, economic stressors, cultural differences, and fear of deportation. Additionally, the shortage of bilingual mental health providers creates a severe mental health desert. To understand the severity of anxiety and depressive symptoms among a sample of the Latino population in the Gallatin Valley, the prevalence of poor mental health among Latino immigrant men was statistically analyzed. At Proyecto SALUD primary care clinics,

depression was estimated using the Spanish version of the Patient Health Questionnaire-2 and Patient Health Questionnaire-9. Anxiety was estimated using the Spanish version of the General Anxiety Disorder - 7. Descriptive statistics were used to calculate proportions of depression and anxiety. Multiple linear regression models were used to examine the associations between outcome variables and sociodemographic factors. Regression analysis of the PHQ-9 showed that income predicted depressive symptoms: patients in the lowest income category ($0-$500) had significantly higher depressive symptom scores compared to higher income patients ($\beta = 2.35$, $p = 0.021$). Insurance status moderated these results. These results suggest that the relationship between income and depressive symptoms is conditional on access to health care coverage. These descriptive statistics reveal that economic hardships are a driver of depressive symptoms among Latino men in the Gallatin Valley and that access to health insurance is a critical barrier to care to protect the effect financial strain has on one's mental health.

Acknowledgements: USP - Undergraduate Scholars Program

Beyond the Pavement: Advancing Rural Health Equity and Built Environment In Choteau, Montana

Everlyne Onyinkwa, Health & Human Development

Mentor(s): Michelle Grocke-Dewey, Health & Human Development

Rural communities face persistent health inequities often tied to infrastructure and policy. In Choteau, Montana, a rural town of 1,700 residents, aging sidewalks, limited crosswalks, and seasonal hazards restrict safe walking and biking, especially for older adults and families. We examined how the built environment influences physical activity in order to make recommendations to increase physical activity, thereby improving various facets of physical and mental health for community members.

We used a convergent mixed-methods design guided by the Social Ecological Model. Surveys (n=67) measured physical activity, perceptions of infrastructure, and safety. Semi-structured interviews (n=7) captured residents' perspectives on barriers and opportunities for change.

Survey respondents overwhelmingly identified environmental barriers: 99% cited cracked sidewalks, 67% reported missing crosswalks, and 58% pointed to winter conditions. Interviews reinforced these findings as residents described inequities in sidewalk maintenance, limited signage, and unsafe intersections. Participants also noted seasonal challenges and gaps in infrastructure that restricted active living. Despite these barriers,

70% rated walkable routes as “very important,” reflecting strong community interest in built environment improvements as a means to increase walkability and bikeability for all ages and abilities.

Infrastructure, such as sidewalks, bike lanes, and safe crossings, functions as a public health intervention by promoting physical activity and reducing injury risks. By advancing equity-focused planning, implementing low-cost improvements (e.g., signage, benches, bike racks), and promoting policy advocacy, communities can foster activity-friendly, health-promoting rural environments.

Centering resident voices demonstrates the urgency of addressing infrastructure inequities and offers actionable strategies to promote rural health equity and physical activity.

Acknowledgements: EHHD

“What Is Congress Doing to Protect Our Kids?”: A Thematic Content Analysis of Congressional Hearings on Youth and Social Media Between 2020–2025

Melissa Rollins, English; Sophia Rotello, Health and Human Development; Lily Allen, Health and Human Development

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

This study examines how federal lawmakers and invited witnesses frame youth social media use during U.S. congressional hearings. Public discourse and research increasingly links adolescent social media engagement to concerns such as mental health challenges, academic difficulties, cyberbullying, suicide, and human trafficking, yet the ways policymakers construct and respond to these issues remain underexplored. Using a qualitative content analysis of federal congressional hearing transcripts (n = 17), three themes were identified: (1) child outcomes of social media use, (2) legislative and procedural processes around children's social media use, and (3) proposed solutions and future directions. Findings illuminate how congressional framing may influence public understanding and policy development surrounding child and youth digital well-being. There is bipartisan support for creating policy to enhance youth's health and safety in the context of social media, but congress has yet to act. The study highlights gaps in existing discourse and underscores the need for longitudinal research on youth outcomes, as well as comparative analysis of social media policies implemented in other countries that may inform future U.S. policy efforts.

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The Bayesian Knee: Uncertainty of Knee Position and Reliance on Sensory Priors Increases as Sensory Feedback Increases During Stepping Movements

Colten Smith, Health & Human Development; Trysten Morse, Education, Health & Human Development; Lilith Mueller, Education, Health & Human Development

Mentor(s): Tyler Whittier, Health & Human Development

Despite efforts to understand risk factors for knee injuries, these injuries remain prevalent in athletic, military, and healthy adults of all ages. Additionally, the rate of re-injury following a primary Anterior Cruciate Ligament (ACL) rupture remains high at approximately 40%. While traditional rehabilitation has yielded minimal effects, a growing body of evidence suggests that ACL injuries result in significant neural damage. One impactful impairment is the loss of crucial sensory receptors that inform the central nervous system (CNS) of vital information regarding the state of the knee during movement. This damage leads to impaired motor control leaving the knee susceptible to additional injury. In this study, we applied a Bayesian model to estimate the degree of uncertainty in the state of knee in healthy individuals during a full body stepping movement. The purpose of this study was to apply the principles of Bayesian motor control to understand knee control in healthy individuals performing an ecologically relevant stepping task. To address this purpose, 15 healthy young adults (5 females, mean age = 21.3 ± 1.5 years), performed a full body visuomotor adaptation task in virtual reality (VR). In this assessment, participants attempted to move a cursor into various targets with a one-legged step, compensating for cursor shifts under different levels of visual uncertainty. Motion of the cursor was controlled by a marker attached to the participant's knee. We hypothesized that as sensory feedback became more uncertain, participants would rely more on their sensory priors and have increased intrinsic uncertainty regarding the state of their knee. Results showed a significant increase in the bias toward sensory priors when estimating knee position as visual uncertainty increased ($p < 0.001$, $d = 3.95$). Additionally, the amount of intrinsic sensory uncertainty in estimates increased significantly as their visual feedback was limited ($p < 0.001$, $d = 0.60$). These findings support the use of Bayesian modeling to quantify sensory uncertainty during whole-body movement and provide a foundation for detecting clinically meaningful sensory impairments. Future work will extend this approach to ACL-injured individuals to uncover sensorimotor consequences of injury.

Sex Specific Differences in Squat Range of Motion

Summer Yeoman, Health & Human Development; Bryce Peterson, Food Systems, Nutrition & Kinesiology; Adrianna Yeats, Food Systems, Nutrition & Kinesiology

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

Previous studies have determined that women have a lower center of gravity, likely due to anatomical differences in the pelvis as women are proven to generally have larger, wider pelvises. However, little has been done to evaluate how this anatomical difference affects range of motion when it comes to squatting ability. The goal of this study was to determine sex differences in squat depths across both single reps and fatigued reps, through evaluating range of motion during a barbell back squat routine. To investigate this, trained subjects were asked to participate in an intense workout, followed by three testing days. Participants completed all sets of squats at 70% of their estimated 1-RM. Range of motion and velocity were recorded via a linear position tracker (RepOne Device, Version 0.7.4). Female participants (n=7) were found to have an average standardized ROM of 0.378 ± 0.049 mm ROM/ mm height (mean ± SD), while male participants (n=15) were found to have an average standard ROM of 0.384 ± 0.045 mm ROM/ mm height (mean ± SD) (t = 0.030). These numbers do show a significant difference between means. To summarize, the data reflects the notion of females having a higher relative range of motion compared to height when squatting. Understanding biomechanical differences between males and females during squat workouts is important to consider when developing a training program, as different variations between the groups may help reduce injury risk, as well as personalize training regimens for apex results.

HUMANITIES

The "Justified" Aggressor: Parallels between Henry V and Putin's Expansionist Rhetoric

Ava Fox, English

Mentor(s): Gretchen Minton, English

This research examines Shakespeare's Henry V in relation to Putin's invasion of Ukraine and the similarities between political war rhetoric across history and literature alike. The paper especially focuses on the ability for a leader to appear as a protector or "justified" through this rhetoric. Shakespeare's Henry V presents a war-driven King who justifies conflict through historical, religious, and strong nationalistic principles, all of which help solidify his position as a strong leader and create a perceived need for an unjust war. Similarly, the rhetoric of President Putin in the war on Ukraine also exploits spurious historical and nationalistic ties in Eastern Europe. By analyzing the political rhetoric used by Henry V and

Putin it becomes clear that narratives of war are not as ever-changing as it would seem. Rather, contemporary and historical conflicts rely on similar story-telling motifs and rhetoric as a way to create their own political narrative, which inevitably present authoritarian leaders as powerful, decisive, and ultimately justified in their pursuit of expansionist conflict.

Acknowledgements: USP - Undergraduate Scholars Program

Law & Labor : Trinidad & Tobago

Lukas Kosel, History and English

Mentor(s): Daniel Grant, History & Philosophy

Slavery existed in the British colonies in the Caribbean after the abolition of the slave trade in 1807. As such, African laborers were subject to labor in Trinidad and Tobago under the express system of slavery until the institution's deconstruction in 1834. However, labor exploitation continued further still, extending to other migrant labor groups. In addition to Black/African laborers, the Colonies of Trinidad and Tobago turned to indentured Chinese and Indian laborers to meet labor demands. These demands, though, were largely manufactured by the West Indian planters who owned the plantations; central to the narrative is that they specifically sought out foreign migrant laborers early on. In 1889, Trinidad and Tobago were unified into a single colony under British rule, and the conditions of their unification affected the trajectory of labor perceptions moving forward. Labor legislation, historical documentation, and census records indicate public and private perceptions of laborers and how they shifted over time. While there were changes before 1888, the unification of Trinidad and Tobago was the primary factor in a shift from reliance on foreign to local migrant labor forces in the islands.

Acknowledgements: Archivists at the National Archives of Trinidad and Tobago

"Their Bones Need Toil:" Understanding the Great Famine Through the Lens of Colonialism

Alexie Ratliff, History & Philosophy

Mentor(s): Daniel Grant, Department of History & Philosophy

The Irish Potato Famine, or Great Famine, is often examined by the damage the blight– known as phytophthora infestans– had on the potato crop and the ways it affected the

Irish's diet, as the Irish diet was heavily dependent on the potato. Instead, the Great Famine begs to be understood through the larger lens of colonialism that the Irish had been subject to since the twelfth century, with the British imposing power structures upon the Irish that failed to understand the needs of those under British rule. Focusing on laws such as the Irish Poor Laws and the Extended Poor Law of 1847, combined with the continued export of Irish crops at the height of the Great Famine, the British failed to provide adequate aid and instead further harmed a population that they deemed uncivilized in an effort to cull the population of Ireland in order to better enforce their traditions– namely their religion– on the population. Instead of only focusing on the blight as the culprit, it is necessary to understand how colonization fails to understand the local power structures and imposes laws aimed to 'civilize' and people that the British believed to be uncivilized due to their religion alongside their ways of life.

The World of the Dalai Lama: Buddhist Logic, Nagarjuna, and Quantum Physics

Alexander Strahn, History & Philosophy

Mentor(s): Prasanta Brandyopadhyay, History & Philosophy

His Holiness the Dalai Lama has argued that there are meaningful points of convergence between certain Buddhist claims and the findings of contemporary quantum mechanics (The Universe in a Single Atom, 2005). Drawing on Nagarjuna's Mūlamadhyamakakārikā (2nd century CE), the Mahāyāna Buddhist tradition advances doctrines such as saṃsāra and the ultimate emptiness (śūnyatā) of all phenomena, defending these claims through rigorous logical analysis.

In contemporary philosophy, scholars such as Mark Siderits, Graham Priest, Yasuo Deguchi, and Jay L. Garfield have drawn upon Buddhist logic—particularly Nāgārjuna's reasoning—to support and develop theories of dialetheism.

However, quantum physics has advanced significantly since 2005. In light of recent developments—such as quark-level entanglement, time-fractal structures, the Quantum Hall Effect, Relative Quantum Mechanics, and related theoretical innovations—together with their associated logical and philosophical implications, current research seeks to reassess the extent to which these developments may be meaningfully compared with classical Mahāyāna Buddhist thought.

Acknowledgements: USP - Undergraduate Scholars Program

Beyond Dichotomous Division in Emergence

Nolan Verrill, History & Philosophy; Gordon Brittan; Yves Idzerda, Department of Physics

Mentor(s): Prasanta Bandyopadhyay, History & Philosophy

Naturalistic dualists such as David Chalmers distinguish two types of emergence. Weak emergence involves higher-level properties that, although novel, are in principle deducible from lower-level properties, yet still require further explanation to become fully intelligible and to be shown as governed by underlying principles. Strong emergence, by contrast, is not deducible at all, with consciousness serving as Chalmers's central example.

We draw on Simpson's paradox (SP): the reversal of a trend when data is aggregated, to investigate the emergence of life. SP illustrates how population-level properties can arise that are absent at the level of subpopulations. Our aim is to develop a middle-ground account of emergence that lies between weak and strong emergence by applying SP to two competing theories of the emergence of life. Otherwise, we argue, one is forced to revise weak emergence in a way that introduces an additional shortcoming for naturalistic dualism, namely, a problem of weak underdetermination.

In response to a possible response from naturalistic dualists, we conclude that they have yet to provide an argument for there must be only two types of emergence and because of this there is room for another concept between the two Chalmers specifies.

Acknowledgements: USP - Undergraduate Scholars Program

MATHEMATICS

Learning the Potential for A Levitating Particle

Derek Jollie, Mathematical Sciences

Mentor(s): Scott McCalla, Mathematical Sciences

Levitating particles have been used to search for dark matter, to measure the electron magnetic moment, and to measure the gravitational constant. However, levitated particles vibrate, and it is challenging to extract the exact governing potential from this stochastic trajectory. We are using kernel regression and Gaussian process priors along with Bayesian optimization to extract the potential from measured particles satisfying a second-order Langevin equation. We hope to extract the governing potential in the magneto-gravitational trap with the desired accuracy and precision required for high precision measurements of the gravitational constant G. In addition, we show the effectiveness of machine learning

algorithms on stochastic physical data. With this learned potential energy surface, we will be able to measure the gravitational constant with precision never before seen, and it could assist in other experimental domains.

Acknowledgements: USP - Undergraduate Scholars Program

Statistical Analysis of Rock-Salt Deicer Performance

Connor Mizner, Mathematical Sciences

Mentor(s): Samidha Shetty, Mathematical Sciences

Snow and ice have a dramatic impact on road safety, worsening vehicle maneuverability and pavement grip. To reduce the risk of weather-induced roadway collisions, researchers aim to develop winter road management techniques that are both effective and inexpensive. In collaboration with the Western Transportation Institute at Montana State University, we use a custom-built trafficking machine to collect data on the performance of seven commercially available rock salt deicers in Montana. Over the course of four different road condition periods within a single experimental trial (dry pavement, initial compressed snow, trafficked snow with deicer, and plowed snow), we record friction measurements from the surface of the roadway. Over the entire data collection period, we conduct multiple experimental trials on combinations of deicer application variates and environmental condition variates. Given the hierarchical nature of the resulting data, we use mixed effect regression to capture latent experiment-level variation while isolating the impacts of deicer type, deicer application rate, initial snow density, and road condition on various friction summary measures (mean, median, maximum, minimum, variance). In addition, we investigate if the main effects for each variate differ by levels of other variates. We present the results of the analysis within the context of current winter road management standards, aiming to better inform practice in Montana and expand on the current body of research regarding in-lab assessment of decider efficacy.

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Predicting Continuous Dynamics of Gene Regulatory Networks by Boolean Models

Jolene Niglio, Mathematical Sciences

Mentor(s): Breschine Cummins, Mathematical Sciences; Tomas Gedeon, Mathematical Sciences

Analyzing the dynamics of regulatory networks is an incredibly well-researched area of study. My project contributes to this analysis by making a connection between two different regulatory network modeling frameworks. One framework is known as Dynamical Signatures Generated by Regulatory Networks (DSGRN). DSGRN computes the dynamics of a given regulatory network across all parameters for that network. These dynamics are predictions of how gene production in the network changes over time. Monotone Boolean functions (MBFs) are a natural subset of DSGRN. An open question that remains is how the dynamics of MBF parameters may inform the additional dynamics present in corresponding DSGRN parameters. Through the creation of rigorous definitions and examples, we are formalizing a construction of what we refer to as the transition set. We have utilized this construction to draw connections between the dynamics generated by monotone Boolean functions and those generated by DSGRN.

Acknowledgements: USP - Undergraduate Scholars Program

Addressing the Generalized Multivariate Behrens-Fisher Problem in High-Dimensional Data

Korathotage Lakviru Perera, Mathematical Sciences

Mentor(s): Mark Greenwood, Mathematical Sciences

This research addresses a critical limitation in the standard Permutational Multivariate Analysis of Variance (PERMANOVA), specifically its sensitivity to unequal group variances (heteroscedasticity). In high-dimensional distance-based situations, test statistics such as the standard pseudo-F (F1) can produce misleading results, with inflated Type I error rates. This is a challenge known as the Generalized Multivariate Behrens-Fisher problem. This study investigates the effectiveness of the recently proposed statistic, F2, as a solution to this problem in distance-based hypothesis testing.

We utilized a simulation-based approach to compare the performance of the statistics F1 and F2. Synthetic high-dimensional datasets were generated with varying degrees of heteroscedasticity. Our findings demonstrate that F1 is consistently misled by heteroscedasticity, yielding smaller p-values ($p < 0.05$) even when group locations are identical. Conversely, F2 maintained nominal Type I error rates reasonably well by correctly partitioning location differences from dispersion effects. We developed the F2Adonis2 R package, providing a user-friendly tool for researchers to evaluate shifts in group centers in the presence of unequal noise levels. To demonstrate the use of F2 and our R package, the results are applied to real-world biological datasets.

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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 conducted bacterial growth curve analyses in human blood assays to identify and correct procedural errors, resulting in a polished protocol. This refined methodology will now be applied to compare growth patterns across three bacterial strains. 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 the 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 Aqp3b as an Upstream Regulator of FGF Signaling and Xbra Expression

Ava Banionis, Microbiology & Cell Biology

Mentor(s): Christa Merzdorf, Microbiology & Immunology

The fibroblast growth factor (FGF) pathway is a signaling pathway contributing to the activation of the noncanonical Wnt/PCP pathway via the Wnt11 ligand, and thereby central nervous system (CNS) development in early vertebrate embryos. Aqp3b is a transmembrane protein responsible for the transport of water, glycerol, and small, polar, uncharged molecules. Research in the Merzdorf lab has shown Aqp3b as necessary noncanonical Wnt/PCP signaling, causing coordinated cellular movement resulting in convergent extension (CE), but the mechanism through which Aqp3b-mediated regulation occurs is unclear. Gastrulation establishes the three germ layers of the embryo; CE first occurs in gastrulation. During CE, dorsal marginal zone (DMZ) cells of the mesoderm change shape and intercalate to produce a narrow band of cells, the notochord. The notochord is a signaling center inducing overlying ectoderm to become neural and later give rise to the CNS. Research in the Merzdorf lab implicates Aqp3b as an upregulator of FGF signaling. FGF signaling is necessary for Xbra expression. Xbra is a known upregulator of Wnt11 and target genes of Xbra may contribute to CE through Wnt/PCP. Aqp3b knockdown causes Xbra downregulation, implicating Aqp3b as an upregulator of Xbra. Confirming Aqp3b as a regulator of Xbra expression, and therefore CE, will be determined through western blot of X. laevis embryos treated to upregulate or inhibit Aqp3b. Revealing the cellular signaling process through which aqp3b contributes to Xbra expression is necessary to understand the mechanisms through which CE is regulated, the notochord is formed, and therefore the CNS.

Acknowledgements: USP - Undergraduate Scholars Program

The Potential of Fungal Scaffolds for Biomineralized Engineered Living Materials Striving Toward Sustainable Concrete

Alexis Behn, Chemical & Biological Engineering

Mentor(s): Chelsea Heveran, Mechanical & Industrial Engineering; Ethan Viles, Mechanical & Industrial Engineering

Concrete is the most widely used construction material, yet its production contributes to nearly 8% of global CO_2 emissions, driving the need for sustainable alternatives. Biomineralization, performed by microorganisms, offers a pathway to manufacture construction materials with potentially reduced environmental impact. Incorporating microbes into these materials introduces living functionalities, such as self-healing properties. As a result, Engineered Living Materials (ELMs) represent a promising approach to sustainable, biologically integrated alternatives to conventional concrete. Mycelium has been shown to scaffold bacterial biomineralization and improve viability of the

biomineralizing bacteria, S. pasteurii. However, the mechanisms behind the improved viability remain unknown. Further, other species of fungi have not been explored yet for optimizing this system. Here we investigate two different species of fungi for optimizing the manufacturing of biomineralized ELMs and how mycelium scaffolds improve the viability of S. pasteurii. The growth rates of two species of fungi, N. crassa and F. venenatum, were investigated because the large-scale manufacturing of these systems relies on the ability to rapidly produce mycelium. Additionally, the ability of S. pasteurii to attach to the mycelium scaffold and its ability to feed off the mycelium were investigated to further elucidate mechanisms behind improved viability. The growth rates of these two organisms were investigated in malt broth media and modified Vogel's media. N. crassa cultured in Vogel's media had the highest growth rate of all conditions. Based on these results, N. crassa was used for the following investigations. Qualitative confocal data in preliminary attachment studies showed entrapment of S. pasteurii cells within the mycelium. Further attachment experiments are ongoing to confirm if S. pasteurii attaches to the scaffold. To understand if S. pasteurii can feed off of the mycelium scaffold, we will perform growth studies of the bacteria cultured in phosphate buffer saline supplemented with mycelium scaffolds. These findings inform organism and media selection for ongoing ELM development and further the potential of fungal-bacterial systems to improve the sustainability of our built environment.

Acknowledgements: USP - Undergraduate Scholars Program

Testing the Effectiveness of Novel Antimicrobial Peptides Against Diverse Bacterial Strains

Brooke Binando, Microbiology & Cell Biology

Mentor(s): Mensur Dlakić, Microbiology & Immunology

Antimicrobial resistance (AMR) is an escalating international health crisis that reduces the effectiveness of existing antibiotics and increases mortality from bacterial infections. This study strives to evaluate the antimicrobial potential of novel peptides identified from natural reservoirs via proteome mining, with the objective of identifying alternative treatments that may directly prevent deaths from AMR infections. Seven antimicrobial peptide candidates selected from Yellowstone Lake sites and Washburn Hot Springs, predicted using the deep learning-based proteome mining (APEX) method, will be tested. Peptide sequences were back-translated into DNA, codon-optimized for Escherichia coli, and cloned into expression vectors. Following transformation and expression, peptides were purified and tested in vitro against a range of clinical and non-clinical bacterial

strains. Antimicrobial activity will be assessed using growth curve analysis generated from microplate reader assays across different peptide concentrations. Predicted results include inhibition of bacterial growth by one or more peptides. Based on previous studies, several peptides are expected to exhibit antimicrobial activity, with effects such as reduced growth rates or a lack of growth at specific concentrations. Two candidates were tested briefly, and did not significantly affect E. coli growth compared to the control. The structures of these peptides need to be verified, and each peptide requires further testing. The production of several peptides is currently being optimized and will be tested for antimicrobial activity. This study will provide insight into the effectiveness of these unexplored reservoirs. Identification of potent candidates may contribute to the development of new treatments that address antibiotic resistance in healthcare.

Acknowledgements: USP - Undergraduate Scholars Program

Exploring How Diet Modulates Jamaican Fruit Bats' Anti-Viral Response

Connor Buchanan, Ecology

Mentor(s): Agnieszka Apple, Microbiology & Immunology; Heather Walk, Microbiology & Immunology

Bats can host many viruses – often very lethal viruses – without developing severe illness. Understanding how they achieve this homeostasis could reveal new insights into immune regulation and the factors that influence viral spillover to other species. This project investigated how diet affects Jamaican fruit bats' anti-viral immune response. Current research suggests that type I interferon (IFN-I) cytokines, proteins part of the immune system's early anti-viral defense, help control viral shedding in bats. However, the regulation of the IFN-I pathway in bats is poorly understood. In this experiment, the induction of the IFN-I pathway in response to bat influenza virus (H18N11) in bats fed different diets was investigated. Inhibitory interferon-stimulating genes, specifically USP18 and SOCS1/3, are known to increase in activity before the antiviral gene MX1 declines in expression. The existence of this trend in bats would suggest that bats' immune system suppresses their anti-viral immune response to prevent overactivation while also suppressing viral expression. To test this hypothesis, gene expression was analyzed using quantitative PCR (qPCR) on preserved bat rectal swab samples collected under various dietary experimental conditions in previous experiments. While the inhibitory ISGs' data were not significant, it was found that suboptimal-fat diet bats had the least viral shedding compared to the two other dietary groups.

Acknowledgements: USP - Undergraduate Scholars Program

Determining the function of a PHP-ATPase based antiviral defense system in bacteria

Danielle Cahill, Microbiology & Cell Biology

Mentor(s): Blake Wiedenheft, Microbiology & Immunology

Bacteriophages (phages) are viruses that infect and replicate within bacteria. Phages are the most prevalent and diverse biological entities on Earth, imposing an immense selective pressure on bacteria, which has led to the to the evolution of immune systems that protect the cell from infection. Many of these bacterial immune pathways rely on unique enzymes and mechanisms that remain largely unexplored, yet past discoveries demonstrate that these immune systems have activities that can be creatively repurposed for transformative applications in biotechnology, medicine, and agriculture (e.g. CRISPR-Cas). One such defense mechanism, named Ppl, is a PHP-ATPase protein fusion that acts as an immune response against T3, T7 and λ phages. Recently, Ppl was classified as a dual-signal lethal defense system, where the ATPase domain detects decreased cellular nucleotide triphosphate (NTP) pools and releases the PHP nuclease to cleave host genome 3' hydroxyl overhangs, killing the cell. We hypothesize that the lambda-derived gam protein, which inhibits recombinant repair pathways in the cell, activates the Ppl immune response during phage infection. We first test this hypothesis with co-expression toxicity assays and then use the gam protein to further elucidate ppl nuclease activity. This demonstrates the Ppl system's potential to act as a tightly controlled tool that can be used to cleave specific DNA substrates, opening up avenues for biotechnical utilization.

Investigating the honey bee antiviral defense mechanisms

Evelyn Graham, Microbiology & Cell Biology; Hunter Charles, Plant Sciences & Plant Pathology; Naomi Kaku, Plant Sciences & Plant Pathology

Mentor(s): Michelle Flenniken, Plant Sciences & Plant Pathology

Honey bees (Apis Melifera) are important plant pollinators in the US and around the world. However, pathogens and agrochemical exposure have led to high average annual colony losses since 2008. Positive-sense single-stranded RNA viruses have been a primary factor in declining colony rates, including deformed wing virus (DWV) and sacbrood virus (SBV), but infection is often asymptomatic (Parekh et al., 2021). Multiple experiments are underway in the Flenniken lab to determine the impact of inapparent viral infection on individual honey bee fitness. For example, graduate student Naomi Kaku studied flight assays as a proxy for honey bee health, as well as the effect of heat stress and virus on

honey bee heat shock protein expression (Kaku et al., 2025). These projects have exposed me to academic research techniques and skills, including quantitative PCR (qPCR), RNA extraction, cDNA synthesis, and data analysis utilizing statistical programs (R). Most recent work has been with graduate student Hunter Charles to understand the relationship between thyme oil, a phytochemical and putative immune stimulant, and virus abundance (Parekh et al., 2021). It was hypothesized that virus abundance would be lower in honey bees fed varying doses of thyme oil augmented sucrose sugar, compared to bees fed sucrose syrup alone. Using qPCR and gel electrophoresis to analyze the data, thyme oil was found to act as an immunostimulant and resulted in reduced levels of virus infection. Further research and real-world applications are needed to confirm the impact of these findings.

Acknowledgements: USP - Undergraduate Scholars Program

On-Chip In-Drop RT-qPCR Microfluidic Device

Chris Gritzmaker, Chemical & Biological Engineering; Grace Ducharme

Mentor(s): Emma Loveday, Microbiology & Immunology

Analysis of RNA via conventional bulk RT-qPCR can be a valuable tool; however, current methods obscure cellular heterogeneity within the sample, as they are performed on bulk cellular material rather than at the single-cell level. Due to the lack of understanding of the heterogeneity, there is limited knowledge of nucleic acid kinetics within individual cells. This project aims to continue to develop a microfluidic device that can immobilize single droplets, each containing a single infected cell, in a manner compatible with a programmable thermocycler, enabling on-chip in-drop RT-qPCR. Droplet identity will be maintained consistently throughout the RT-qPCR process, revealing how viral particle production varies across infected cells. The device is fabricated by bonding embossed thermoplastic elastomer components to glass slides or alternative substrates. The device design and fabrication are ongoing, as device geometry and bonding protocols are being refined to meet functional specifications. Preliminary results demonstrate successful droplet immobilization within the device; however, bubble formation and bond lifting have been identified as key technical challenges that are under investigation. The primary application within the Loveday Lab will be to quantify viral RNA expression and characterize cell-to-cell variation in viral particle production from primary nasal cells, with successful validation positioning the platform as a generalizable approach for studying transcriptomic heterogeneity across cell types and disease contexts.

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Mapping Orthobunyavirus Proteins that Mediate Neuroinvasion in Human Brain Endothelial Cells

Katherine Hanson, Microbiology & Cell Biology

Mentor(s): Alyssa Evans, Microbiology & Immunology

The California serogroup (CSG) of orthobunyaviruses contains mosquito-transmitted viruses that can cause neurological disease in both children and adults. La Crosse virus (LACV) is the leading cause of pediatric encephalitis in the United States while James Town Canyon virus (JCV) is more commonly associated with neurological disease in adults. LACV is both neuroinvasive, capable of crossing the blood brain barrier (BBB), and neurovirulent, causing disease within the brain. JCV is neurovirulent but not neuroinvasive. The viral M segment, which encodes for two virion glycoproteins (Gn and Gc) as well as a non-structural gene (Nsm), has been linked to differences in neuroinvasion. This study aims to determine which M segment-encoded gene enables LACV to cross the BBB while JCV cannot. Human brain endothelial cells (HBECs), the primary cell type of the BBB, were infected with LACV and JCV, and host responses to both viruses were analyzed with quantitative polymerase chain reaction. Ongoing experiments focus on generating chimeric viruses by swapping genes in the M segment. Infection of HBECs with these chimeric viruses will identify which M segment-encoded gene is responsible for eliciting different host responses between LACV and JCV. This poster will clarify baseline differences in host responses to LACV and JCV as the first step in identifying which viral gene allows for neuroinvasion.

Acknowledgements: USP - Undergraduate Scholars Program

Determining the Relationship Between Aquaporin-3b and Calcium Transients in the Neural Plate

Joshua Harrington, Microbiology & Cell Biology; Josephina Moretti, Chemical and Biological Engineering

Mentor(s): Christa Merzdorf, Microbiology & Immunology

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

Neurulation is the closure of the neural tube, the embryonic precursor to the spinal cord and brain. When neurulation goes awry, birth defects such as spina bifida, anencephaly, and craniorachischisis can occur. These birth defects are life-threatening. 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, we have performed live time-lapse imaging of Xenopus laevis frog embryos injected with a Ca2+ fluorophore and developed a program to analyze the time-lapse series for calcium waves. Aqp3b is inhibited in the embryos using a morpholino oligonucleotide (MO). A control MO and uninjected embryos have been used to ensure validity. Post-imaging the embryos are left to develop until a separation between the neural ectoderm and dorsal mesoderm can be identified to ensure on-target injections. This year we performed the fertilizations, injections, and imaging, and perfected the Python program. We hypothesize that Aqp3b helps regulate calcium waves during apical constriction, a fundamental process for neurulation. We expect to see a change in amplitude, length, and amount of calcium waves when aqp3b translation is inhibited.

Acknowledgements: USP - Undergraduate Scholars Program

PRC2 silences Abd-B to promote gastric cell development

Rachel Hertz, Chemistry & Biochemistry; Dave Lyons, Micobiology & Immunology

Mentor(s): Steven DeLuca, Microbiology & Immunology; Samantha Baker, Microbiology & Immunology

Copper cells are acid-producing, mitochondria-rich cells in the Drosophila middle midgut region, and have copper-induced fluorescence, whereas interstitial cells provide structural support and help maintain gut homeostasis.[BS1.1] Both cell types originated from a common intestinal stem cell. These cell types parallel human gastric lineages and share conserved developmental pathways, which makes the Drosophila stomach a good translational model for understanding epithelial differentiation and how its disruption can lead to metaplasia or carcinogenesis. This project investigated how polycomb-mediated gene silencing contributes to gastric cell differentiation and development, focusing on the repression of the Hox transcription factor Abd-B. Abd-B silencing is hypothesized to be a factor in gastric cell differentiation. Polycomb Repressive Complex (PRC2) is an epigenetic silencing complex that modifies chromatin to silence genes. RNA interference was used to deplete E(z), the catalytic subunit of PRC2, to test whether loss of H3K27me3 dependent silencing affects Abd-B expression in gastric cells. Transcriptomic profiling revealed that Abd-B became one of the highest-abundance transcripts upon E(z) knockdown, which

indicated silencing. Fluorescence imaging validated these findings at the protein level and showed Abd-B expression in E(z) RNAi stomachs. These results support a model in which PRC2 silencing is required for proper gastric cell differentiation. This work focused on early molecular level outcomes, and phenotypical results were not yet established. These findings highlighted the importance of epigenetic silencing in gastric cell differentiation and suggest that future studies should examine how PRC2 interacts with additional transcriptional regulators to stabilize gastric cell fate.

Investigating the oligodynamic effect in slime molds and its effects on various metals, surface and bulk properties

Matthew Mayes, Microbiology & Cell Biology

Mentor(s): Bret Davis, Physics

This project investigates the oligodynamic effect on a slime mold (an ameoboid eukaryotic protist). The oligodynamic effect explains the toxicity of certain metals against bacteria and has long been utilized in anti-microbial applications. This research aims to determine whether Physarum polycephalum will distinguish and navigate around potentially toxic metals (gold, silver, copper, rhodium, nickel, iron, tantalum, silicon, tungsten, iridium, platinum, tin, and indium) when moving towards a food source, the impact said metals may have on its physiology, and the induced chemical changes to the metals both on their surfaces and in the bulk. A slime mold moves across the landscape by branching and growing its plasmoidal body in the direction of nutrients or more livable conditions. P. polycephalum is a unique slime mold that has demonstrated a rudimentary intelligence by solving mazes and avoiding toxic substances. Despite bacteria being thoroughly examined, the consequences of the oligodynamic effect on slime mold have yet to be understood. Various metal samples will be placed within the slime mold environment to ascertain if they will influence the paths taken by the slime mold. Surface and bulk elemental analysis (by Auger electron spectroscopy and energy dispersive spectroscopy), as well as high-resolution imaging by scanning electron microscopy, will be used to analyze the metals before and after exposure. Time-lapse photography will be used to determine the paths taken by the slime mold. Findings from this project could be applied to fields such as engineering or medicine, including its use as an advanced biological sensor.

Acknowledgements: USP - Undergraduate Scholars Program

Detection of Herpesvirus in Montana Fish Populations

Odhran McLaughlin, Microbiology & Cell Biology

Mentor(s): Zoe Pratte, Microbiology & Immunology; Frank Stewart, Microbiology & Immunology

Since 2022, Montana fish populations have experienced a concerning condition characterized by severe cranial lesions. This potential emerging disease has been observed across multiple freshwater systems, including Big Hole, Beaverhead, and Ruby Rivers, and may be linked to broader population declines. While prior investigations identified Aeromonas sobria and other bacteria associated with afflicted fish, these microbes may represent secondary infections rather than primary causative agents of disease. Here, we investigate whether herpesvirus, a known cause of dermatological lesions in fish, is associated with this emerging condition. We used PCR to screen for conserved herpesvirus genes in 889 fish swab samples collected between 2023 and 2025 for health surveys by Montana Fish, Wildlife, and Parks, a collaborator in this project. This screen did not yield positive amplification, although a negative result may be due to strain divergence from our PCR primers or low viral abundance in the samples. To complement a PCR-based screen, we applied shotgun metagenome sequencing to a subset of samples. The resulting data are being assembled into contigs, which will then be analyzed using VirSorter2 to detect viral sequences. Potential herpesvirus matches will be validated through BLAST searches against reference databases. The results will help assess herpesvirus presence in affected wild fish populations for which confirming, or ruling out, a viral etiology would advance understanding of this emerging health concern and inform management strategies for Montana's fish populations. This work complements ongoing efforts to identify drivers of aquatic population declines and support the conservation of freshwater biodiversity.

Acknowledgements: USP - Undergraduate Scholars Program

Photophysical Characterization of Fluorous Rhodamines with Different Counterions

Brekken Meznarich, Microbiology & Cell Biology; Helen Lin, UCLA - Department of Chemistry and Biochemistry; Ellen Sletten, UCLA - Department of Chemistry and Biochemistry

Mentor(s): Mikhail Drobizhev, Microbiology & Immunology

F68Rhodamine+ (FR+) is a novel fluorophore made to visualize perfluorocarbon (PFC) nanoemulsions. PFC nanoemulsions are biologically inert (they occupy an orthogonal phase; neither organic nor aqueous) and are used in medicine to deliver oxygen to cells. Recent focus is on their distribution within cells, as their applications in research are still

being investigated. For FR+ to be optimally used in imaging, the one and two-photon photophysical properties must be determined. Two-photon (2P) characteristics are of particular importance as 2P methods allow deeper imaging and higher spatial resolution. The photophysical characteristics of fluorophores are altered by their molecular environment and solvent. FR+ was paired with fluoruous counterions of different sizes (smallest to largest: chloride-, BArF-, OMeBArF-, GBArF-). Each pair was tested in two solvents: hexafluoro-2-propanol (HFIP, polar) and perfluorooctyl bromide (PFOB, nonpolar). The absorption spectra, fluorescence emission and excitation spectra, fluorescence quantum yields, and lifetimes of each were measured. These are important for fluorescence imaging applications, including confocal microscopy, super-resolution microscopy, and fluorescence-lifetime imaging microscopy (FLIM). The 2P characteristics necessary for 2P fluorescence microscopy (2P fluorescent spectra, cross sections, and polarization ratio) were also discovered.

In HFIP, much of the individuality between the different counterion pairs was obliterated. The FR+s had very similar maximum absorption, excitation, and emission wavelengths and quantum yields. Though there was a difference in the two-photon characteristics, everything suggests poor association of the counterions due to HFIP's polarity. Furthermore, there was great variance in these characteristics in PFOB, suggesting a much closer association. This allowed for the identification of trends between the size of the counterion and these characteristics (e.g., the quantum yield increases dramatically with larger counterions, 0.21 to 0.93). This suggests that the molecular conformation is being influenced by the counterion, with extreme effects on its photophysical properties.

Mechanisms of Developmental Regulation in Drosophila melanogaster

Chloe Nelson, Microbiology & Cell Biology

Mentor(s): Steven DeLuca, Microbiology & Immunology

Hox genes determine the segmental patterning of vertebrate embryos from anterior to posterior. These genes aid in cellular differentiation, the process of determining the function of a cell through modifications to gene expression. Hox genes are involved in the development of many human cancers, making this research relevant to furthering cancer identification and treatment.

The purpose of this research is to uncover the mechanistic regulation of Hox genes in the model organism Drosophila melanogaster. Previous research has concluded that two groups of proteins, Polycomb Group (PcG) and Trithorax Group (TrxG), inhibit and promote Hox gene expression, respectively. Preliminary models of Hox gene regulation propose that

a prominent PcG protein, Scm, forms large aggregates on Hox genes, inhibiting their expression in improper segments. Two proteins of interest, tna and velo, alter the aggregate size and subsequent effectiveness of Scm polymerization and silencing. It is not understood the extent to which tna and velo alter the activity of Scm nor the interactions between the proteins. Uncovering the regulation of Scm contributes to an understanding of Hox genes and developmental patterning.

To uncover the interactions between these proteins and DNA, genome analysis will be performed using chromatin immunoprecipitation (ChIP). This data will indicate the DNA targets of the proteins of interest beginning the elucidation of their interactions. To dive further into the effects of tna, velo, and Scm on Hox genes, RNAi will also be used to observe phenotypic abnormalities in embryos.

Acknowledgements: USP - Undergraduate Scholars Program

The Role of Gut Microbiota in Modulating Arsenic-Induced Bladder Toxicity Following Antibiotic Treatment

Alexandria Neumann, Chemistry & Biochemistry

Mentor(s): Trenton Wolfe, Microbiology & Immunology; Seth Walk, Microbiology & Immunology

Arsenic is a common environmental contaminant and a known human carcinogen linked to bladder cancer and other chronic diseases. Although the harmful effects of inorganic arsenic are well established, the biological factors that influence how the body responds to arsenic exposure are not fully understood. Recent research suggests that the gut microbiome plays an important role in regulating arsenic metabolism and toxicity. This project examines how disruption of the gut microbiota by antibiotics affects arsenic-induced damage in the bladder.

Building on previous work from the Walk Lab, which showed that co-exposure to the antibiotic cefoperazone (CEF) and sodium arsenate (iAsV) increases bladder damage in mice; this study will focus on a more toxic form of arsenic, sodium arsenite (iAsIII). Wild-type (WT) and As3mt-knockout (As3mt-KO) mice will be exposed to 20 ppm iAsIII with or without CEF for seven days. Bladder tissues will be analyzed using field emission scanning electron microscopy (FE-SEM) to evaluate tissue damage. Arsenic levels and forms in tissue, urine, and stool will be measured using LC-ICP-MS, and RT-qPCR will be used to assess gene expression related to arsenic metabolism.

We hypothesize that disrupting the gut microbiome with antibiotics increases susceptibility to arsenic-induced bladder damage, even in WT mice that are normally resistant. This study will improve understanding of how the microbiome influences arsenic toxicity and helps inform environmental health risk assessment.

Acknowledgements: USP - Undergraduate Scholars Program

Investigation into the Metabolic Profile of Loaded MLO-Y4 Cells

Casey Odegaard, Center for Biofilm Engineering

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

Abstract: Osteocytes respond to the flow of nutrients and waste in the lacunar-canalicular system (LCS) [1,2]. The degree of shear stress promotes mRNA expression of pathways that lead to catabolism or anabolism [2]. Osteocytes are known to downregulate RANKL/OPG and upregulate COX-2, key effectors in the anabolic response, due to specific levels of fluid flow shear stress (ffss) [2]. Osteocyte metabolism is largely unknown, thus the relationships between metabolism and ffss are to be discovered [3]. This research aims to determine osteocyte metabolism due to ffss and to consider its capabilities in stimulating anabolic bone remodeling. MLO-Y4, osteocyte-like cells, will be subject to an environment of ffss in ranges of (0-35 dynes/cm2) for durations of (1-4 hours) and in oscillating fluid flow (OFF) models, at rates of (0-2 Hz). The results are expected to show the promotion of an anabolic response in OFF but a catabolic response in steady flow [4]. An untargeted metabolomic analysis will be conducted to highlight key metabolic pathways of interest. In order to quantitate these pathways of significance a targeted metabolomic analysis will be conducted to obtain specifics on osteocyte metabolic profiles that express pro-anabolic signals. The results of this study will help us in the progression of novel diagnostics and treatments of degenerative bone disease.

Acknowledgements: USP - Undergraduate Scholars Program

The effects of Aqp3b expression and inhibition on Gsc and Xbra

Abigail Pilskalns, Microbiology & Cell Biology

Mentor(s): Christa Merzdorf, Microbiology & Immunology

During Xenopus gastrulation, coordinated cell behaviors, which include cell migration and convergent extension, are essential for establishing the three germ layers. These processes

are regulated by the antagonistic transcription factors Goosecoid (Gsc) and Xbra, which function as a molecular switch to ensure cell migration in the prechordal mesoderm and convergent extension in the chordamesoderm remain spatially distinct. Aquaporin 3b (Aqp3b), a membrane channel protein facilitating water and glycerol transport, has been implicated in gastrulation. Still, its regulatory relationship with Gsc and Xbra in whole embryos is not yet fully understood. This study investigates whether Aqp3b expression and inhibition produce consistent effects on Gsc and Xbra across experimental contexts.

RT-PCR experiments in animal caps and Keller explants previously demonstrated that Aqp3b overexpression increases Xbra and decreases Gsc expression, while morpholino-mediated inhibition of Aqp3b produces the opposite pattern. To test whether these findings extend to whole embryos, in situ hybridization was performed on Xenopus embryos at stages 11.5–12. Aqp3b inhibition decreased Xbra expression, consistent with prior results. However, Gsc showed an unexpected response: Aqp3b expression increased rather than decreased Gsc expression, suggesting the relationship between Aqp3b and Gsc may be more complex than previously indicated.

Acknowledgements: USP - Undergraduate Scholars Program

Diffusion of Small Molecule Inhibitors in Agarose Gels

William 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 joint disorder marked by the degradation of the structures that enable smooth interactions between the bones in a joint, resulting in inflammation, swelling, and debilitating pain. OA is a leading cause of disability worldwide and results in annual medical costs of $65 billion per year. The goal of this project was to explore the impacts metabolic inhibitors have on loaded and unloaded cartilage cells. In order for this project to be successful, a pilot study was conducted to identify how inhibitors diffuse into agarose gels. The inhibitor's used were metformin (MET), an inhibitor of mitochondrial complex 1 in the electron transport chain, and monoiodoacetate (MIA), an inhibitor of glycolysis. Agarose gels were spiked with 10, 20, 30, 40, and 50 μM of each inhibitor. Gels that were not spiked were placed in media containing these concentrations of each inhibitor for 24 hours, allowing for diffusion. The gels were processed and sent to the mass spectrometry machine. In a 10 μM solution, 55.76% of the MET and 62.64% of the MIA diffused. In 20 μM solution, 77.51% of the MET and 76.14% of the MIA diffused. In 30 μM

solution, 73.08% of the MET and 88.37% of the MIA diffused. In 40 and 50 µM solutions, too high of a concentration of inhibitor was present for the mass-spec to identify. This pilot study allows us to understand the amount of inhibitor the cells casted in agarose will be exposed to, which is crucial for the future study.

Acknowledgements: USP - Undergraduate Scholars Program

A novel biofilm behavior in Vibrio cholerae

Molly Roush, Microbiology & Cell Biology

Mentor(s): Diane Bimczok,

Cholera is a severe and potentially fatal diarrheal infection caused by the Gram-negative aquatic bacterium Vibrio cholerae. There have been seven major cholera pandemics between 1817 and the present day, and there are an estimated 4 million cases and 143,000 deaths each year. V. cholerae utilizes quorum sensing—the transmission of small metabolites called autoinducers as a mode of communication—to modulate biofilm formation and virulence as it transitions between the aquatic milieu and the human small intestine. Biofilm association confers protection from antimicrobials, environmental stressors, and host defenses; and has also been shown to induce a hyperinfectious phenotype. Nitric oxide (NO) is an antimicrobial secreted by the human small intestine and has been found to act “analogously to an autoinducer” in V. cholerae, interacting with NO-sensor systems NosP and HNox to regulate biofilm gene expression. Bimczok Lab has discovered that in response to high concentrations of NO and a host epithelial surface, V. cholerae forms "inside-out biofilms”: unattached, spherical aggregates with an immotile bacterial shell and motile bacteria within. We have termed these peculiar aggregates “vibrioids”. Our experiments have revealed that vibrioid formation is clonal and peaks at 20-24 hours, with quantity gradually declining afterwards. Vibrioids formed in both wild-type and nitric oxide sensor-knockout V. cholerae but were more abundant and robust in wild-type. Motility studies have revealed no significant difference between wild-type and NO sensor-knockout strains under normal conditions; but a significant decrease in motility in NO sensor-knockout strains when NO is present. This spring, I am focusing on the precise mechanisms of vibrioid formation and dispersal. My procedure involves infecting human intestinal epithelium with wild-type V. cholerae, treating with NO, and culturing in an environmental control chamber within the Keyence microscope. This allows timelapse imaging and video capture throughout vibrioid formation and dispersal. A timelapse from hour 14-24 was obtained with imaging at 10X magnification every 20 minutes, and the same conditions were repeated in a second experiment from hour 16-28. These images

were arranged consecutively into videos. This revealed that the immotile shell remains relatively the same thickness as the vibrioids approach their final size of 200-400microM, and dispersal occurs via “shrinking” rather than “breaking open”. In subsequent experiments, I plan to repeat the timelapse procedure within the incubation chamber, but capture videos at 40-60X magnification and use Imaris software to compare motility within the vibrioids at different stages of the life cycle.

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V. cholerae in Motion: Investigating the Effect of NO-sensing System Mutation on Motility in Vibrio cholerae.

Cedar Stellon O'Donnell, Chemistry & Biochemistry

Mentor(s): Diane Bimczok, Microbiology & Immunology

Vibrio cholerae is the gram-negative, aquatic bacteria which acts as the causative agent of Cholera. Cholera is caused by V. cholerae’s secretion of cholera toxin within the host’s gastrointestinal system, and is characterized by severe diarrhea and dehydration. Nitric oxide (NO) is a compound produced by intestinal epithelial cells as a response to infection, acting as a natural antimicrobial. V. cholerae has two NO-sensing systems, the NosP family of bacterial hemoproteins and heme-nitric oxide/oxygen binding system (H-NOX), which play important roles in biofilm formation and dispersal, regulating virulence, and motility. This project aims to investigate the effect of mutations to the NosP and H-Nox systems on the motility of V. cholerae, building on proteomic data that showed significant upregulation of flagellar proteins in the mutants. The motility of strains without NosP, without H-NOX, and without both systems were imaged in the presence and absence of nitric oxide and compared to the motility of a wild type strain that underwent the same treatment. The resulting videos were analyzed using Imaris tracking software to measure the mean speed and track displacement of the bacteria, finding the NO-sensing system mutants to be significantly slower than wild type when treated with nitric oxide. Understanding the impact of NO-sensing systems on the motility of Vibrio cholerae may create valuable insight into the previously unknown mechanism of transition between sessile to motile states during colonization of the host intestine, ultimately contributing to our understanding of biofilm formation and dispersal in V. cholerae.

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Evaluation of Antimicrobial Treatments Against Dried Biofilms

Sadie Tucker, Ecology; Kelli Buckingham-Meyer, Center for Biofilm Engineering; Lindsey Miller, Center for Biofilm Engineering; Liz Sandvik, Center for Biofilm Engineering

Mentor(s): Chris Jones, Center for Biofilm Engineering

Biofilms are formed by microorganisms adhered to a surface in a self-produced sticky matrix. Biofilms are responsible for most infections and a significant portion of industrial and food contamination, yet current laboratory methodologies only represent hydrated biofilms and neglect to accurately represent the behavior of many dry biofilms found in real-world environments. To evaluate the effectiveness of different treatment chemistries against dry biofilms, we have integrated the use of a CDC reactor (ASTM E3161) and the single tube method (ASTM E2871), combined with a controlled-humidity chamber. In this approach, biofilms are grown, dried to equilibrium at a defined humidity, and then treated with various disinfectants to assess their resilience before and after drying. When treated with three different biocides after drying, S. aureus and P. aeruginosa biofilms responded to the treatments differently. P. aeruginosa biofilms became more sensitive after drying, whereas S. aureus showed no change in sensitivity. Our findings demonstrate that biofilm response to treatment varies with drying status, organism, and treatment chemistry. Existing biofilm-specific treatment evaluation methods do not account for the effects of drying. A deeper understanding of how drying influences the resilience of biofilms formed by different microorganisms, particularly in response to a range of chemical treatments, will improve both the development of biocides and the guidelines for their proper use.

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NEUROSCIENCE

Developing Matched Filters for Analyzing Excitatory and Inhibitory Communication in Electrophysiological Signals

Ava Arbogast, Electrical & Computer Engineering; Anja Kunze, Electrical and Computer Engineering

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

Excitatory (E) and inhibitory (I) communication patterns in neuronal circuits are key to assessing normal versus disordered neuronal functionality. Specifically extracting the ratio between excitatory and inhibitory neurons (E/I ratio) from electrically recorded signals is

critical to determine circuit stability and communication effectiveness, as well as abnormalities. However, extracting individual excitatory and inhibitory signal shapes from temporally overlapping electrophysiological recordings still imposes challenges. Here, we are exploring a set of three distinct signal processing methods to improve the template for matched filter design to detect excitatory and inhibitory signal shapes from extracellular recordings performed with a microelectrode array on differentiated human neuronal progenitor cells. Matched filters are known to separate noise from electrical and acoustic signals and will be used in our study to improve the accuracy of E/I spike activity, based on a cell-specific signal template library using established trough-to-peak neuronal signal characteristics. In summary, improving matched-filter design will deepen our understanding of neuronal communication and functionality in bottom-up engineered neuronal circuitry.

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Quantifying Co-release and Co-transmission in Dual Neurotransmitter Neurons

Evelyn Brittin, Microbiology & Cell Biology

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

The mechanism of communication between neurons is largely understood to begin with a presynaptic neuron packaging one type of small-molecule neurotransmitter (SMN) into vesicles for release. These types of neurons are referred to as single neurotransmitter neurons (SNTs). Interestingly, there is a subset of neurons that co-transmits two types of SMNs, known as dual neurotransmitter neurons (DNTs). These neurons are becoming increasingly appreciated for their diverse but not yet well understood mechanisms, as they continue to prove significant in various forms of sensory processing and neurodegenerative disease.

The key mechanistic bottleneck in dual-transmitter biology is distinguishing whether two transmitters are packaged into the same synaptic vesicles (co-release) or into distinct vesicle pools (co-transmission). Understanding and applying the functional importance of DNTs necessitates increased investigation into the anatomical and physiological mechanisms of dual neurotransmission. We hypothesize that quantifying co-release versus co-transmission in dual neurotransmitter neurons will provide insight into the functional importance and dynamicity of these neurons. In Drosophila Melanogaster we have investigated the packaging of neurotransmitters into vesicles, as DNTs co-transmit two SMN types that can either be packaged into separate vesicles or co-localized. Through

a technique known as expansion microscopy that expands the tissue tenfold isotropically, separate vesicles within one synapse can be visualized; combined with fluorescent tagging of vesicular transporters via the split-GAL4 system, we can then determine whether co-localization is present in a DNT and define its signaling mode. This is essential for understanding the contribution of neurotransmitter packaging to normal and pathological brain function.

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The Effect of Gestures on Language Acquisition in Individuals with Autism Spectrum Disorder

Mara Campbell, Psychology

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

About 25-30% of individuals with Autism Spectrum Disorders (ASD) are non-verbal or have difficulties with language. Gestures can help both those with ASD and typically developing children with language acquisition. However, little research has been conducted to see if gestures can aid in the acquisition of determiners, which are words used before nouns and include articles (“the”) and demonstratives (“that”). This project builds off previous research that employed a technique called the Fishy-Turtle task, in which participants play a computer game where they drag either a fish or turtle icon to various objects, guided by a research assistant who is using spoken determiners. This is then replicated with gestures added to the determiners. Previous studies used screen-based eyetracking to analyze the data from the Fishy-Turtle task and measure how gestures may improve comprehension of determiners. However, this method could not be used with participants who engaged in excessive movement. Therefore, this project employed the use of different eyetracking technology, Tobii Pro Glasses, to include more diverse participants. Tobii Pro Glasses were used to collect data from seven participants. A methodology for analysis was developed; however, many challenges appeared in the process, such as technological difficulties leading to slow and time-intensive data analysis (frame by frame adjustments of eye gaze measurements). Ultimately, data for only one participant was analyzed fully. While complications have halted this project for now, the experience reinforces the importance of considering the methodology of data analysis in the planning stages of an experiment, prior to data collection.

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Characterizing Signaling and Feedback Architecture of Dual-Neurotransmitter Nuerons Innervating the Drosophila Male Reproductive System

Colum Smith, Microbiology & Cell Biology; Marta Chaverra, Cell Biology

Mentor(s): Steve Stowers, Microbiology & Immunology

Neurons that release more than two small-molecule neurotransmitters have been identified as playing important roles in brain function, cognition, and peripheral nervous system regulation, and have been implicated in psychiatric and neurologic disorders. Particular dual-neurotransmitter neurons (DTNs), which innervate the Drosophila male reproductive system and co-release octopamine and glutamate (OGNs), are used here as a model for studying DTNs more broadly. The signaling architecture, regulatory sensory feedback, and downstream targets of OGNs were previously poorly understood. Using cellular–specific split–GAL4–driven fluorescent labeling, immunostaining, and confocal microscopy, screens of pathways and molecular signaling mechanisms associated with OGNs were performed. Seventeen neuropeptide receptors expressed in tissues downstream of OGNs and eleven neuropeptides within the neurons themselves were identified, indicating a role for neuropeptides in modulating OGN signaling. Sensory mechanoreceptor expression was identified in epithelial cells of the reproductive tract, but not OGNs or nearby sensory neurons, suggesting that feedback is relayed indirectly through non-neuronal tissues. Examination of the glutamatergic ionotropic GluRII receptor complex downstream of OGNs revealed expression of the GluRIIE receptor but not GluRIIC, challenging the canonical GluRII complex structure needed for a functional receptor. Lastly, a novel ovulin–mScarlett3 fluorescent reporter that tracks secretion from the accessory gland was validated to transfer into the female reproductive tract during mating. These findings shed light on the molecular and circuit signaling features of OGNs, providing frameworks for future research into the neural contributions to male reproductive function and DTN signaling more broadly.

Acknowledgements: USP - Undergraduate Scholars Program

PHYSICAL CHEMISTRY

Rethinking aqueous behavior of PFOA: Indications of aggregation

Jackilyn Hemphill, Chemistry & Biochemistry; Robert A.Walker, Chemsitry and Biochemistry

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

Per- and polyfluoro alkyl substances (PFAS) are a class of synthetic, environmentally persistent chemicals that pose serious threats to human health. First synthesized in the late 1930s, PFAS proved to be an effective fire retardant and water-resistant compound. These materials became indispensable components in a host of applications throughout the 20th century. However, PFAS were eventually correlated with serious, chronic health concerns leading to their regulation and eventual phase-out from commercial use. Although the health consequences resulting from PFAS exposure are well documented, the fundamental questions about PFAS behavior in aqueous solution remain unanswered.

In this study, the behavior of perfluorooctanoic acid (PFOA), a common legacy PFAS, was examined using temperature dependent Dynamic Light Scattering (DLS) and Differential Scanning Calorimetry (DSC). DSC measurements identified a melting point of 45°C, considerably lower than the previously reported ~55°C. Temperature dependent DLS measurements were performed on PFOA solutions with concentrations ranging from 0.1 to 20 mM. These concentrations are all well below the suggested critical micelle concentration of 26.5 mM. Temperature dependent measurements from 10°C to 70°C demonstrated reversible aggregation behavior for aqueous solutions containing PFOA. PFOA aggregates ranged in diameter between 200+ nm at lower temperatures to as small as 35 nm at higher temperatures. These particle sizes are much larger than those assigned to micelles formed by traditional surfactants such as SDS and imply that PFOA activity in water may be considerably less than previously believed.

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

Synthesis and Characterization of Enantiopure R-$Au_2Cu_2(ptt)_4$ Nanoclusters for High-Efficiency Circularly Polarized Phosphorescence

Erin Jones, Chemistry & Biochemistry

Mentor(s): Erik Grumstrup, Chemistry & Biochemistry

MNCs are ultra-small aggregates of atoms or molecules ranging in size from 1-10 nm, frequently behaving similarly to bulk semi-conducting materials. MNCs are a promising material for CP- LEDs and quantum emitter technologies due to their structural tunability, stability, and high photoluminescent (PL) quantum yields. A major challenge in designing

highly luminescent MNCs is a lack of unified understanding of their emission mechanisms, mostly due to their structural diversity and complexity. This research aims to synthesize enantiopure R- $Au_2Cu_2(ptt)_4$,a metal nanocluster with PL reported PL quantum yields as high as 96%. The synthesis coordinates R-4-phenylthiazolidine-2-thione (R-ptt) with a gold(I) (MeSAuCl) and a copper(I) [$Cu(CH_3CN)_4(PF_6)$] in a dichloromethane/acetonitrile/triethylamine mixture. Successful synthesis would provide a foundation for investigation of exciton binding energy and reduced electron-phonon interactions to influence phosphorescence in chiral metal nanocluster systems.

Refining Statistical Mechanical Modeling Methods for Gas Adsorption

Peyton Summerhill, Chemistry & Biochemistry

Mentor(s): Nicholas Stadie, Chemistry & Biochemistry

To mechanistically and energetically understand adsorption of gases on porous materials (such as porous carbons, zeolites, metal-organic frameworks, and more), modeling is performed by fitting measured adsorption uptake data to models derived from first principles. However, two important parameters in these models, A (which describes the behavior of the bound adsorbate within its site) and ε (the energy of adsorption), appear to be highly correlated and may be conflated with one another during fitting. It is the goal of this project to refine our otherwise reliable modeling methods by using quantum models (including particle in a box, the harmonic oscillator, and a modified delta function) and experimental data (neon gas uptake on the metal-organic framework BFF-1) to specify the relationship between correlated parameters A and ε. The updated method will yield improved reliability of the bound adsorbate's state (given by A) and more accurate binding energy values (ε), thus providing greater insight into the behavior of important energy materials across a wide variety of adsorption systems.

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From DMF to MOX: A Sustainable Solvent Switch for Amide Coupling Reactions

Gavin Thorson, Chemistry & Biochemistry; Blake Chennai, Chemistry and Biochemistry; Vittal Kamath, Chemistry and Biochemistry; David Fialho, Chemistry & Biochemistry

Mentor(s): David Fialho, Chemistry & Biochemistry

N,*N*-Dimethylformamide (DMF) is a ubiquitous, dipolar, aprotic solvent in organic synthesis, valued for its broad solvent compatibility and favorable physiochemical properties. However, concerns about DMF's role in reprotoxicity and hepatotoxicity have resulted in increased regulatory restrictions and efforts across industry and academia to phase out its use. Thus, the need for greener alternatives is particularly acute in reactions where DMF is frequently employed. Among these, amide and peptide coupling reactions represent the most commonly performed reaction class in the synthesis of active pharmaceutical ingredients (APIs) and constitute the dominant use of DMF in medicinal chemistry. Despite numerous proposed substitutes, few solvents provide a general replacement for DMF. Here, we identify 3-methyl-2-oxazolidinone (MOX), a potentially biodegradable compound, as an effective alternative solvent for DMF in amide couplings. Amide couplings conducted in MOX in the presence of common coupling reagents and bases afforded consistently high yields, with diminished performance observed for sterically hindered and poorly nucleophilic substrates. These results demonstrate that MOX is a viable replacement for DMF in amide coupling reactions.

Acknowledgements: USP - Undergraduate Scholars Program, INBRE - IDeA Network for Biomedical Research Excellence, Department of Chemistry and Biochemistry

PHYSICS AND SPACE SCIENCE

Development of a Low-Cost Diode-Based Radiometer

Milo Anderson, Physics

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

The Environmental Monitoring and Biophotonics Research (EMBR) Lab at Montana State University, in collaboration with the Optical Remote Sensor Laboratory (ORSL), is developing a low-cost device to help calibrate optical remote sensors. This project focuses on measuring optical irradiance, which describes how much optical power reaches a detector over a given area. Earlier work in the lab produced a device that measures light at different wavelengths and records the associated intensity using diode-based detectors. Building on this, the author investigated the use of light-emitting diodes (LEDs) as light sensors. When LEDs are wired in reverse, they can generate an electrical current when light strikes them, similar to a photodiode. By placing green, red, and near-infrared LEDs alongside a standard photodiode on a circuit board, the system showed promising results in relating wavelength to light intensity. The final hope for the radiometer is an output plot of

radiometric, or sunlight, intensity versus wavelength based on light striking the detector. Commercial radiometers typically cost around $1,800, which can limit access for students and researchers. The goal of this diode-based radiometer is to significantly reduce costs while maintaining useful performance. Future work includes improving calibration and expanding the use of the device in environmental monitoring. One long-term goal is to mount the radiometer on a drone to measure solar irradiance with an onboard camera set to record reflected light from the ground, supporting broader remote sensing applications.

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

Andrea Astorga Bedoya, Physics

Mentor(s): Anne Lohfink, Physics

During the black hole accretion process, soft photons from the accretion disk are up-scattered by hot electrons in the corona, producing X-ray radiation. The nature of the electrons in the corona remains uncertain; most models assume they follow a purely thermal distribution, but evidence suggests that acceleration processes could produce a non-thermal tail. We investigated 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 form of the X-ray reflection process. To achieve this, we developed a computational model that allowed for both thermal and non-thermal components and studied the X-ray spectra of one accreting supermassive black hole. Preliminary results show a drastic change in the Chi-Squared value for non-thermal contributions greater than 10 percent, suggesting that the non-thermal contribution is less than 5 percent. Results also show a change in the reflection parameter values, indicating the influence of non-thermal components in the estimation of these. These constraints are important because they will improve our understanding of the energy budget in the accretion process.

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Relativistic Electron Atmospheric Loss Energies in the Parallel and Perpendicular Directions

Kyle Burke, Physics

Mentor(s): John Sample, Physics

Relativistic electron atmospheric loss involves electrons captured in the Earth's magnetic field hitting the Earth's atmosphere. Using data from the REAL (Relativistic Electron Atmospheric Loss) satellite [1], we gathered data about the different energies present within the electrons coming to the atmosphere from the Earth's magnetic field. The satellite has five different sensors on it oriented in different directions, and when observing a spike of electrons on the dusk side of Earth from November 15, 2025, we observed differences in the energies of the particles coming from the detectors perpendicular to and parallel to the Earth's magnetic field. The isotropy ratio is the ratio of electrons from one direction to the other and comparing the perpendicular and parallel directions shows that there are more higher energy electrons hitting the perpendicular direction than the parallel direction. The data has 12 bins of electrons, with bin 0 being the lowest energy and bin 11 being the highest energy of electrons. Using Python to graph the ratios for each bin and the best fit line, the max and mean of the isotropy ratio for each shows a positive increase in isotropy ratio of 0.269 per bin and 0.004 per bin respectively. This data shows that the electrons hitting the perpendicular detector tend to be of higher energy than those hitting the horizontal detector, and future research will involve seeing if these differences depend on what side of the Earth the satellite is on. References

[1] https://real-cubesat.jhuapl.edu/flight_data/

Measuring Core Loss of Materials used in Magneto-Gravitational Trap

Sierra Holleman, Physics; Connor Murphy, Physics

Mentor(s): Brian D'Urso, Physics

Magnetic levitation particle traps use pole pieces alongside magnets in order to focus the magnetic field. These pole pieces are made out of magnetic materials and are subject to eddy current losses which can impact measurement precision. Using a simple procedure for measuring core loss [1] we tested 3 materials: Hiperco, heat-treated Hiperco, and a graphite composite. Each material was tested at a range of frequencies with and without magnets placed on either side of the core. We found the graphite composite core had an average loss of 33 watts per meters cubed with a deviation of 3 percent and had a consistently higher loss with magnets in place. In contrast, the Hiperco had an exponential rise in loss with respect to frequency and an inconsistent change in loss with magnets in place. Likewise, the heat-treated Hiperco core had an exponential growth in loss but with overall smaller loss than the Hiperco. These results indicate that the graphite composite,

with its consistently low energy dissipation, is the optimal material for minimizing eddy current losses in high-frequency magnetic traps.

Magnetic Field Driven Metal-to-Insulator Transitions in Low-Carrier-Density Materials

Madeline Lamb, Physics; Genevieve Smith, Physics

Mentor(s): John Neumeier, Physics

A transition from a metallic to an insulating state (metal to insulator transition, MIT) indicates changes in the localization of charge carriers, likely opening new energy gaps. Applied magnetic fields are known to cause the formation of Landau Levels, quantized energy levels equally spaced by $\hbar\omega_c$, in 2D systems. Four low carrier density materials with varying crystallographic geometries, Highly Oriented Pyrolytic Graphite (HOPG), Strontium Titanate ($SrTiO_3$), Lithium Purple Bronze ($Li_{0.9}Mo_6O_{17}$), and Bismuth undergo a magnetic field-induced, temperature-dependent metal-to-insulator transition. This work investigates the connection between thermally activated electron excitations between Landau Levels and metal-to-insulator transitions in these four low-carrier-density $n \sim 10^{16}...10^{17}$ materials, using measurements of electrical transport properties for each material. Electrical resistivity was measured for temperatures of 1.9 K to 296 K, and magnetic fields oriented perpendicular to the current direction ranging from 0T to 9T. Comparison to a parallel resistors model in which two regimes dominate the electrical resistivity, a temperature-independent shunt resistivity, and the theorized excitations between Landau Levels determine the accuracy of this energy quantization, as well as the simplicity of the two resistor terms to universally describe electronic behavior in low carrier density materials.

Maintaining local paraxial validity in high-NA optical cavities

Maksym Makarchuk, Computer Science

Mentor(s): Matt Jaffe, Physics

Modeling optical cavities with high numerical apertures (high-NA) is challenging because standard paraxial approximations fail when light propagates at large angles or interacts with strongly curved optical elements. These regimes are important in quantum photonics, where accurate predictions of cavity modes and losses are essential for optimizing device performance. This work develops a more general framework for analyzing such non-paraxial cavities.

The approach represents the optical field as a superposition of Gaussian beamlets (Gausslets), each propagated under locally paraxial physics along its ray path. Gausslets are initialized on the optics, propagated through a full round trip, and assembled into a discrete round-trip operator. Eigenanalysis of this operator yields cavity eigenmodes, round-trip loss from eigenvalue magnitudes, and phase shifts analogous to the Gouy phase.

Results show that this method captures cavity behavior in regimes where traditional models break down. However, the current single-segment implementation is limited in accuracy when local paraxiality must be re-established, particularly after reflections from flat or strongly curved optics.

Ongoing work introduces a segmented propagation scheme, where partial operators are computed, the field is re-expressed in locally adapted Gausslet bases, and segment operators are combined before eigenanalysis. This extension is expected to improve accuracy and broaden applicability while maintaining computational efficiency.

Acknowledgements: USP - Undergraduate Scholars Program

Readout of Optical Resonator Arrays for Quantum Computing

Bridger McGimpsey, Physics

Mentor(s): Matt Jaffe, Physics

A key requirement for building a successful neutral-atom quantum computer is the ability to create a large array of atoms and read out their states quickly. Optical resonators are a key enabling technology for this. However, building an array of optical resonators coupled to atoms requires precise methods for creating, aligning, and characterizing the resonant structures of light produced by the resonators. Here, we use an interferometric imaging technique to measure the light emitted from the optical resonator array. By interfering the resonator outputs with a tilted reference beam on a camera, we are able to recover both the strength and phase of the optical field from each site, allowing us to characterize the resonant array of light. Once atoms are loaded into this array, we can then individually read out their states. In addition to aiding in state readout, we show that this technique can also reliably detect signals consisting of only a few photons using a very low-cost camera.

Acknowledgements: QCORE

Illustrating Black Hole Parameter Estimation

Piper Morris, Physics; Aiden Gunderson

Mentor(s): Neil Cornish, Physics

Following the first direct detection of gravitational waves in 2015, the field has experienced rapid growth. As the field matures, educational resources are needed to demystify parameter estimation techniques and illustrate how physical parameters map to observable waveform features. We present a graphical user interface (GUI) that provides real-time visualization of gravitational wave parameter estimation for binary black hole mergers. Using interactive sliders, users explore how waveform morphology responds to changes in physical parameters including component masses, spins, chirp mass, mass ratio, and effective spin. The tool employs matched filtering techniques on both simulated and real LIGO detector data, displaying the signal-to-noise ratio (SNR), strain amplitude and phase as parameters are adjusted. Users can toggle between multiple views: component versus quasi-orthogonal parameter spaces, signals from the LIGO Livingston and Hanford detectors, and data residuals. Users observe in real time how the matched filter SNR varies across parameter space, demonstrating how maximum likelihood estimation identifies the parameters most consistent with the observed data. To our knowledge, this is the first interactive tool to provide continuous, real-time visualization of the parameter-waveform relationship in gravitational wave analysis, offering an intuitive complement to traditional lecture-based instruction.

Analysis of Solar Wind Parameters for Stream Interaction Regions Observed by MAVEN and WSA-ENLIL

Sophia Owen, Physics; Sarah Henderson, Physics

Mentor(s): Rachael Filwett, Physics

Solar wind is a continuous stream of plasma and energetic ions from the sun's outer corona that extends into the heliosphere. Fast and slow solar winds frequently interact to form compressed plasma regions, known as stream interaction regions (SIRs). Modeling space weather events, such as SIRs, is important to understanding their properties and predicting how they will impact planetary environments. The Wang-Sheeley-Arge (WSA)-ENLIL stationary solar wind model generates reliable space weather predictions at 1 AU; however, understanding how well models predict solar wind parameters beyond 1 AU will be essential in future endeavors, such as Martian exploration. In this study, we compare in-situ solar wind parameters during SIRs measured by the Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft to parameters predicted by WSA-ENLIL to analyze the accuracy of WSA-ENLIL at 1.5 AU. We find that WSA-ENLIL consistently underpredicts the

solar wind proton density and interplanetary magnetic field (IMF) magnitude, while solar wind velocity is well predicted. Additionally, we observe correlations between the underprediction of parameters and the extrema of the solar cycle.

Modeling Tidal Evolution in Binary Neutron Stars

Sophia Owen, Physics

Mentor(s): Hang Yu, Physics

A system of binary neutron stars (BNSs) consists of two neutron stars (NSs) orbiting each other. BNSs evolve as gravitational wave (GW) radiation removes orbital energy from the system, reducing the orbital separation and increasing orbital angular velocity until the NSs collide and merge. Due to their finite size, each NS experiences quadrupole-dominant tidal perturbations that increase in magnitude as the orbital separation decreases. Additionally, BNSs may experience tidal lag, where the major axis of tidal perturbation of each NS lags behind its companion. In this work, we analyze the orbital and tidal interactions of BNSs during inspiral. We model the BNSs using linear perturbation theory and solve a system of ordinary differential equations by focusing on the tidal response of one NS while treating the other as a point mass. We produce a 2D animation to visualize the inspiral, where we observe an increase in both the quadrupolar deformation of the NS and its lag relative to its companion.

Acknowledgements: USP - Undergraduate Scholars Program

Semi-Autonomous Calibration and Error Management for Distributed Magnetometer Networks

Nolan Poncin, Physics

Mentor(s): Rachael Filwett, Physics

Affordable, widely deployable magnetometers offer the potential to significantly expand geomagnetic data coverage, but only if their measurement quality meets established scientific standards. Ensuring accuracy and consistency across distributed, minimally supervised instruments remains a major limitation to their broader adoption in archival research. This work investigates whether low-cost magnetometers can achieve research-grade performance through operator-accessible, semi-autonomous calibration methods. Building on established ellipsoid-fitting approaches that model sensor distortions as affine transformations in the sensor frame, we explore practical calibration workflows requiring

limited control and minimal training. Framed as an exploratory study of both calibration effectiveness and the broader challenge of error management in distributed instrumentation, preliminary results indicate that these methods reduce measurement error by an average of 40.6% relative to raw data, with a calibration spread of approximately 1214.0 nT (1σ) across repeated trials. Automatic heading estimation yields a standard deviation of 17.107°, though absolute accuracy remains uncertain. These findings support the feasibility of semi-self-calibrating magnetometer networks, with future work focusing on improving heading accuracy, reducing variability across calibrations, and establishing robust uncertainty metrics for large-scale deployment.

Optimizing a Nonlinear Optical Crystal Setup to Produce Slightly Non-Degenerate Entangled Photon Pairs

Jesse St. Onge, Physics

Mentor(s): Krishna Rupavatharam, Physics; Bradley Slezak, Physics

Entangled photon pairs are a key resource in quantum communication experiments. These pairs are most efficiently generated via nonlinear optical processes in PPLN and BBO crystals. The objective of this research project aimed to optimize the production of slightly non-degenerate photon pairs in the 1.5-micron wavelength range generated by these crystals. The project was divided into three stages: Second Harmonic Generation (SHG), amplification using an Erbium Doped Fiber Amplifier into Spontaneous Parametric Down Conversion (SPDC), and photon counting using a Superconducting Nanowire Single Photon Detector (SNSPD). Optimization was performed using a continuous-wave laser to later be extended into the pulsed-laser regime. For SHG, optimal performance was achieved using a 5mm crystal at 30 °C, a 75mm focusing lens, and an incident wavelength of 1550.7nm. For SPDC, a physical geometry yielded 58% coupling of the incident SHG light, delivering approximately 82% coupling for vertically polarized light, and 81% for the horizontally polarized leg. The SNSPD analyzed the optimized setup and counted sorted photon pairs, yielding various count rates and a dead time of approximately 2.0×10^{-8} seconds. The resultant optimized pulsed-laser pump was intended for other experiments in the lab.

Acknowledgements: Spectrum Labs

Through a Different Light: Imaging Solar Activity Through Spectroscopy

Rebekah Swanson, Chemical & Biological Engineering

Mentor(s): Ryan Hannahoe,

Throughout the summer of 2025 solar maximum, with the help of her mentor, Ryan Hannahoe, and partner, Addie Zumwalt, Rebekah Swanson captured the solar disk in light wavelengths of Calcium-K (Ca-K) and Hydrogen Alpha (Hα). Through the Montana Space Grant Consortium, Rebekah partnered with the Montana Learning Center in Canyon Ferry, MT, to explore solar astronomy. With no previous experience in solar imaging, she learned to calibrate and operate the ML-Astro Spectroheliograph (SHG) 700. Once scans of the sun were taken, Rebekah was able to convert those scans into images, compile multiple scans into a single image, and adjust the brightness and contrast of the image to ensure visibility of features and optimal image quality. A spectroheliograph operates by scanning across the surface of the sun, picking up light in a limited wavelength range. The wavelengths of light that the SHG captures are emitted when an electron of a particular atom changes discrete energy levels (orbitals). Therefore, when observing the solar disk in the wavelength Hα, one is observing the photon given off by the reaction that created Hα.

These reactions occur at all times because of the high-energy state of the sun. By condensing and processing the captured photon emissions in a specific wavelength, an image of the sun in that wavelength is created. This image can show features such as granulation, prominences, filaments, and sunspots. In addition to this, quantitative data such as the direction and velocity of plasma motion can be extracted.

Acknowledgements: MSGC - Montana Space Grant Consortium

Active Solar Irradiance Observer (ASIO)

Samuel Williams, Physics; Christopher Entzel, Physics; Ian Garcia, Physics; Jake Weber, Physics; Sarah Palowski, Physics

Mentor(s): Charles Kankelborg, Physics

Scheduled for launch in 2027 aboard the NASA MUlti-slit Solar Explorer (MUSE) mission, the Active Solar Irradiance Observer (ASIO) is designed to investigate the fundamental mechanisms of solar atmospheric heating and plasma instabilities. While MUSE observes the basic properties of the corona, ASIO enhances the mission's diagnostic capabilities by providing high-cadence measurements of solar flux with integrated source location functionality. This instrument specifically targets the identification of sub-second Quasi-Periodic Pulsations (QPPs) across Soft X-ray (SXR), Hard X-ray (HXR), and Extreme Ultraviolet (EUV) bands to determine potential temporal offsets in energy release. Furthermore, ASIO will track the spatial dynamics of SXR sources during solar flares to

quantify their motion across the solar disk and analyze the thermal evolution of the flare late phase on centi-second timescales. By resolving these rapid transitions, ASIO provides critical insights into the energetic processes governing flares and coronal mass ejections, bridging the gap between steady-state coronal properties and impulsive solar events.

PSYCHOLOGY

Existential Isolation and Shared Reality as Predictors of Mental Health in U.S. Veterans: A Measurement Refinement Pilot Study

Erin Alexander, Psychology; Isaac Doll, Psychology

Mentor(s): Peter Helm, Psychology

The transition from military to civilian life can present psychological challenges for many veterans, particularly related to feelings of connection and belonging. While social support has been widely studied in veteran populations, less is understood about deeper psychological experiences of connection and disconnection, such as existential isolation and shared reality. The present study examined how existential isolation and shared reality relate to mental health outcomes among U.S. military veterans. A sample of 251 veterans completed an online survey measuring existential isolation, shared reality, PTSD symptoms, depression, anxiety, stress, perceived social support, and loneliness. Results indicated that veterans reported significantly greater existential isolation when considering civilians compared to fellow veterans, $t(250) = 11.85$, $p < .001$, $d = .75$, suggesting a substantial psychological divide between veteran and civilian communities. Correlational analyses showed that higher existential isolation was associated with greater psychological distress and loneliness, while shared reality was associated with higher perceived social support. Regression analyses indicated that general existential isolation significantly predicted PTSD symptoms, stress, anxiety, and depression. When analyses were separated by gender, male veterans reported higher levels of existential isolation and stronger associations between existential isolation and psychological distress, whereas shared reality with fellow veterans appeared to have a stronger protective role among female veterans. These findings highlight the importance of understanding psychological connection and disconnection in veteran mental health and suggest that fostering shared understanding among veterans may support psychological well-being during the transition to civilian life.

Acknowledgements: Veterans Transitions Research Lab

Lateral violence experiences among American Indians in substance use recovery: Exclusion and rejection

Alina Cofod, Psychology; Morgan Neavill, Psychology; Anabella Mullen; Cell Biology and Neuroscience; Julie Gameon, Psychology

Mentor(s): Monica Skewes, Psychology

American Indians and Alaska Natives (AI/ANs) experience substance use disorders (SUDs) at a higher rate than the rest of the U.S. population (CBHSQ, 2021). These health disparities have been connected to historical trauma and discrimination (Warne & Lajimodiere, 2015) and may lead to instances of lateral violence (Whyman et al. 2021). Lateral violence is a common phenomenon in oppressed groups that occurs when individuals internalize prejudiced beliefs and behave in discriminatory ways toward each other (Wright, 2025). The goal of this study was to understand the relationship between lateral violence and SUD recovery among AI people. We conducted a secondary analysis of 25 key informant interviews and seven focus groups that were part of a community-based participatory research project on a rural AI reservation. From this analysis, four main types of lateral violence were identified: Exclusion and Rejection, Gossip and Psychological Undermining, Social Manipulation, and Stigma and Distrust. Under the overarching theme of Exclusion and Rejection, the following supporting codes were identified: cultural exclusion, peer rejection, and social rejection. Participants viewed lateral violence as a significant barrier to recovery for members of this community. Exclusion and rejection were identified as key forms of lateral violence impacting recovery. Understanding how lateral violence impacts recovery from SUDs allows for better-informed treatment and assistance for those in recovery. Further research is needed to understand the role of lateral violence in SUD recovery in the general population and other AI/AN communities.

Examining Attention and Physiological Regulation in the Link Between Cognitive Reappraisal, Emotional Suppression, and Anxiety

Grace Harper, Psychology

Mentor(s): Brandon Scott, Psychology

Past research has shown certain emotion regulation strategies are tied to increased or decreased anxiety disorder symptoms, such as emotional suppression and cognitive reappraisal. Other theory and research suggest that one's ability to employ attention and physiological processes may also play a role in regulating anxiety. This project's purpose is

to investigate whether college students' ability to control their attention and physiological states moderate the association between these two ER strategies and anxiety symptoms. We are still collecting data and have no preliminary findings to report. Participants will have physiological data collected through an electrocardiogram and respiration belt during a 5-minute resting baseline. Next, they will complete a questionnaire, including a brief demographic form, the Screen for Adult Anxiety Related Disorders, and Emotion Regulation Questionnaire. Participants will finally complete the Attention Control Squared battery which consists of three brief tasks: Stroop Squared, Flanker Squared, and a Simon Squared task. We expect (1) a negative association between reappraisal and anxiety, such that more use of reappraisal will be related to lower levels of anxiety, but only for those students with greater attention and physiological control and (2) there will be a positive association between expressive emotional suppression and anxiety symptoms such that more use of suppression will be associated with higher levels of anxiety, but only for those individuals with greater attention and physiological control. Our study will help us to better understand the circumstances under which certain emotion regulation strategies may reduce or augment feelings of anxiety.

Acknowledgements: USP - Undergraduate Scholars Program

Experiences with Social Manipulation among American Indians in Substance Use Recovery

Annabella Mullen, Microbiology & Cell Biology; Morgan Neavill, Psychology; Alina Cofod, Psychology; Julie Gameon, Psychology

Mentor(s): Monica Skewes, Psychology

American Indian populations experience multiple levels of trauma due to colonization, which contributes to disordered substance use (Skewes & Blume, 2019; Warne & Lajimodiere, 2015). Lateral violence is defined as intentional efforts by one's social network to disrupt one's efforts toward sobriety. Lateral violence has been attributed to internalized negativity toward one's own identity and belonging within their own community (Whyman et al., 2021). I will report findings from a qualitative research study on substance use recovery that was conducted in partnership with a rural American Indian community. Specifically, our team conducted a thematic analysis of experiences with social manipulation, a particular type of lateral violence that emerged from the data. Qualitative data were collected from 25 key informants and seven focus groups taking place with cultural leaders, treatment providers, people with substance use disorder (SUD), and family members of people with SUD. Four types of lateral violence emerged from the data:

Exclusion and Rejection, Gossip and Psychological Undermining, Social Manipulation, and Stigma and Distrust. Under the theme of Social Manipulation, four key codes—obligation, peer pressure, sabotage, and financial targeting were identified. These codes were identified as barriers to recovery from SUD. Better understanding of lateral violence will allow for more culturally-informed treatment. Further research is needed on how to prevent and mitigate the impacts of lateral violence so individuals in recovery may more easily achieve their sobriety goals.

Lateral violence in substance use disorder recovery among American Indians: A qualitative approach to measure development

Morgan Neavill, Psychology; Alina Cofod, Psychology; Annabella Mullen, Psychology; Julie Gameon, Psychology; Monica C. Skewes, Psychology

Mentor(s): Monica Skewes, Psychology

Recovery from substance use disorders (SUDs) occurs within social networks of friends, family, and the broader community. These networks can support recovery or may undermine it through lateral violence (LV), defined generally as marginalized groups directing oppression toward one another. LV may be especially influential in American Indian (AI) communities due to their collectivistic cultural orientations and strong social ties. However, no research has examined how LV impacts SUD recovery among AI individuals and there are no validated scales available to measure this. This study aimed to develop a scale assessing LV in recovery using qualitative data from a larger community-based participatory research project addressing substance use disparities. Data included secondary findings from key informant interviews (n = 25) and seven focus groups (n = 35) with AI adults (18+) representing diverse SUD experiences. Transcripts were analyzed using thematic analysis to identify experiences of LV during recovery. Four primary themes emerged: (1) exclusion and rejection, (2) gossip and psychological undermining, (3) social manipulation, and (4) stigma and distrust. These themes informed the development of preliminary scale items. An expert panel of AI community members (n = 10) reviewed items for clarity, comprehension, and cultural appropriateness. Revisions were made based on feedback, and an additional focus group (n = 10) will further refine the measure. Findings highlight the role of LV in shaping recovery and provide an initial step toward a culturally grounded measure to assess its impact on SUD outcomes among AI populations.

Who Wrote This? How AI Source Labels and Argument Framing Affect Persuasion and Credibility

Leon Therrien, Psychology

Mentor(s): Ian Handley, Psychology

As AI-generated content permeates the media and information we encounter daily, researchers and the public are beginning to ask how and why it may be reshaping the way people think, particularly around persuasion and messaging. This study examines how perceiving an essay as AI-authored versus human-authored shapes people's evaluations of its persuasiveness, the credibility of its source, and the reasoning behind those judgments. Using a 2×2 between-subjects design, participants are randomly assigned to one of four conditions, reading a persuasive essay under conditions that vary by source label (AI vs. human) and argument type (emotional vs. rational appeal). This design allows examination of whether source label affects attitude change and credibility, and whether the emotional or rational framing of the argument moderates that effect. Understanding how source perception and argument framing jointly influence persuasion carries real implications for media literacy, public discourse, and the ethical use of AI in communication. If people respond differently to emotionally versus rationally framed arguments depending on whether they believe AI wrote them, this has consequences for how AI-generated content is deployed and whether audiences are truly equipped to recognize and critically evaluate its influence. Grounded in a controlled experimental setting, this study contributes to an empirical foundation for understanding how AI authorship attribution shapes the persuasion process.

Acknowledgements: USP - Undergraduate Scholars Program

Relationship Between Sleep Patterns and State Authenticity as Fit to Environment (SAFE) in Freshman University Students

Jacob Wiener, Psychology

Mentor(s): Linying Ji, Psychology

The purpose of this project is to investigate whether the sleep habits of freshmen university students are related to their perception of authenticity. Sleep deprivation has been found to negatively impact wellbeing and mood. In addition, prior research has shown that sleep loss causes social withdrawal and loneliness. In the authenticity literature, a relationship has been established between subjective wellbeing and authenticity, as well as mood and authenticity, but no prior research has directly investigated a relationship between sleep and authenticity. State Authenticity as Fit to Environment (SAFE) conceptualizes authenticity as the relational fit between individuals and their environment across three

dimensions; self-concept fit, goal fit, and social fit. The SAFE scale consists of 15 items (5 for each dimension) on a 7 point Likert scale. Sleep health was measured by RU-SATED, a multidimensional self report questionnaire. Statistical analysis, including correlation analysis and linear regression will examine associations between each dimension of SAFE and each dimension of RU-SATED. Participants are Montana State University students (N=64).

Acknowledgements: USP - Undergraduate Scholars Program

The Impacts of Mindset and Attitude on Persuasive Messaging

Anna Wiseman, Psychology

Mentor(s): Ian Handley, Psychology

The present research examines how mindset and attitude accessibility jointly shape persuasion. Building on prior work demonstrating that similarity mindsets increase reliance on accessible knowledge while dissimilarity mindsets promote nonroutine information use, this study seeks to conceptually extend these effects to argument quality in persuasion. Specifically, the experiment aims to replicate and refine Handley et al.'s (2024, 2025) third study by testing whether a similarity versus dissimilarity mindset moderates the influence of strong versus weak persuasive arguments when prior attitudes are either activated or not. To address limitations in earlier work, the current study incorporates an exploratory thought confidence measure and replaces the politically charged topic of gun control with the more neutral issue of nuclear power. The survey structure and questions largely copy those used by Handley et al. (2024, 2025). Participants are induced into either a similarity or dissimilarity mindset, receive questions that activate their attitudes on either nuclear power or an irrelevant topic, read a persuasive message with either strong or weak argument quality, and finally, report their attitudes on nuclear power after having read the message.

Acknowledgements: USP - Undergraduate Scholars Program

SOCIAL SCIENCES

Montana's Energy Future Illuminated by the Atom in a Commonsense Approach to Hybrid Clean and Stable Energy

Stewart Baker, Political Science

Mentor(s): Paul Lachapelle, Political Science

Montana is facing rising energy costs alongside increased demand from both commercial and residential consumers, with fossil-fuel plants closing and reopening, an increased reliance on imported electricity, and concerns about grid stability. The question of how Montana will get clean, reliable energy going into the future is in question. Using my “common sense” methodology, nuclear energy will be the cornerstone of a hybrid approach to stable, clean electricity across Montana. Using a research synthesis approach to data collection, using keywords: Renewable, Levelized Cost of Energy (LCOE), Small modular reactors, fissile material life cycle, solar Degradation, energy storage, and Montana energy projections. The argument against nuclear energy has historically been concerns of radioactive waste, safety, costs, and proliferation of fissile materials. Research articles and policies from the World Nuclear Association dispel myths associated with safety and radioactive waste. Terra Power's Small Modular Reactors (SMRs), a sodium-cooled power plant in Wyoming, is decreasing the LCOE of nuclear energy, with the Lazard Institute indicating the total LCOE of nuclear power is lower than offshore wind and comparable with Wind+ storage of onshore generation. Montana can and needs to take the lead on nuclear energy to minimize continued environmental damage from coal plants while stabilizing energy costs for Montanans by supplying continuous, clean baseline power for the state, anticipating future power needs outlined in the Energy Information Administration projection reports.

Damaging Narrative Nutrient Standard in Montana Rivers

Ryder Ferguson, Liberal Studies Degree

Mentor(s): Paul Lachapelle, Political Science

This research evaluates the political and ecological implications of Montana House Bill 664, which transitioned state water quality metrics from numeric to narrative standards. While intended to provide flexibility for the agricultural sector, this shift creates significant risks for Montana’s aquatic ecosystems and public health. Using peer-reviewed analysis of "Nutrient Legacies” (Frei et al., 2021), scholars have discovered that narrative standards, which are measured based on reactive measures instead of proactive, allow the accumulation of nitrogen and phosphorus, used mainly for agricultural practice, to leak into soil and groundwater. This accumulation has been found to delay ecosystem recovery and disproportionately impacts different regions and groups. This includes well owners and Indigenous communities who rely on these polluted waters for cultural and domestic use. This research project demonstrates the tensions between the people of Montana's rights to

clean and healthy waters and environment, and current legislative priorities. Drawing on insights from climate and water conservation experts at the Greater Yellowstone Coalition, this project highlights the tension between current legislative priorities and the constitutional right of Montanans to a clean and healthful environment. The research concludes that restoring a numeric water-quality measurement system policy is essential for long-term watershed health and environmental equity. By integrating Montana DEQ scientific surveys with Tribal water expertise and agricultural stakeholder input, the state can maintain water quality without placing burdens on farmers.

Acknowledgements: USP - Undergraduate Scholars Program

Building up Bozeman

Mary Frerichs, Architecture

Mentor(s): Paul Lachapell, Health & Human Development

City of Bozeman recently finished 2025 off target to meet climate neutral goal for 2050 (NBC, 2025). Because buildings make up 50% of Bozeman's emissions this is an area that can use improvement. Bozeman has become reliant on Northwestern Energy's transition to electric energy but this reliance poses problems. Electricity can and often is generated from coal (in Montana almost 1/3 of electricity comes from coal (energy information administration, n.d.)). Because of this, Bozeman needs to become more self reliant by incentivizing new developments to follow the Living Building Challenge, LEED certifications, or IECC. These certifications all require buildings to meet certain requirements that ensure the use of little to negative energy and LEED especially requires buildings to design thoughtfully in terms of material, water efficiency, and indoor air quality. This ensures that quality buildings will be valued in Bozeman rather than exclusively quantity.

Evaluating Cross-Cultural Uses of Cyber Threat Intelligence

Marty Green, Liberal Studies Degree

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

Cyber security defense strategies have struggled to keep pace with evolving nation state behavior between countries. National and cultural approaches to cyber capabilities is affected by the culture to which these governments belong. This study focuses on how national context and culture influence and develop the employment of state cyber

capabilities. This struggle is due to the rapid expansion of cyber activity, international norms, and attribution mechanisms. Due to these disparities, there is uncertainty about the current stance to cyber defense and risk escalation between nations. To understand global patterns of cyber behavior, a study analyzing comparative analysis of national cyber strategies, doctrine documents, threat intelligence reports, and documented state-linked cyber incidents from 2008 to the present was conducted with dataset of major incidents compared, compiled, and categorized by governmental actor, operational objective, target sector, tactics, and strategic impact. In addition, several focused case studies utilizing world powers to examine how these specific countries translate doctrine and cultural perspectives into real-world cyber operations. Through reviewing and comparing different doctrines, cyber operations and tendencies can outline anticipating threats and building meaningful defense which is essential to understanding the cyber landscape. The study identifies differences in how states deploy cyber capabilities based on their strategic culture, political systems, and resource environments. By clarifying how cultural and strategic factors shape cyber behavior, this research aims to support improved attribution processes, more effective defensive planning, and stronger international cooperation in addressing the emerging cyber landscape.

Montana AI Data Centers Will Be the Reason You Can't Ski

Shane Grogan, Political Science

Mentor(s): Paul Lachapelle, Political Science

The proposed Quantica Infrastructure data center that would be built in Broadview, Montana, is just roughly 30 miles outside of Billings. NorthWestern Energy, the provider of more than 760 megawatts of electricity to roughly over 60% of Montana's population, has previously signed a deal to give more than 1000 megawatts of power to the new data center being built on 5000 acres of land. "Large data centers can consume up to 5 million gallons per day, equivalent to the water use of a town populated by 10,000 to 50,000 people." (Yañez, 2025). Auburn, Virginia, aka Data Center Alley, home to around 200 data centers, has seen an increase across the board in Land Surface Temperature (LST), affecting not only Auburn but the surrounding areas/towns/cities. (Zhang, 2025). In a study done by Cornell University, "We found that Virginia, Texas, and Oregon had the highest CO2e emissions attributable to data centers: 30.08, 9.63, and 8.92 MT of emissions, respectively. Illinois was fourth with 6.22 MT, and California was seventh with 4.37 MT of CO2e emissions." (Guidi et al., 2024) AI is here, and Big Tech corporations want to expand into our beautiful lands and suck the resources out for an "AI revolution". If we as Montanans don't

take the legislative steps to stop, limit, and ban these companies, this won't be the same Montana, and winters for snow sports will be shorter than even this year.

Acknowledgements: USP - Undergraduate Scholars Program

Wetland Protections in Bozeman

Leisher Gugino, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

In September of 2025, the Bozeman City Commission approved an updated wetlands ordinance that strengthens protections for wetlands in the city. The updated ordinance was described by the Gallatin Watershed Council as the most progressive wetland code in Montana. This poster examines the scientific basis for strong wetland protections and the importance of enforcing the ordinance. Wetlands provide essential ecosystem services, including carbon sequestration and flood mitigation. Research confirms that established wetlands are one of the most effective carbon sinks and are important for climate change mitigation, while urban development continues to be a leading driver of wetland loss across the United States, a pressure directly related to Bozeman's rapid growth. Bozeman's new ordinance establishes a mitigation priority order requiring developers to pursue on-site mitigation first, followed by local watershed credits, and then external mitigation banks. However, without enforcement, developers are likely to select the cheapest available option, which is a wetland bank in Twin Bridges, MT. This would remove the ecological benefits of wetlands from the local watershed and undermine the ordinance's intent. Proposed federal rollbacks to the Clean Water Act could remove protections for a majority of wetlands in Gallatin County, leaving Bozeman's local ordinance as the last line of defense for these systems. The conclusion is that strong policy is necessary but insufficient. Enforcement will determine whether Bozeman's wetlands continue to provide critical climate and ecosystem benefits as the city grows.

Montana Waters are Getting Hotter and it's Stopping you from Fishing

Kailer Hegna, Political Science

Mentor(s): Paul Lachapelle, Political Science

Rising temperatures, driven by climate change, are raising water temperatures and destroying cold-water trout habitats in the Greater Yellowstone Area. The optimal water temperature for cold water trout is between 55-65°F. When water temperatures reach 73°F

for three consecutive days, the Montana Department of Fish, Wildlife, and Parks (FWP) enacts “Hoot Owl” closures. In 2025, the first Hoot Owl closures happened over two weeks before those in 2015 and almost a month and a half before restrictions in 2019. Researchers found warming water temperatures and reduced stream flows force fish to abandon their natural habitats and crowd into smaller, deeper, and colder areas of our rivers leading to an increased risk of disease, predation, and invasive species leading to worse spawning and later worse adult populations. The Greater Yellowstone Climate Assessment's projections show that within 20 years, 17% of Greater Yellowstone area rivers will exceed sustainable temperatures for trout and is expected to double by 2080. To maintain our state’s great trout fisheries and the rural economies they support, I recommend 4 policy solutions: 1) Increase interagency data sharing via a shared database for FWP, US Forest Service, conservation nonprofits, and universities; 2) Alert anglers in a “warning” phase before the 73°F threshold; 3) Restore and protect riverside vegetation to provide shade and lower water temperatures; 4) Develop co-managed planning platforms with all stakeholders, not just agencies.

Data Centers and Their Impact on Montana Locals and Climate Change

Zach Henry, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

Montana’s vast land availability, cool climate and inexpensive utility prices have made the state a major destination for the construction of data centers. As the need for more digital infrastructure expands on a global scale, companies are drawn towards regions that have access to cooling and a lot of available land, making Montana the perfect destination. Data centers consume large amounts of water and electricity and can be harmful to the environment with excessive use. But they can be a strong boost to the economy for local communities. Therefore, there are many positives and negatives to data centers drawing a fine line between opinions. Do we sacrifice the environment for our own financial benefit? Or do we sacrifice the wealth and knowledge that data centers bring with them? Montana places high value on water due to the strong agricultural community in the state and the ever growing population. Keeping Montana clear of large-scale data centers to prevent an increase in water consumption/price, noise pollution and electricity prices is very important. This poster dives into the impact of data centers on Montana communities, exploring water and energy usage rates, land use development and the overall ecosystem surrounding data centers and how we as a community can make a difference.

Democracy Divided

Sadie Jenkins, Political Science

Mentor(s): Steven Krichhoff, English

This paper argues that the United States faces a structural democratic crisis driven not by policy disagreement but by identity-based partisanship. Drawing on research in political psychology, democratic theory, and media studies, it traces the rise of affective polarization—emotional hostility toward opposing partisans—from post-1960s partisan realignment to the present. Grounded in social identity theory, the review demonstrates how American political parties have evolved into comprehensive "mega-identities" that fuse race, religion, geography, and culture into morally incompatible coalitions, producing partisan animosity that now rivals racial bias in intensity and behavioral consequence. The paper examines how elite-driven polarization and a fragmented media environment—marked by cable news narrowcasting and social media echo chambers—amplify division and erode the informal democratic guardrails of mutual toleration and institutional forbearance. Empirical evidence reveals that public support for democratic norms is increasingly conditional, with only a small fraction of Americans consistently prioritizing democratic principles over partisan loyalty. Conventional accountability mechanisms—electoral consequences, normative commitment, and institutional restraint—have been significantly weakened by overlapping forms of mass, electoral, and elite polarization. The paper concludes that affective polarization is simultaneously a psychological phenomenon and an elite-driven political strategy, and that restoring democratic resilience requires interventions across multiple levels of the political system.

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Bottom-Up Aid and Institutional Memory Can Combat Climate Challenges

Blake Lindemann, Political Science

Mentor(s): Paul Lachapelle, Political Science

The 2025 closure of the Environmental Justice Thriving Communities Technical Assistance Center (EJ TCTAC) at Montana State University, following federal budget reallocations, created a critical "adaptation gap" for 28 Tribal Nations and rural communities across Montana, Wyoming, Utah, Colorado, North Dakota, and South Dakota. This research explores the socio-economic consequences of this closure for the affected communities, and advocates for a self-sustaining resource similar to that of the EJ TCTSC (Center here-on), as a means to cover this gap. This study analyzes the "multiplier effect" of technical assistance. Recent data collected in light of the closures found that for every $1.00

allocated to these programs, an estimated $2.56 in regional value was generated. As such, the withdrawal of federal funding represents a $6.4 billion loss in economic opportunity. This paper outlines a new model to create a university-led Center, self-sustained via a tiered membership fee structure based on population and revenue. This Center would solve the “Track Record Paradox," where underserved communities remain underserved because they lack a history of funding, and thus are excluded from federal grants. By creating a centralized resource for technical problems, grantwriting, and legal aid, Montana State University would restore the capacity of communities across the Rockies and Great Plains in effectively addressing the 21st Century challenges of the climate crisis and environmental change. This research concludes that a stable,locally managed technical hub is a necessity in a building a stronger, climate resilient future for the Northern Rockies and Great Plains.

Acknowledgements: USP - Undergraduate Scholars Program

American Pikas under threat of Global Warming

Matthew McGraw, Political Science

Mentor(s): Paul Lachapelle, Political Science

The American Pika is a small herbivorous mammal that lives among talus and boulder fields in western North America. Despite their round, rodent-like appearance, they are most closely related to rabbits and hares. Global warming and climate change present a significant threat to Pikas here in Montana, as well as across the United States. This is due to the fact that Pikas have a very limited ability to regulate higher temperatures as a result of pikas have no effective cooling mechanisms. Unlike many mammals, pikas cannot pant, sweat, or use saliva for evaporative cooling. This makes them very vulnerable to overheating above ~25–29°C air temperature for more than a few hours. Research shows that pikas try to maintain internal temperatures by slowing their metabolic rate as external temperatures rise. Unfortunately, they cannot continue to slow their metabolic rate past the ~25–29°C threshold. This physical constraint is reflected in their behavior. As temperatures increase, pikas forage less frequently. A case study done on the Pika population on Niwot Ridge in Colorado found that increased days of warmer temperature (GDD= Days above 0° C) correlated with a decline in recruitment rates (introduction of new individuals). Additionally, Pikas are also threatened by the loss of winter snowpack that comes with global warming. Usually, the snowpack insulates their rocky habitat from extreme colds. With snowpack projected to continue to decline at high-elevation sites, Pikas face a multi-seasonal threat from global warming and climate change.

Community Choice Aggregation (CCA) in Montana

Jake Moore, Political Science

Mentor(s): Paul Lachapelle, Political Science

While the City of Bozeman has set emissions reduction goals for the coming years, it lacks the necessary authority over electricity procurement needed to effectively reach these goals. Currently, Northwestern Energy controls electricity procurement decisions in the state of Montana, and its actions are overseen by the Montana Public Services Commission. Adopting a Community Choice Aggregation (CCA) model is the next step Bozeman must take to stay on track to achieve its clean electricity goals. Community Choice Aggregation "allows local governments to procure power on behalf of their residents, businesses, and municipal consumers from an alternative supplier while still receiving transmission and distribution service from their existing utility provider" (State Climate Policy Dashboard, 2025). Following the adoption of a CCA, the City of Bozeman would negotiate on behalf of its residents to secure low-cost renewable electricity. Municipalities with a CCA have "higher amounts of clean energy consumption and/or lower electricity prices" (State Climate Policy Dashboard, 2025). So if CCAs result in cleaner energy and lower costs, why hasn't Bozeman instituted one? The main hurdle is that CCAs are not recognized as legal under current Montana law. Montana must pass a law permitting municipalities to aggregate customers and procure electricity in bulk. This law would then be subject to regulation by the Montana Public Service Commission before Bozeman could pass an ordinance creating a CCA.

Are our parking lots naked?

Samuel Nelson, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

Montana State University has 25 parking lots listed for students to park in on campus. Nearly all of these parking lots are paved with dark asphalt that absorbs solar radiation and releases it back into the environment as heat, commonly known as the Urban Heat Island Effect. Montana State University is also not independent in how it gets its electricity, having to purchase it from outside sources. This research focuses on the possibility and the plausibility of reducing the heating effects of parking surfaces through various covering

structures, with an emphasis on the impact a shade structure with photovoltaic capabilities would bring to the university. A plan to convert or cover the current parking spaces on campus will require taking into account all of the different uses for parking areas, the size of these lots, and the out-of-pocket cost incurred by the university. Some potential solutions would be building shade structures, increasing greenery in the lots, constructing more multi-level parking, and doubling the use of the lots as solar farms. While there are many different routes a project like this could take, no matter the path, it will cost the school in space and funds, but could very well prove to be beneficial or even profitable in the long run.

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Oral Health Assessment in a sample of the Latino Population in Gallatin County

Maya Putnam, Health & Human Development

Mentor(s): Sally Moyce,

Poor oral health is highly prevalent in today's society and is closely linked to the development of other preventable yet common diseases. Thus, advocating for oral health in communities disproportionately affected by poor oral hygiene is of great importance. This project sought to identify common oral health behaviors and their associations with oral health outcomes in a sample of the Latino population in Gallatin County. Additionally, it intended to understand how an overall oral health risk score correlated with various social determinants. Data collection occurred at four free mobile primary care clinics sponsored by Proyecto SALUD during the months of May through October of 2025. Oral health data included questionnaires about behaviors and visual examinations by a trained dental assessor. Other variables were collected via self-reported questionnaires. The results given by 86 participants were analyzed in this study. These results were categorized into three summary measures of overall risk: behavioral, visual assessment, and reducible. 30% of the sample exhibited seven or more behavioral risk factors. 30% of the sample had 3-4 risk factors based on visual examination. Behavioral risk scores were statistically significantly associated with assessment risk and overall risk. Overall, these results demonstrate that common oral health behavioral habits are closely aligned with visually observable tooth decay. Addressing these behavioral risk factors may play a role in reducing overall oral health risk and associated poor health outcomes among disproportionately affected populations.

Acknowledgements: USP - Undergraduate Scholars Program

Wildfire Impacts on Montana — How does wildfire smoke in Montana impact vulnerable populations? What can we do?

Ryann Smith, Political Science

Mentor(s): Paul Lachapelle, Political Science

Wildfire smoke has become an increasingly more prominent issue in Montana due to climate change and longer wildfire seasons. In my poster I will focus on how wildfire smoke affects public health and the impacts the wildfire seasons have on Montana communities, specifically vulnerable ones. I will be looking into policy solutions to reduce the impacts of smoke effects on public health. Using government reports and climate research, specifically based on Montana, my poster will be looking at trends among wildfire activity, air quality, and health outcomes. Wildfire smoke contains tiny particles that make it harder to breathe and can make already existing health issues worse. Research shows that smoke exposure is linked to respiratory and health problems and has been associated with a 7.2% increase in respiratory hospital visits in the Western U.S.. However, certain groups get affected disproportionally. The groups that get affected worse are children, older adults, outdoor workers, and low-income communities who might have fewer resources in order to protect themselves. Climate change is making wildfires happen far more frequently and more severe, wildfires in Montana are expected to double by 2050. These impacts don't just affect the ecological aspect. It also affects the economy. Up to 11,000 jobs and $281 million in income are at risk. As of late, responses have often focused on short-term solutions rather than long-term prevention, which is a problem I want to address. In conclusion, stronger and more equitable policies are needed to protect public health. Being from Bozeman, I have personally been affected by these worsening wildfire seasons, and I can only wish to vouch for the vulnerable. Addressing wildfire smoke requires long-term policy changes to reduce risks and protect vulnerable communities.

The Cyber Frontier of Political Warfare: How States Use Cyber Operations to Influence and Destabilize Political Systems

William Stephenson, Political Science

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

Cyber operations are now a key part of political warfare, with governments using digital tools to influence other countries' political systems. By spreading disinformation, hacking, and using propaganda, governments can shape institutions without resorting to military force. These tactics pose a serious challenge to political stability. This research examines how states use cyber operations to influence politics. It compares case studies from various countries including, Russia, China, and Iran. The study uses content analysis to find patterns in messaging and online manipulation, and policy analysis to review how governments and cybersecurity experts respond to these threats. To analyze this information, this research uses theories of hybrid warfare, soft power, and information warfare, among others. This study concludes that cyber operations are central to modern political warfare and are very effective. States often use disinformation, hacking, and psychological tactics together to shape political narratives, interfere in elections, and reduce trust in the opposition's government. While this may differ from traditional war through military force, these methods are effective due to their affordability and difficulty of being traced.

Acknowledgements: DoW- Department of War

Fossil Fuel Workers Need Alternatives: Establishing a Just Transition in Our Changing World

Karter Wight, Land Resources & Environmental Sciences

Mentor(s): Paul Lachapelle, Political Science

Like many extractive communities, Colstrip's workforce faces an increasingly unstable regulatory and market environment, with federal decisions swinging rapidly between potential plant closure and short-term expansion. Recent reporting shows that the mine supplying Colstrip was authorized for expansion just a year after federal rules threatened to shut the plant down completely. This volatility creates uncertainty for rural workers and communities whose livelihoods depend on coal. Comparative research demonstrates that coal-dependent regions without proactive planning experience long-term economic decline, while communities that secure a structured just transition, achieve greater economic stability and self-sufficiency. Colstrip's economic profile closely mirrors these vulnerable regions, and the Montana Public Service Commission (PSC) holds significant influence over whether Montana communities experience unmanaged decline or planned, worker-centered transitions. A structured just transition plan would not force immediate closure; rather, it would be a risk-management strategy grounded in evidence from other coal regions. Key components include workforce training in alternative energy

technologies, job pathways in land and water restoration to protect rural communities, and early-retirement or bridge-benefit options for workers. In the US, Colorado's Office of Just Transition, established in 2019, provides wage replacement, retraining support, and community-planning grants for coal towns facing mine and plant closures. Early outcomes show improved economic resilience and reduced worker displacement. A planned transition for Colstrip would protect workers, stabilize rural communities, and ensure that Montanans who have powered the state for decades are not left behind.