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Table of Contents

Colleges.....	4
College of Agriculture	4
College of Education, Health & Human Development.....	10
College of Engineering	12
College of Letters & Science	26
Alphabetical Listing of Students.....	50

COLLEGE OF AGRICULTURE

William Baker: Microbiology & Immunology

Mentor: Susy Kohout – Cell Biology and Neuroscience

New Discoveries About Voltage-Sensing Phosphatase Through Voltage Clamp Fluorimetry

Voltage-sensing phosphatase (VSP) is the only protein known to link transmembrane voltage to intracellular enzymatic activity. VSP contains a transmembrane voltage-sensing domain (VSD) that undergoes a conformational change in response to fluctuations in local membrane voltage. Through its movement, the VSD communicates with an intracellular phosphatase domain (PD) to modulate its activity. Therefore, VSD function is a crucial element of VSP physiology because it translates voltage into a signal that can be read by its corresponding phosphatase enzyme.

Voltage clamp fluorimetry (VCF) is a technique that allows one to observe a protein change shape in real-time while controlling its electrical environment. With new VCF data, we have demonstrated that the voltage-dependent behavior of the VSD shifts significantly under a few specific mutations to its amino acid sequence suspected to disrupt VSP dimerization. For example, a VSD expressing the mutations F127A, I131A, I134A, and L137A (collectively termed S1Q) exhibits movement at much lower voltages than wild type VSD. Therefore, our VCF data surrounding S1Q correlate possible monomer/dimer states of VSP with the nature of its voltage dependence.

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

Jade Berghoff: Land Resources & Environmental Sciences

Mentor: Danielle Ulrich – Ecology

Comparing the Crown Architecture of Whitebark and Limber Pine Seedlings

Climate change is happening, and the effects it will have on high elevation forests are largely unknown. Two keystone species, whitebark pine (*Pinus albicaulis*) and limber pine (*Pinus flexilis*), are essential for headwater stream control, snowpack retention, and soil stabilization. There is little research conducted on the two species due to the fact that they are indistinguishable in the absence of mature cones. Developing a quantitative way to distinguish between the crown architectures and seedling morphology of whitebark pine seedlings (WPS) and limber pine seedlings (LPS) could open opportunities for future studies to be conducted on the effects climate change will have on these habitats. Recording how crown architectures and seedling morphology differ between the species will give way to understanding the amount of light that is photosynthesized, which influences seedling establishment. A variety of measurements were recorded on fourteen WPS and twenty-six LPS including maximum crown height, maximum crown width, stem length, root length, and stem base diameter. Preliminary results quantify 2.1 times greater fascicle density in LPS in comparison to WPS. These findings should be of value to researchers looking to better understand where these species will be able to establish under current climate change concerns.

Acknowledgements: Undergraduate Scholars Program (USP)

Hannah Dreesbach: Microbiology & Immunology

Mentor: Matthew Fields – Microbiology and Immunology

Determining the Effects of Flow Rate on Microbial Localization and Metabolism in a Simulated in situ Terrestrial Subsurface Environment

Microorganisms in terrestrial subsurface environments play important roles in nutrient cycling and anthropogenic contaminant degradation – functions essential to maintaining healthy aquifers. These communities remain highly understudied, especially with regards to spatially resolved information. This project, currently ongoing, seeks to

gain a better understanding of how environmental factors such as flow rate impact biomass distribution and metabolic activity. A previously optimized packed bed reactor (PBR) system is being used to simulate background subsurface conditions at the Oak Ridge National Laboratory Field Research Center (ORNL FRC), where historic contamination has led to extremes in pH, metal concentrations, and nutrients such as nitrate. Three experimental groups have been outlined for studying the effects of flow rate: abiotic reactors inoculated with bromide (to generate breakthrough curves of an isolated substrate), abiotic reactors inoculated with bromide and fluorescent microspheres (in order to visualize localization of inert non-charged particles), and biotic reactors inoculated with FRC-relevant bacterial isolates of *Rhodanobacter* and *Acidovorax* spp. Initial abiotic runs have been sampled for the presence of bromide, nitrate, and fluorescent microspheres and LR white embedded cores have been taken to analyze microsphere distribution. Future work will compare results from abiotic runs to those of biotic runs, with specific attention to differences in spatial distribution between microspheres in abiotic runs and microbial cells in biotic runs. Results from this project will allow for a better understanding of the impact of media flow rate on biomass distribution and metabolic activity.

Acknowledgements: KaeLee Massey, Heidi Smith, Undergraduate Scholars Program (USP)

Natalee Glanville: Animal & Range Sciences

Mentor: Carl Yeoman – Animal and Range Sciences

Bacterial Immune Modulation of Neonatal Ruminants

Neonatal ruminants are thought to be born sterile. They acquire microbiota from the mother following parturition, during skin-to-skin contact from the udder, from the surrounding environment, and their mother's colostrum. Ruminant microbiota is responsible for a large portion of nutritional intake, production of vitamins and animal health development and maintenance in general. While most studies of the bovine GIT microbiome focus on the pre-gastric rumen, the ileocecal region shows to play a vital role in the immune system as well. Previous research on the microbial and immunological development of neonatal ruminants has identified correlations between 56 microbial taxa in the GIT and serum immunoglobulin titers. While using bovine intestinal organoids (BIOs) that are derived from small intestinal epithelial cells, we sought to determine the ability of distinct bacteria to modulate cellular immunological responses to enteric pathogens and minimize the breakdown of barrier function by enteric toxins. Identifying microbes that improve Bovine immune function could lead to the development of direct-fed microbials that would benefit regional and national producers and by reducing morbidity and mortality of livestock.

Acknowledgements: Undergraduate Scholars Program (USP)

Sophie Grimm: Land Resources & Environmental Sciences

Mentor: Jack Brookshire – Land Resources and Environmental Science

Quantifying Carbon Sequestration from Recent Woody Plant Expansion Across the Northern Great Plains

Maximizing terrestrial carbon sequestration is a necessary step in mitigating climate change. Different terrestrial ecosystems store varying amounts of carbon in above- and belowground biomass, but these pools may shift under projected climate change. For instance, herbaceous ecosystems globally are experiencing a shift toward increasingly woody vegetation. These dynamics play an integral role in the global carbon budget and may aid future climate mitigation. This project aims to analyze how woody plant expansion influences carbon sequestration in the Northern Great Plains (NGP). The NGP makes up ~3.5% of North American land area and consists primarily of grassland (62%) with roughly one-third cropland and the rest shrubland and forest. We asked which landcover type has experienced the greatest tree cover and carbon sequestration change over the last twenty years. By modeling the relationship between MODIS percent tree cover, ESA CCI landcover type, and gridded biomass carbon, we simulated vegetation carbon dynamics across all major landcover types. We found that the total biomass carbon sequestration rate across the NGP is 14.6 Mt CO₂/yr, 61% of which is stored belowground and mainly in grasslands. However, we document extensive tree cover changes across the region, with the highest

relative changes in forested regions but the most extensive total changes across grasslands. Tree cover change and carbon sequestration are positively related, indicating significant implications for the potential CO₂ sink strength of the NGP in the future under continued tree cover increase.

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Lillian Heys: Microbiology & Immunology

Mentor: Shawna Pratt – Chemical engineering

Comparing growth rates of Pseudomonas aeruginosa and Staphylococcus aureus in single-cell and bulk cultivation approaches

Chronic wounds, which can take an excess of four weeks to heal, affect approximately 6.5 million US citizens every year². Staphylococcus aureus and Pseudomonas aeruginosa are two microbes that are particularly prevalent in chronic wounds, and interactions between the two are correlated with increased community robustness. Although these microbes are found to communally co-exist in chronic wounds, they are often observed to be antagonistic when co-cultured using standard bench-top microbiology methods. The aim of this research is to understand the emergence of synergistic growth between these two microorganisms starting from precisely controllable numbers of bacteria in microscale drops created using drop-based microfluidics. In this work, we first established growth rates for P. aeruginosa and S. aureus individually in microfluidic drops. Once the individual growth rates were established, ratios of P. aeruginosa and S. aureus were cultured together in microfluidic drops, and changes in growth rates were analyzed. We also compared the growth rates in droplets to bulk growth rates for both the individual microbes and the consortia. Finally, we investigated whether the symbiotic effects of co-culturing are due to heterogeneous interactions between sub-populations of P. aeruginosa and S. aureus. Microfluidics allowed control of population dynamics with single cell precision and enabled observation of the role of cellular heterogeneity upon interspecies interactions. The research presented here allowed us to determine the effect of drop culturing on bacterial growth as a first step in developing a method for evaluating microbial interactions starting from single cells.

Acknowledgements: Connie Chang, Undergraduate Scholars Program (USP)

Janessa Kluth: Animal & Range Sciences

Mentor: Timothy DelCurto, Megan Van Emon – Animal & Range Science

The use of ruminal temperature probes to estimate water intake and water intake behavior of beef cattle

The objective of this study was to evaluate if ruminal temperature probes can be used to accurately estimate daily water intake and water intake behavior in beef cattle. Sixteen ruminally-cannulated cows (8 two-year-olds, 8 three-year-olds) were individually penned and used in a series of digestion studies that evaluated forage intake, supplement intake, and water intake. A SmaXtec bolus was placed in the reticulum of each animal for the entirety of the digestion study periods and water intake was measured with GrowSafe feed technology. The SmaXtec bolus measured temperature, pH, and activity at ten-minute intervals. The SmaXtec ruminal bolus temperature data was paired with individual time-stamped watering events derived from the GrowSafe system for the duration of the digestion study periods. We used 70% of the data to train the model with the remaining 30% used to validate the model. Potential variables to influence ruminal temperature in relation to water intake were relative ruminal temperature change, ambient temperature, time post-feeding, and ruminal/reticular volume. Best model fit was determined with AIC (Akaike's Information Criterion) and by calculating marginal and conditional R² for generalized mixed linear models. The ability to predict water intake and water intake behavior in group settings with one common water source will be beneficial to nutritional management of livestock.

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Sydney Nesson & Faina Toole: Microbiology & Immunology

Mentor: Steve Stowers – Microbiology and Immunology

Dual Neurotransmission Circuitry and Mechanisms Underlying Regulation of Aggressive Behavior

Over the last twenty years it has become increasingly clear that many, if not most, neurons use multiple neurotransmitters. Here it is proposed to use octopamine/glutamate dual neurotransmitter neurons (OGNs) in the fruit fly *Drosophila melanogaster* as a model for understanding the signaling mechanisms of dual neurotransmitter neurons. Octopamine (OA) is the insect analog of norepinephrine. Like norepinephrine neurons in the locus coeruleus (LC) brain region of humans, OA mediates the fight-or-flight response to threatening environmental stimuli. Previous studies of dual neurotransmitter neurons in mammals have determined that sometimes both neurotransmitters are used for conveying information to downstream neurons, while other times glutamate is only used to enhance the filling of the primary neurotransmitter but not for signaling (vesicle synergy). The powerful genetic advantages of *Drosophila* have been leveraged to determine if specific OA neurons signal using glutamate to their downstream target neurons. This was accomplished first by determining which of the 17 *Drosophila* glutamate receptors are expressed in the downstream target neurons and subsequently by assessing whether the glutamate receptors that are expressed are localized to post-synaptic contact sites. Specifically, the hypothesis to be tested is whether glutamate released from OGNs is used for signaling to their downstream target neurons MBON-5 and MBON-11. Successful generation of a conditional epitope-tagged allele of the NMDA-R2 has been shown to give puncta distribution throughout the brain. This research will not only have implications for dual neurotransmitter neurons in general, but also for understanding human behaviors mediated by the LC.

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Naomi Redfield: Animal & Range Sciences

Mentor: Shelly Hogan – McNair Scholars Program

Oral Micro-mineral Treatment in Yearling Beef Cattle to Decrease Morbidity and Increase Performance

This trial was designed to test the hypothesis that stressed yearling beef cattle individually treated with an oral micro-mineral product would result in decreased BRD, foot rot, and pinkeye infections in the first 60 days while grazing pastures and would show an increased ADG during the 100 day grazing period. This trial utilized 1150 head of yearling steers, intact heifers (to evaluate increased pregnancy rate), and spayed heifers with average BW 550 lb. (293 kg) in areas of Idaho and Montana. Cattle had unknown background and nutritional history, with no metaphylaxis treatment on arrival. Cattle were randomly sorted off trucks (after processing and a six-hour transportation to summer pasture (during May 20-22, 2020). Half were treated with an oral micro-mineral product composed of zinc (Zn), copper (Cu), selenium (Se), and cobalt (Co), at a dosage of 20 ml / 227 kg immediately prior to pasture turnout. Treatment data for BRD and other abnormalities was analyzed to determine if treatment resulted in decreased morbidity and mortality during the first 60 days of the trial compared to untreated cattle. Results showed decreased morbidity in all groups and increased ADG in two groups of 13.2-18.9 lbs. during the 100-day grazing period. The intact heifers showed a 2% increase in pregnancy compared to the control group. This product has potential to be used in yearling beef cattle for improved health by decreasing morbidity, increasing performance, and improving profit in stressed yearling beef cattle during grazing on summer pastures.

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Gabrielle Rizzo: Microbiology & Immunology

Mentor: Edward Schmidt – Microbiology & Immunology

Induction of an Antioxidant Response System by Genetic and Biochemical Manipulation of Keap1-Nrf2 Interaction

Aerobic respiration—an essential metabolic process yields abundant quantities of cellular energy. Significant oxidative stress is a consequential byproduct of incomplete aerobic respiration. Oxidative stress impairs cellular

processes via damaging cellular machinery. This creates vulnerability to cancer and autoimmune disease. Two fundamental defense systems that neutralize oxidative stress are the thioredoxin reductase (TR) and glutathione reductase (GR) antioxidant systems. The TR and GR antioxidant systems utilize NADPH to reduce cellular disulfides. This mechanism fuels neutralization of oxidant accumulation in cellular environments via copious redox enzymes. However, with overwhelming presence of specific xenobiotics (e.g. acetaminophen), the TR-GR antioxidant defense system can become ineffective. With TR-GR defense systems inhibited, cells induce an alternative antioxidant response—the Keap1-Nrf2 system. Nrf2-negotiated transcription in mouse livers upregulates cytoprotective proteins (e.g. carbonyl reductase 3, NADPH quinone oxidoreductase 1, and heme oxygenase 1) that metabolize TR-GR-inhibiting xenobiotics. NADPH production is thus correspondingly increased, ensuing alternative activation of the TR-GR defense system. Keap1 represses Nrf2 transcription. The proposed study utilized 2-cyano-3,12-dioxo-leana-1,9-dien-28-oic-acid (CDDO)—a synthetic electrophilic Nrf2 activator—to induce an Nrf2 response in wild type (WT) versus TR-GR-null mouse livers. CDDO is hence an inhibitor of Keap1, allowing independent assessment of increased Nrf2 expression in oxidatively stressed livers.

Acknowledgements: Colin Miller, Undergraduate Scholars Program (USP)

Rachael Robbins: Land Resources & Environmental Sciences

Mentor: Danielle Ulrich – Ecology

Variation in Seedling Stomatal Traits among 3 High Elevation Pine Species

High alpine tree species are threatened by climate change, pathogens, and insects. Plants respond to such environmental stressors through adjustments or adaptations in morphological and physiological traits (Marenco et al., 2017). Stomata, small pores on leaves through which plants exchange water and CO₂ for photosynthesis, are vital for evaluating and understanding plant responses to climate change (Sniezko et al., 2018). In this study, in greenhouse-grown 5-year old seedlings, I examined variation in stomatal traits (stomatal density, stomatal size) in two populations from contrasting climates of three high-elevation pine species: whitebark pine (*Pinus albicaulis*), limber pine (*Pinus flexilis*), and Great Basin bristlecone pine (*Pinus longaeva*). I also measured stomatal traits in whitebark pine seedlings of three different ages: 2, 3, and 5 years old. Needle samples were collected from seedlings, and random segments on each needle were used for evaluating stomatal density and size. I hypothesized that a) older trees, b) populations originating from climates with high light exposure, and c) the species limber pine will have a higher stomatal density and higher LMA. ANOVA and linear mixed models in R were used to determine the effect of species, population, and age on the response variables: stomatal density and size.

Acknowledgements: Undergraduate Scholars Program (USP)

Susanna Walsh: Land Resources & Environmental Sciences

Mentor: Jack Brookshire – Land Resources & Environmental Sciences

Comparative analysis of root characteristics and soil microbial community dynamics across two bioenergy cropping systems on marginal land in SW Montana

Marginal lands, unsuitable for food production, across the Northern Great Plains (NGP) have considerable potential for perennial cellulosic bioenergy production. The use of these lands for bioenergy carbon capture and storage (BECCS) could help mitigate climate change while producing local sustainable energy. Considerations for agricultural management in the semi-arid climate conditions of the NGP focus on crop and fertilizer optimization strategies to enhance productivity and ecosystem function while minimizing negative environmental effects. Management decisions can also dictate the allocation of carbon (C) and nitrogen (N) in above and belowground plant components which can affect soil processes that in turn drive C sequestration and storage in agroecosystems.

Two perennial grasses differing in photosynthetic pathways (C₄ and C₃)—switchgrass (*Panicum virgatum*) and tall wheatgrass (*Thinopyrum ponticum*)— were fertilized with a novel cultured cyanobacterial biofertilizer and

conventional urea and compared to unfertilized controls over three years. Belowground responses were quantified and compared using root biomass, chemistry, and changes in microbial community dynamics. We report that total above and belowground productivity was greatest in the fertilized tall wheatgrass treatments compared to switchgrass, with the biofertilizer matching urea biomass output. There was no effect of fertilization on total productivity in the switchgrass plots. Furthermore, root C:N ratios and calculated nutrient use efficiency were greatest in tall wheatgrass. Despite higher productivity in tall wheatgrass, we find higher abundances of bacterial and fungal species important to C cycling and nutrient acquisition associated with switchgrass.

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COLLEGE OF EDUCATION, HEALTH & HUMAN DEVELOPMENT

Havilah Burton: Health & Human Development

Mentor: Wan-Yuan Kuo – Food Product Development Lab

What role does food sovereignty play in bringing an invasive fish species to market? A collaborative study with the Confederated Salish and Kootenai Tribes

The Confederated Salish and Kootenai Tribes and their subsidiary Native Fish Keepers Inc. are working to remove invasive trout from Flathead Lake and use this fish to nourish their people. Previously our research group created a value-added smoked fish product in conjunction with the tribes. Two questions were raised, one: can a product made from an invasive species be called Native? And two: how does this commercial product fit into the non-profit designation of the corporation? This study sought to answer these questions to advance food sovereignty movements by exploring the definition of native foods and sustainability purposes of value-added native foods.

An online survey was distributed to tribal members on the Flathead Indian Reservation, and food service workers throughout Montana. The survey asked for knowledge and usefulness of the lake trout, and perceptions around Native foods and food sovereignty to understand the status of potential markets for a Tribally created smoked fish product.

Both groups strongly identified the trout as wild, but 55% of Natives identified the trout as Native, ancestral, or traditional, compared to 39% of non-Natives. Most people in both sectors had heard of the trout and are interested in having trout and other Native foods available. There are strong concerns from both groups that Native foods be produced by Native people and go first to benefit Natives.

This study shows that ongoing Tribal work in sustainability and food sovereignty is more important to people than whether a food is historically identified as Native.

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Anna Kristiansen: Health & Human Development

Mentor: Mary Miles – Health & Human Development

Changes in Insulin Resistance after 12 Weeks of Lentil Consumption

Insulin is a pancreatic hormone that facilitates glucose uptake and contributes to the function of liver and adipose tissue. Insulin rises after a meal to maintain blood sugar, but in insulin-resistant individuals, cells become unresponsive and excess blood sugar promotes weight gain. Insulin resistance is a key characteristic of metabolic syndrome, which is strongly linked to obesity. Regular pulse consumption may be a promising low-cost strategy to improve insulin resistance and metabolic health. In this preliminary analysis of a randomized control trial, non-diabetic overweight and obese adults underwent a 12-week dietary intervention where participants received either control or lentils mid-day meals daily for 12-weeks. Before and after the intervention, participants completed a high-fat meal challenge with hourly blood sampling for 5-hours after their meal. Fasting and postprandial blood samples were used to determine concentrations of triglycerides, glucose, cholesterol, free fatty acid, and insulin. The purpose of this study was to evaluate how regular long-term lentil consumption affects the insulin response and other metabolic health markers. It is believed that the participants who regularly consumed lentils will show decreased insulin resistance after the meal intervention.

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Bailey Stroh: Health & Human Development**Mentor: Cara Palmer – Psychology*****Got Ghrelin?***

Poor sleep is known to impair a range of functions, including the immune system, metabolism, learning, memory, and emotional functioning (Walker & Stickgold, 2006). Two hunger-regulating hormones, leptin and ghrelin, are affected by sleep. Leptin decreases appetite and ghrelin stimulates it. When sleep deprived, ghrelin spikes and leptin decreases, leading to an increase in hunger. The current study examined associations among sleep and food cravings in a sample of healthy undergraduate students. Sleep was measured objectively using actigraphy for one week. Food cravings were assessed using a behavioral task where participants were presented with a series of healthy and unhealthy food images, and they reported on how much they were craving that food. Overall, participants reported craving healthy food more than unhealthy food ($t(42) = 3.43, p = .001$), but both types of cravings were positively associated with one another ($r = .55, p < .001$). Participants were generally healthy sleepers, and on average they slept for 444.57 minutes (range = 316.14-545.33, SD = 41.00). No sleep patterns were associated with healthy or unhealthy cravings. Overall, findings suggest that sleep patterns were not associated with food cravings. Hunger-related hormonal changes may be more prevalent for those with unhealthy sleep patterns, or at more extreme levels of sleep loss.

Acknowledgements: Undergraduate Scholars Program (USP)

Evan Telford: Health & Human Development**Mentor: David Graham – Health and Human Development*****The relationship between muscle contraction dynamics and balance recovery performance***

Poor balance is a risk factor for falls and exercises that challenge balance are a key component of exercise-based fall prevention. Exercise is a proven intervention to prevent falls in community-dwelling older adults. Perturbation-based training (PBT) has been shown to be effective. It is reactive, dynamic, and imposes a challenge to balance, providing superior outcomes relative to reduced fall incidence. Literature suggests PBT more accurately simulates real-world falls, providing a greater threat to balance and hence a greater stimulus for learning how to recover balance via proactive control mechanisms. While results of PBT studies are promising, no one has yet described the muscular mechanisms by which PBT improves balance recovery ability. Therefore, the purpose of this study was to develop an exploratory procedure to evaluate the relationship between muscle contractile dynamics and balance recovery performance. Five participants completed a single testing session where they experienced 5 perturbations using the tether release method. During testing, participants' movements were measured using a motion capture system. Balance recovery performance was graded using the margin of stability, and muscle contractile dynamics were assessed via contractile velocity of a medial gastrocnemius fascicle. Contraction velocity was calculated by tracking end points of the fascicle throughout contraction. Participants demonstrated comparable balance recovery performance to that previously published. We suggest this technique can be effectively used to determine the role of muscle contraction dynamics in balance recovery. This represents an important step in a research strategy aimed at determining the mechanisms responsible for improving balance in older adults.

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COLLEGE OF ENGINEERING

Michael Angyus: Chemical & Biological Engineering

Mentor: Blake Wiedenheft, Robin Gerlach – Microbiology & Immunology, Chemical & Biological Engineering

New High pH High Alkaline Adapted Microalgae for Biofuel Production

Microalgae have received interest for biofuel production due to their biomass productivity and high lipid content without the use of crop soil. Photosynthesis in algal cultures is limited by depletion of dissolved inorganic carbon which is currently addressed through expensive CO₂ sparging. In addition, contaminating species result in culture crashes which are addressed by expensive closed tube reactors. An alternative approach to these problems is to culture microalgae in high pH, high alkaline media which provides a surplus of dissolved carbon and is toxic to contaminating species. To search for new strains adapted to these conditions, we sampled Soap Lake, WA (pH 10, 100mM bicarbonate) and isolated 13 green algae through iterative streaking and colony picking. These strains were compared to a current high alkaline adapted strain, SLA-04 for their suitability for biofuel production. Comparison of lipid production through Nile Red staining revealed two strains that produced more lipid than SLA-04. These two strains, SLBG50-31 and SLBG50-27 also produced similar specific growth rates to SLA-04 (0.2175, 0.2268, and 0.2015 day⁻¹ respectively) based on cell counts in controlled tube reactor growth experiments. To confirm these preliminary results, further experiments have been conducted using Gas Chromatography Mass Spectroscopy and biomass production. Results from these experiments are being analyzed.

Acknowledgements: Calvin Cicha, Undergraduate Scholars Program (USP)

Catherine Bauer: Chemical & Biological Engineering

Mentor: Brent Peyton – Chemical Engineering

Method Development for Measuring Bacterial Growth in Iron-Precipitate Containing Cultures & Growth Comparisons for Nitrate Dependent Fe(II) Oxidation

Nitrate-dependent Iron Oxidation (NDFO) occurs when denitrifying bacteria use Fe(II) as an electron donor and nitrate as the electron acceptor. NDFO is mediated by anoxic bacteria and can help remediate metal and metalloid contaminants by producing Fe(III) minerals, which adsorb these toxins. However, Fe(III) minerals interfere with optical density (OD) measurements of cell density, so it was necessary to develop and verify accuracy of a method to fix this issue. *Ps. stutzeri* was grown in a low-phosphate freshwater mineral medium with additional vitamins, acetate, trace minerals, and PIPES buffer. The medium was sampled regularly for growth measurements. Initial tests involved known concentrations of amorphous Fe(III) oxide and *Ps. stutzeri*. To measure the optical density of samples, hydroxylamine was added to reduce the iron, removing its interference with the OD method of quantifying cell concentration. To establish this method, a standard curve was generated for the OD measurements compared to concentrations calculated via plate counts. Future work will include comparisons of growth rates within NDFO cultures in the presence and absence of iron.

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Isaac Boyd: Electrical & Computer Engineering

Mentor: Bradley Whitaker, David Hedges – Electrical & Computer Engineering

Predicting the Spread of COVID-19 with Neural Networks

In late 2019 SARS-CoV-2 (COVID-19) was exposed to the public. Attempts to contain the virus and mitigate its effects have been hampered by its easy transmissibility. Therefore, it has become necessary for government policymakers as well as healthcare organization policymakers to know where COVID-19 will spread to next so they can prepare for hospitalizations and try to avoid outbreaks. In recent years, Convolutional Neural Networks (CNNs) have been successful in tracking diseases. A study on Tuberculosis in 2019 showed that by using a CNN to analyze

image data the team could diagnose a patient with tuberculosis with an accuracy of 96.63%. The benefit of using this machine learning technique is that a large array of data, static and time-varying, can be composed into a more usable and holistic model. In this research, we will develop a model using CNNs to track and forecast the regional spread of COVID-19. In our model, we will strive to utilize static variables through Keras's functional application programming interface. This will allow us to take a multivariable input and convert our time-varying data into a model biased by the static traits of individual regions. We also plan to implement a binary classifier to account for skewed data in rural areas where daily case counts are often near zero and infection rates are lower. This model will be used to predict hospitalizations as well as future outbreaks on a county by county basis for Montana, Wyoming, South Dakota, North Dakota, and Idaho.

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Christina Denny: Center for Biofilm Engineering

Mentor: Ellen Lauchnor, Christopher Allen – Civil and Environmental Engineering

Observations of Carbon and Nitrogen Removal in Treatment Wetlands

Treatment Wetlands (TW) require little mechanical and energy input yet still have the potential to treat water as effectively as conventional systems, but TW implementation has been limited by a lack of knowledge of their treatment capacity and design standards. This project aims to increase TW application by understanding the complex and interrelated biogeochemical processes that drive TW treatment. The basic mechanisms of TW are similar to conventional systems because both rely on microbes to perform processes such as nitrification, denitrification and decomposition of organic matter, however in TW, these microbial processes benefit from the influence of plants. These processes can be tracked through Chemical Oxygen Demand (COD) and nitrate levels. The experiment includes wetland plants such as *Carex*, *Phragmites*, and *Schoenoplectus* growing in individual columns and being fed artificial wastewater every two weeks. To assess COD and nitrogen removal, water from the wetland columns was sampled one hour, three days, seven days and fourteen days after feeding. Data consistently showed that almost all of the COD treatment was happening in the first three days. With this information, more samples were collected in the first three days with the intention to calculate a rate of removal and determine the removal efficiency. In addition to bulk scale data, I will measure oxygen flux near roots and compare these findings to bulk data to see if they are representative of each other. Our observations so far provide evidence for the consistency and reliability of TW.

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Martina Du: Chemical & Biological Engineering

Mentor: Ross Carlson – Chemical and Biological Engineering

Optimizing Exchange Economics in Synthetic Microbial Ecology Systems

From medical chronic wounds to environmental nitrogen cycling in the soil, bacterial productivity is often reliant on cooperation, competition, and trading of nutrients. Due to the complexities of natural microbial communities, synthetic microbial ecology systems can be engineered to model strain dynamics and limitations to help reduce extraneous variables and to better understand metabolic interactions between cells. The presented synthetic ecology model is composed of two *E. coli* strains that have been genetically modified to force an obligatory symbiosis when grown in M9 minimal media with lactose as the sole carbon source. The coculture consists of a lactose catabolizing *E. coli* strain that cannot synthesize the essential amino acid arginine and an *E. coli* strain that cannot catabolize lactose but evolved to overproduce arginine. Collectively, the two strains can grow via cross-feeding. Strain abundance and ratios were used as metrics in planktonic and biofilm cultures to study the economics of metabolite exchange and metabolic stressors under coculture batch conditions. Individual strain behaviors were examined in M9 minimal media supplemented with various carbon sources to allow for metabolite accumulation to better understand coculture exchanges without simultaneous production and consumption. It was discovered that similar consortia compositions were reached in batch culturing regardless of the initial strain ratio.

Additional findings indicate that increased rates of pyruvate secretion in the lactose catabolizing strain arose in conjunction with various gene deletions. In addition to batch culturing, a chemostat was designed to acquire baseline steady-state data of the system for future experiments with hypermutator strains.

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Camryn DuBois: Mechanical & Industrial Engineering

Mentor: Scott Monfort – Mechanical & Industrial Engineering

Influence of Multitasking Ability and Changes of Sensory Information on Walking Stability

Peripheral nervous system (PNS) impairments are risk factors for fall related injuries. A better understanding that the central nervous system attempts to compensate for PNS impairments may improve prevention strategies for falling. PNS impairments were induced in healthy populations by vibrating the ankle musculature to impair joint position sense. A cognitive task was also given to each participant to divide attention. Changes in neural activation were measured during treadmill walking trials with functional near-infrared spectroscopy. We hypothesize that vibration (i.e., interfering with PNS information) will be associated with increased prefrontal cortex activation during single-task walking, but not during dual-task walking. We have collected 6 of the proposed 10 participants and plan to report our results at the time of the Research Celebration.

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Payton Dupuis: Chemical & Biological Engineering

Mentor: L. Keith Henry – Biomedical Sciences

Toward identifying a novel binding site on the human serotonin transporter through computational docking of VK03-51.

Selective serotonin reuptake inhibitors (SSRIs), such as S-citalopram (S-CIT), are antidepressants that block the reuptake of serotonin back into the presynaptic neuron. S-CIT can bind the serotonin transporter at a high-affinity (S1) and a low-affinity (S2) site. Characterization of a photoactivatable S-CIT analog, VK03-51, revealed a unique binding pattern consistent with it binding to S1 and a previously unknown site we term S3. To identify the S3 site, RosettaLigand was used to computationally dock VK03-51 into an inward-facing, ibogaine-bound, human serotonin transporter (SERT) derived from cryo-electron microscopy (PDBID 6DZZ). A total of 100,000 docked complexes were generated and scored, with the top 5% subjected to cluster analysis to identify probable binding sites. The structures were filtered by eliminating complexes where VK03-51 docking overlapped with S1 or S2 or in areas of the transporter inaccessible from the extracellular side. Additionally, the top VK03-51 complexes were compared to structures generated by parallel docking with the S-CIT analog VK03-83 which does not bind at S3 to perform a subtractive binding analysis. To facilitate subsequent biochemical discrimination of the binding sites, residues within 5Å of VK03-51 or the reactant azido N atom were determined for use in designing strategies for peptide mapping and substituted cysteine accessibility method analysis. Identification of the S3 site could have significant impact on serotonergic regulation based on its potential to allosterically alter transporter function without blocking substrate translocation offering a novel approach to modulate SERT function not currently available.

Acknowledgements: Vivek Kumar, Amy Newman, Roxanne Vaughan, McNair Scholars Program, Federal funding through research mentor (NSF, NIH, NASA, DOE, etc.)

Austen Eriksson, Takumi Kammerzell: Mechanical & Industrial Engineering

Mentor: Mark Owkes, Phil Stewart – Mechanical & Industrial Engineering, Chemical & Biological Engineering

Biofilm Modeling

Biofilms are everywhere. From alpine streams to wastewater treatment plants complex multilayered biofilms exist. These films grow with respect to the nutrients provided by their environment and break apart according to their thickness amongst other physical properties specific to each biofilm. The addition and detachment of biomass

often reaches a state of equilibrium in a given environment. A one-dimensional biofilm model was created in MATLAB for user specified conditions within a continuous stirred tank reactor. This model utilizes numerical methods to iteratively solve for the diffusion of nutrients into a biofilm over a variable span of time as well as the depletion of nutrients in the tank reactor as they are integrated into the biofilm. Monod growth kinetics are used to calculate the respective growth rate of the biofilm and therefore its change in size over time. In the final model, the growth of multiple species is to be considered in the same continuous stirred tank reactor with a given set of nutrients. The methods and concepts utilized in this initial modeling will be used to rewrite the MATLAB script in another coding language, such as C, in order to develop a graphic user interface for the program to be run intuitively by users. Considerations for efficiency and convergence and stability of modeled differential equations have been the prime areas of focus throughout the modeling process to ensure accurate solutions for a wide range of user inputs.

Acknowledgements: Undergraduate Scholars Program (USP)

Michael Espinal: Mechanical & Industrial Engineering

Mentor: Chelsea Heveran, Adrienne Phillips – Mechanical & Industrial Engineering, Civil engineering
Evaluation of the Interfacial Bond Between OPC Mortar and Biomineralized Waste Plastic

The enormous global dependency on plastic, now exacerbated by the COVID-19 pandemic, necessitates new sustainable solutions for repurposing plastic waste. Plastic-reinforced cementitious materials (PRC), such as plastic-reinforced mortar (PRM) may be suitable applications for repurposing plastic waste. However, including plastic fibers in PRM decreases strength. Our lab found that microbially induced calcium carbonate precipitation (MICP) biomineralization treatment increases the compressive strength of PRM. The strength increase was observed for some plastic types (PET, PVC) but not others (ABS, LDPE, PP, PS). The purpose of this study was to assess whether MICP treatment of common waste plastics alters the bond quality between the plastic and cement matrix in PRM. Single fiber pullout tests, after 7 and 28 days of curing, and scanning electron microscopy were used to assess bond quality. After both time points, no significant change in bond strength or the energy absorption capabilities was found between treated and untreated plastics except for PVC at 7 days where a reduction in bond strength for treated fibers was observed. The energy absorption capabilities of the plastics during pullout did not significantly change when treated with MICP. While bond strength did not improve, other explanations for the increased strength previously found, such as increased PRM hydration due to MICP treatment, likely caused such phenomenon to occur. This work contributes an important piece of the puzzle to understanding how mineralization treatment influences the strength of PRC and contributes to the global effort to develop new methods to reuse plastic waste.

Acknowledgements: Dr. Cecily Ryan, Abby Thane, Seth Kane, Undergraduate Scholars Program (USP)

Samantha Hall: Chemical & Biological Engineering

Mentor: Ryan Anderson – Chemical & Biological Engineering

Development of a Fully Coupled Three-Dimensional Computational Fluid Dynamics Model of a Reversible Solid Oxide Fuel Cell for Analysis of Flow Maldistribution and Performance

Fuel cells are becoming an increasingly attractive method of producing clean energy. Solid Oxide Fuel Cells (SOFC) produce electricity from a fuel source such as hydrogen gas, while Solid Oxide Electrochemical Cells (SOEC) perform the opposite process. A Reversible Solid Oxide Fuel Cell (R-SOFC) is a combination of an SOFC and an SOEC and can be operated in either direction, providing an advantage by requiring only a single unit to accomplish both processes. The objective of this project is to develop a fully coupled three-dimensional Computational Fluid Dynamics (CFD) model of an R-SOFC to analyze the fluid flow and temperature distribution in the cell based on the laws for conservation of momentum, mass, and energy. This model will be used to predict the effects of various parameters on cell performance and to inform cell and stack design. Preliminary efforts have focused on building a fully coupled model of an SOFC of three parallel gas channels with a single inlet on the anode and cathode sides.

Uneven flow in the gas channels can decrease overall cell productivity. With an initial flow rate of 2×10^{-8} kg/s, the velocity on the anode side ranges from 0 m/s to 1.12 m/s in the inlet with a maximum of 0.40 m/s in the center gas channel, and 0.34 m/s in the outer gas channels, indicating that flow maldistribution is occurring. Additionally, a similar result can be seen on the cathode side.

Acknowledgements: Undergraduate Scholars Program (USP)

Emily Heskett: Environmental Engineering

Mentor: Adrienne Phillips – Civil Engineering

Impacts of Biomineralization Growth in Cold Temperatures

Biomineralization is the precipitation of calcium carbonate through a chemical reaction that is catalyzed by microbes creating a material that is strong and durable. The objective of this research is to understand specific characteristics of calcium carbonate when it precipitates in the cold, specifically what the rates of mineral formation are if the temperature is changed. Changing mineralogy following varying rates of precipitation in accordance with cold temperatures may affect the resulting strength and binding between soil particles, ultimately changing the soil's stability. Biomineralization has the potential to produce viable options and alternatives in stabilizing soil for purposes of erosion control or mitigation of frost heave. Further understanding of biomineralization and, as a result, the production of biocement, would explain when and how to apply the process and material in soil stabilization work. The experiments have been designed to understand the rates of precipitation in cold temperatures and how that impacts the size and morphology of the resulting mineral in the presence of two different types of soil. Measurements by colorimetric Jung Assay examine the urea concentration and microscopy and other methods assist in studying the resulting mineral. This evaluation of biomineralization compared to other cementitious man-made materials would yield a potential way to stabilize soil in an environmentally friendly way.

Acknowledgements: Undergraduate Scholars Program (USP)

Darien Kadriu: Chemical & Biological Engineering

Mentor: Carl Yeoman – Animal and Range Sciences

The effects of Biogenic Amines in the biofilm formation and density of Gardnerella vaginalis.

The vaginal microbiome is the first line of defense against urogenital pathogens. Bacterial vaginosis (BV) is the most common gynecological disorder in women, which has been estimated to affect 1 in 3 women in the US, and involves a shift away from Lactobacillus spp. dominated to one colonized by a diversity of anaerobic species, including Gardnerella spp. Bacteria of the genus Lactobacillus are typically dominant in the vagina and produce sufficient lactic acid to lower the vaginal pH to <4.5 , creating an inhospitable environment for most potential pathogens. Previous research has shown that a group of metabolites known as biogenic amines (BA) are increased with BV. Understanding the mechanism underpinning this shift from a healthy to an unhealthy microbiome is important to protecting women's gynecological and reproductive health. Studying the impact of BAs on G. vaginalis may provide important mechanistic insight into BV and the various gynecological and reproductive diseases it has been associated with. New species of Gardnerella spp. have recently been discovered and have been associated with biofilm formation, a known virulence factor of BV. This project determines the effects of BAs on species of Gardnerella biofilm formation.

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

Samantha Kelderman: Chemical & Biological Engineering

Mentor: Dana Skorupa, Brent Peyton – Center for Biofilm Engineering, Chemical and Biological Engineering

Thermophilic bioconversion of oxidized plastics to value-added products

Microbial degradation could serve as a novel solution for mitigating the vast quantities of plastic wastes accumulating in our ecosystems. Additionally, industrial manufacturing of bioplastics, polyhydroxyalkonates (PHAs) and chemical precursors, dicarboxylic acids (DCAs) are currently infeasible because of need for expensive substrates and high energy input. Because thermophiles survive at high temperatures, they have the potential to utilize partially depolymerized and oxidized plastic wastes (residing at 50-90°C) as a carbon source for growth and could also be used to produce value-added PHAs and DCAs. The goal of this project was to identify a thermophile from Yellowstone National Park (YNP) capable of degrading oxidized plastic wastes PHAs and DCAs. A thermophilic *Geobacillus* isolate from YNP can use docosanoic acid, chemically similar to oxidized plastics wastes, as a sole carbon source. This indicates that this thermophile could be a promising isolate for downstream testing on chemically deconstructed plastic materials. In addition, enrichment cultures were established to mimic in situ environment from samples collected at several high-temperature (>70°C) hot springs in the Heart Lake Geyser Basin region of YNP using 1-docosanol or docosanoic acid as carbon sources. Promising aerobic enrichment cultures were seen for geothermal samples collected at a hot spring site dubbed “Muddy Buddy” and the enrichments were transferred to larger volume serum bottles and placed on a shaker table at 55°C. Growth was observed in culture samples containing docosanoic acid and subsequent streak plates made from cultures, indicating the possibility of isolating a thermophile that can potentially degrade plastic wastes.

Acknowledgements: Undergraduate Scholars Program (USP)

Kayla Kozisek: Chemical & Biological Engineering

Mentor: Robin Gerlach – Chemical and Biological Engineering

Enzyme Degradation of Algal Cell Walls

The world is facing a climate crisis. Carbon dioxide levels are rising, and fossil fuels are being depleted at an ever-growing rate. Biofuels serve as a way to solve both these problems. Algae contain fatty acids that can be extracted and used for production of liquid transportation fuels. One challenge in extracting lipids is the existence of a cell wall. The cell wall makes extracting the lipid bodies internal to the algal cells difficult and expensive. Algal cell walls also affect researchers’ ability to perform genetic transformations. Transformation would provide a way for scientists to alter the algal cell’s DNA to code for desirable features in the cell. A way to remove or degrade the cell wall could increase biofuel production from algae by facilitating lipid extraction by improving the efficiency of genetic transformations.

There are different ways to degrade the cell wall, but the focus of this project was through the use of enzymes. If enzymes are used to degrade the cell wall, then the algal cell will be more permeable. My aims for this project were to determine the optimal enzyme mixture and treatment conditions to disrupt the cell wall of the SLA-04 strain while maintaining cell viability (for genetic transformations). To assess the effect of enzymes on algal cell walls three steps were followed: spotting enzymes on plates to determine which may be the most effective, incubating the algal culture with the enzymes to remove the cell wall, and treating the cell with detergent to determine effectiveness.

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Matthew Magoon & Kenedee Lam: Chemical & Biological Engineering

Mentor: Stephanie McCalla – Chemical & Biological Engineering

Developing an Aptamer Against Acetaminophen to Detect Acetaminophen Toxicity at the Point of Care

Acetaminophen toxicity is a leading cause of acute liver failure, and the diagnosis and treatment of this condition are based heavily on laboratory findings. While there are several antibody-based and enzymatic assays available for detecting acetaminophen toxicity, they have multiple drawbacks including their special shipping and storage requirements needed to preserve the proteins' integrity and their requirement for a clinical lab to perform the test in. DNA aptamers, or short strands of DNA that bind to a specific target, may be superior to immunoassays or enzymatic assays for certain applications because they are more durable and more inexpensive than proteins. Thus, DNA aptamers can allow for cheaper and more robust assays that are particularly well-suited to use in limited resource settings. For this project, work is being done to design a new DNA aptamer through an in vitro technique called Systematic Evolution of Ligands by Exponential Enrichment (SELEX). The goal of this project is to evolve an aptamer that specifically binds to acetaminophen in human plasma, which would eventually allow an assay to be developed that is capable of rapidly providing results at the point of care.

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Evan Martin: Chemical & Biological Engineering

Mentor: Connie Chang – Chemical and Biological Engineering

Optical barcoding of bacterial cells in single-cell drop-based microfluidics

Antibiotic susceptibility testing (AST) is a critical phase in clinical infection therapy where the sensitivities and/or resistances to antibiotics of causative microbes are deduced empirically. Standard clinical AST platforms rely on changes in optical density of a bacterial culture, which require massive cellular proliferation, thus resulting in long test-to-result periods. A proposed solution to this issue is the use of single-cell drop-based microfluidics (DBMF), which involves the creation of picolitre sized aqueous droplets suspended in a carrier oil. These individual drops serve as microscale bioreactors and can be loaded with single bacterial cells and antibiotics at ultrahigh-throughput, or kHz rates. Analysis at the single cell level allows for the observation of bacterial responses to antibiotics in under ~4 hours. However, current proposed DBMF platforms lack parallelization. Here, we demonstrate a droplet barcoding method capable of 25 unique droplet barcodes, which allows for mixing and parallel analysis of 25 assay conditions in droplets at a time.

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Quintin McCoy: Chemical & Biological Engineering

Mentor: Christine Foreman, Markus Dieser – Chemical & Biological Engineering, Center for Biofilm Engineering

Reduction of Biofilm Formation in Metal Working Fluids Through Introduction of Organic Quorum Sensing Inhibiting Molecules

Metal working fluids (MWFs) used in industry to lubricate and cool machinery become hazardous to operator health when populated with microorganisms. Furthermore, biofilm contamination increases resistance to biocides and mechanical cleaning. Biofilm formation is induced by intercellular chemical communication known as quorum sensing. Homoserine lactones (HSLs) are utilized by biofilm forming bacteria, including *Pseudomonas aeruginosa*, to communicate. Therefore, the reduction of HSLs presents a possible avenue to biofilm control. Development of a novel method utilizing quorum sensing inhibiting molecules to reduce biofilm formation in MWFs would have wide-spread beneficial impacts on operator health, equipment maintenance, and MWF disposal. For this work a suite of suspected quorum sensing inhibitors were tested, including psychrophilic microbe pigment extracts, patulin, furanone C-30, and baicalin. The latter three have shown significant growth reduction properties while the

psychrophile's extracted carotenoid pigment has displayed promising effects as well. The biofilm growth in *P. aeruginosa* cultures grown in MWF broth and treated with suspected quorum sensing inhibiting molecules was quantified through cell staining and absorbance measurements at 540nm. Isolation and cloning of a lactonase gene derived from *Geobacillus stearothermophilus* 10 that may be effective in blocking HSL communication is currently in development and efforts will continue to be directed at achieving this. Future work will be targeted at defining minimum inhibitory concentrations of the previously identified possible quorum sensing inhibitors and applying findings to a model machine system.

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Rory Mclean: Computer Science

Mentor: Jim Becker – Electrical and Computer Engineering

Identifying Misconceptions in Student Essay Responses Using Natural Language Processing Algorithms

Analysis of students' writing on conceptual-based questions within STEM courses has been shown to provide unique insights into how students approach problem solving within such courses. Providing tailored feedback on a student's writing is a powerful means of correcting common misconceptions and promoting deeper understanding. Unfortunately, evaluation of writing and providing meaningful feedback is time consuming. This research project is a pilot study investigating basic Natural Language Processing (NLP) algorithms to automatically detect common misconceptions in student responses to short-answer conceptual questions within an introductory course on electric circuit analysis. If successful, such algorithms could be used within a software-based solution for evaluating and providing feedback to students on their writing. Three commercially available NLP tools were investigated for this purpose, and ultimately an open-source NLP rule-based matching engine was selected. The corpus consisted of 185 unique responses to a single conceptual question given to students in the introductory electric circuit analysis course. The corpus was split into a training set (~60% of the corpus) and a test set (~40 % of the corpus). The training set alone was considered when generating rules to identify a misconception within each sentence of a given response. Each rule consisted of a search for an ordered set of between two and four words in order; in some cases, the rules allowed one or more tokens to separate the key words. An F1-score of 0.77 was achieved on the unseen test set when searching for a "sequential" misconception within student responses. Work is currently underway to improve the algorithm's precision, that is, to reduce the number of false positives.

Acknowledgements: Undergraduate Scholars Program (USP)

Rory Myer: Computer Science

Mentor: Brock LaMeres – Computer and Electrical Engineering

Protecting our Nation's Critical Infrastructure from Cyber Attacks

Control system computers are a staple in all valuable process oriented industries. This research project examines how to defeat malware attacks in control system computers by examining both the hardware and software of a control system. A programmable logic controller (PLC) is an industrial control system computer used in the conducted research. The research examines how to replace control system architecture to avoid computer monoculture. Avoiding monoculture, computers running identical software, significantly reduces vulnerabilities in a given system making it more resilient to cyber attacks. The research methods consist of programming control system hardware, and the analysis of the software and languages that implement PLCs.

Acknowledgements: Undergraduate Scholars Program (USP)

Matalin Pirtz: Chemical & Biological Engineering
Mentor: Connie Chang – Chemical and Biological Engineering
Encapsulation and Growth of Gastrointestinal Organoids in Matrigel

Dr. Diane Bimczock is investigating the interaction of dendritic cells (DCs) and *Helicobacter pylori* infected gastrointestinal organoids to better understand infection and health of the gastrointestinal tract. Gastrointestinal organoids are 3D cell structures that need to be cultured in Matrigel, a basement membrane. However, limited migration of DCs in Matrigel is an obstacle to study their interaction with Matrigel encapsulated organoids. Dr. Zahra Mahdieh had the idea to culture the organoids in granular Matrigel which is made of Matrigel microgels packed by centrifugation. Granular Matrigel has a porous structure that allows for migration of DCs in addition to providing a 3D structural support for organoid cultures. Currently, Dr. Mahdieh and I are investigating whether changing the packed structure of granular Matrigel by manipulating of the microgel size and centrifugation force can affect the growth of gastrointestinal organoids.

The first step was the design of new microfluidic devices to fabricate Matrigel microgel with various sizes. Microfluidic devices were designed with the help of Humberto Sanchez on AutoCAD to create Matrigel microgels with four different diameters: 100 μ m, 150 μ m, 200 μ m, and 250 μ m. The gastrointestinal cells will then be encapsulated in Matrigel microgels of four sizes. The Matrigel microgels will then be placed in a 384-well plates, covered in L-WRN media, and centrifuged with different centrifugal forces (0g, 6g, and 1000g). To assess the organoid growth in different conditions (i.e. Matrigel microgel size and centrifugation force), cultures are imaged every three days using inverted confocal microscopy.

Acknowledgements: Zahra Mahdieh, Undergraduate Scholars Program (USP)

Lauren Potyk: Chemical & Biological Engineering
Mentor: Joseph Seymour – Chemical & Biological Engineering
Characterization of Newtonian Fluids Using Rheology

Rheology is the study of flow and deformation. A rheometer, used for these studies, is capable of measuring the bulk response of a fluid upon application of a stress or strain. This enables the characterization of the behaviors and properties of different types of fluids. The study and characterization of fluids is relevant in many industries, including consumer products and pharmaceuticals.

In this project silicon oil and glycerol were characterized. Both of these materials are Newtonian fluids. The objective of this project was to determine the effective viscosity of each material. The overall behavior of fluids was observed from the flow curves produced during testing.

In testing, both these Newtonian fluids showed an ideal response, as anticipated. The flow curves showed a linear relationship between increasing stress in response to gradual increase in applied shear rate. From these flow curves, the effective viscosity was obtained as the constant of proportionality between shear rate and stress. For glycerol this was approximately 0.7 Pa.s and for the silicon oil this was approximately 10 Pa.s.

Acknowledgements: Undergraduate Scholars Program (USP)

Elliott Pryor: Computer Science
Mentor: John Sheppard – Computer Science
Finding Factor Architectures Using Maximum Spanning Trees for Factored Evolutionary Algorithms

An emerging methodology for optimizing large problems is cooperative co-evolution. This divides the variable set into several disjoint groups and optimizes each disjoint set individually before merging back to a global solution over all the variables. A similar method is called Factored Evolutionary Algorithms (FEA), but the groups are not necessarily disjoint. This overlap can improve the global optimization by allowing a 'sharing' of variables between

the group which allows it to better consider the overall function landscape. The efficacy of FEA is strongly dependent on the generation of the factors. This research is focused on developing a method to create the subgroups to improve optimization and time complexity. Using a matrix of mutual information coefficients, we create a maximum spanning tree connecting the most similar variables. Factors are then adjacent variables in the tree. We then compare our novel factorization method to standard differential grouping (used in cooperative co-evolution), as well as overlapping differential grouping and fuzzy spectral clustering designed specifically for FEA models. We use a set of five standard benchmark functions for each algorithm. Only a limited number of tests have been run so far, but results indicate that on average the new method performs better on average and has a smaller standard deviation than any of the other methods.

Acknowledgements: Undergraduate Scholars Program (USP)

Jesse Rector: Electrical & Computer Engineering

Mentor: Anja Kunze – Electrical and Computer Engineering

Developing an ImageJ plugin for automated magnetic force estimations from particle tracking velocimetry

Mechanical forces exerted using magnetic particles within magnetic field gradients have become a practical tool to engineer a host of cellular processes ranging from calcium signaling patterns¹ to directed tissue growth². To characterize the effects of these mechanical forces on cellcultures, it is essential that researchers have access to the specific quantitative magnetic force range, amplitude and direction being applied. However, due to the miniscule scale of these forces ranging from nanonewtons to femtonewtons³, precisely characterizing them in an efficient manner has proven difficult. Here I present a plugin developed in the lab for the ImageJ platform which uses magnetic particle tracking to quickly characterize these mechanical forces for cellular applications. The plugin receives a video of moving magnetic particles in solution within an external magnetic field gradient from the user. Based on the existing TrackMate plugin for ImageJ⁴, particle displacement is identified and tracked over time. This displacement data is then used to calculate particle velocity and acceleration, which are used in the modified Stoke's drag equation to calculate the force the magnetic particles would exert on a specific object at a specific region of interest. Using my plugin, I extracted force values in the nanonewton range from magnetic microparticle videos, and compared them to manual tracking, which yielded a comparable force result. In summary, this newly developed ImageJ plugin will provide advanced access to magnetic force fields and be of advantage to cell-based mechanobiology.

Acknowledgements: Connor Beck, Undergraduate Scholars Program (USP)

Sydney Ross: Chemical & Biological Engineering

Mentor: James Wilking – Chemical & Biological Engineering

Culturing "Unculturable" Bacteria

Many bacteria cannot be cultured effectively in a laboratory setting giving them the name "unculturable". The nature of these "unculturables" in-vitro can be attributed to a failure to replicate the essential environments necessary for growth (1, 2, 3). Many of the current methods used to replicate these environments take significant resources and have a high chance of contamination (1, 2, 3, 7, 8).

Stereolithography 3D printing techniques were used to develop new methods for determining growth conditions for previously unculturable bacteria. Bacteria was encapsulated into macroscale hydrogel cubes and subject these cubes to different environmental conditions by pressing other hydrogel cubes saturated with specific nutrients on the faces of the cube containing bacteria. Nutrients from each of the exterior cubes diffused into the central bacteria cube, creating a complex, multi-dimensional parameter space, composed of multiple gradients in concentration. The bacteria was exposed to many different environmental factors in one system at a given time. This allows the concentrations of the environmental factors to be tested in one system over a short duration of time. The chance of contamination decreased as well as the duration of time and amount of materials necessary to

determine the ideal bacterial environment. Determining these ideal bacterial environments more effectively can ultimately help gain information on biofilm environments.

Acknowledgements: IDeA Network for Biomedical Research Excellence (INBRE)

Kylee Rux: Civil Engineering

Mentor: Chelsea Heveran – Mechanical & Industrial Engineering

Does Oil-Contaminated Plastic Impair the Compressive Strength of Biomineralized Cement?

The increasing production of cement infrastructure and plastics generate major problems to both humans and the environment. The objective of this research is to understand if incorporating oil-contaminated waste plastic in concrete will have sufficient strength, and whether biomineralization helps make this possible. By replacing some of the cement in concrete with unrecyclable waste plastic, the amount of plastic in landfills will decrease, carbon emissions will be reduced, and cement production will lessen. Microbes can induce mineral precipitation, potentially resulting in an improved bond between the plastic and cement. In order to examine our hypothesis, various types of waste plastic were cut into fibers, coated with vegetable oil, and biomineralized using the established microbially induced calcium carbonate precipitation (MICP) protocol. Thus far, preliminary results have shown that plastic fibers coated in vegetable oil prior to biomineralization accumulate less precipitate. Mortar cylinders were then prepared while incorporating individual types of plastic fibers into each sample at a 5% by mass as a replacement for the cement. By the end of this experiment, we will have examined the size and polymorphism of the calcium carbonate precipitate using Raman spectroscopy and scanning electron microscopy, as these factors may influence the overall strength of concrete. The compressive strength of the cylinders will also be tested after curing for 7 days and 28 days. This will provide valuable information regarding whether these plastics, which are otherwise destined for disposal, could serve a new use in the context of manufacturing more eco-friendly building materials.

Acknowledgements: Undergraduate Scholars Program (USP), Empower Program

Jack Shonka: Civil Engineering

Mentor: Anthony Hartshorn – Land Resources and Environmental Sciences

Are snow-mantled, burned slopes at greater risk of avalanching?

On September 4th, 2020, the Bridger Foothills Fire ignited and burned over 8,000 acres of land near Bozeman, Montana, only stopping a few miles short of Bridger Bowl Ski Area¹.

This event prompted my project which aims to understand whether soil burn severity increases avalanche risk. With wildfire activity increasing in the Rocky Mountain region² and an alarming uptick in avalanche deaths in the backcountry in 2021, understanding how wildfires might increase backcountry hazards is essential for public safety.

Avalanches occur when the forces holding snowpack layers to the ground or each other are exceeded by the forces pulling on snowpack layers downslope. Sometimes this process can begin at the soil-snow surface contact plane³.

To determine if increasing soil burn severity increases snowpack instability, I monitored snowpack creep in two test areas (Table 1), one burned more severely and one burned less severely.

Slope angles (~25° or ~47%) and aspect (ESE; ~120°) were kept constant. Stationary and free-moving targets were deployed and measured from static reference points (T-posts)³.

However, a combination of below-average seasonal snowpack; high winds; roads made impassable by snow drifting, rilling, or mud; and the early onset of above-freezing temperatures complicated measurements. Thus far, the project has led to three iterative reflector designs developed to survive hostile weather conditions. Safe mountaineering and transport strategies were developed for motorized and non-motorized site access. Lastly, I developed a preliminary design for a low-cost, automated range-finding system utilizing a Garmin LiDAR.

Acknowledgements: Undergraduate Scholars Program (USP)

Anna Stewart: Chemical & Biological Engineering
Mentor: Nicholas Stadie – Chemistry & Biochemistry
Synthesis of a Triply Periodic Minimal Surface Foam

A three-dimensional material comprised exclusively of carbon whose underlying structure lies on a triply periodic minimal surface (TPMS) is a member of the class of hypothetical carbon allotropes known as schwarzites. These are a class of materials highly sought-after due to their fundamental significance (the last remaining unknown crystalline allotrope of sp²-hybridized carbon) and likely interesting properties (e.g., ballistic conduction at room temperature). Other properties include a large pore volume and high surface area for gas and ion adsorption, making them a class of candidate materials for many applications such as supercapacitor electrodes and gas storage. A true schwarzite has not been synthesized, despite their predicted low energies of formation compared to other fullerenes. This research investigates the synthesis of an interpenetrating schwarzite-like material. A templating strategy has been designed to achieve this through the synthesis of a free-standing graphene foam material whose structure lies on a triply periodic minimal surface (TPMS) by a hard-templating route. This material requires a template with a 1:1 pore to wall ratio; the ordered mesoporous silica template KIT-6 is ideal for this. The pore structure of KIT-6 can be optimized by changing hydrothermal synthesis temperature, by addition of inorganic salts, or by using various combinations of cationic and neutral structure-directing agents. Herein we present preliminary work on the synthesis and characterization of several KIT-6 templates.

Acknowledgements: Undergraduate Scholars Program (USP)

Nathan Stouffer: Computer Science
Mentor: Mike Wittie – Computer Science
Truncating Blockchains with Tangly Statistics

Blockchains have applications in cryptocurrencies, supply chain tracking, and maintaining data integrity. A blockchain keeps an immutable, decentralized ledger of transactions stored in blocks. By design, blocks are difficult to create, so users of a blockchain can trust the longest chain.

Miners control a blockchain collectively, but when sufficiently decentralized, no coalition of miners can gain explicit control over the blockchain. Explicit control allows a coalition to selectively add blocks to the chain, reducing the integrity of the system. Decentralization can be difficult to achieve when blockchains grow in length.

To begin mining, a node needs to bootstrap into the blockchain network. In standard blockchains, one must download and process the entire chain and a long chain (such as Bitcoin) can take days to process. Such a long chain can deter potential miners and entirely prevents those with lightweight devices from becoming miners. Together, these issues make control over the blockchain by a small group of miners more likely.

My collaborators and I devised a new bootstrapping protocol. At a high level, our solution has recent miners vote for a blockchain summary. If sufficiently many votes agree, bootstrapping nodes can trust the blockchain summary and no longer need every block, drastically reducing bootstrapping time. Our protocol allows more nodes to join a blockchain, combatting centralized control of a blockchain.

We produced two types of results: theoretical and experimental. Theoretically, we prove the formal correctness of our protocol. Experimentally, we implemented the protocol and provide some numerical analysis.

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Madison Tandberg: Computer Science

Mentor: Travis Peters – Computer Science

Analyzing Application-Layer Encryption in Bluetooth Devices: Auditing for Encryption

Bluetooth is a wireless technology used in a variety of settings, including home, work, transportation, and healthcare. If Bluetooth devices are not properly secured, there can be real harm to users. Data encryption is a widely accepted security control that protects against many weaknesses in data transmission and communication between all types of devices (wired, wireless, Bluetooth, etc.). Although the Bluetooth protocol establishes encryption standards for packet transmission “over the air”, devices are vulnerable to attacks that steal or manipulate data within a device if they lack internal security. By developing a series of techniques to test for application-layer encryption, this research aims to make the security (or lack thereof) of Bluetooth devices more transparent to end-users.

This project analyzed different techniques to detect whether Bluetooth devices are using application-layer encryption. Results present a series of qualities and metrics that encrypted data possess that Bluetooth data can be tested for. Initial analysis of a subset of Bluetooth devices currently on the market indicates that many Bluetooth devices are not implementing application-layer encryption. This work sets the foundation for future work which will implement these techniques to test Bluetooth devices in pseudo-real time for the presence of application-layer encryption.

Acknowledgements: Undergraduate Scholars Program (USP)

Molly Taylor: Civil Engineering

Mentor: Huyen Bui – Center for Biofilm Engineering

Manipulation of Microbial Communities to Promote Algae Growth

The purpose of this experiment is to increase algae growth for use as biofuel by adding bacterial strains back into an axenic algae culture. The harmful effects of traditional fossil fuels on the environment are becoming increasingly well-known. Algae-based biofuel is renewable and has potential to counteract some of the negative impacts of traditional fuels by reducing atmospheric carbon. Current cultivation techniques, however, are energy intensive and have limited efficiency. Algae is often grown in large ponds of axenic (single-species) culture, which are then susceptible to contamination and subsequent culture failure. In this experiment, I plan to test several bacterial strains that were isolated from cultures of SLA-04 algae in Fall 2020 to see how they impact algae growth when introduced to an axenic culture. I will compare the bacterial strains both individually and in 2-strain combinations using growth plates, microscopy, and genetic testing.

The impact of the bacterial strains on algae growth in liquid media will be measured using daily readings of optical density and fluorescence intensity, as well as nitrogen assays every other day to see how the mixed culture is fixing and utilizing available nitrogen. In addition, I will further determine bacterial identity using 16S rRNA sequencing and epifluorescence microscopy. Already, there are several bacterial strains that show some positive impact on algae growth, which will soon be tested in larger flasks. Eventually, these strains could be grown in large-scale cultivation projects to increase the viability of algae-based biofuel as an alternative, “green” energy source.

Acknowledgements: Undergraduate Scholars Program (USP)

Christy Teska: Chemical & Biological Engineering

Mentor: Christine Foreman, Markus Dieser – Chemical and Biological Engineering, Center for Biofilm Engineering

Investigation of Ice Nucleation Activity of Nano- and Microplastics in Snow and Rain

Major pollutants in our environment today include microplastics and nanoplastics. Plastic is a major contaminant to the earth today which is why this new field of research is rapidly growing. Recent research has shown that these

tiny particles can be carried around the world in rain or snow. Potential effects of the microplastics in precipitation are currently unknown. One area of interest is the potential for microplastics to initiate nucleation of ice, as it has previously been shown that mineral and bacterial particles can catalyze the formation of ice. The question now, is whether these microplastics have the ability to ice-nucleate by themselves. Recently, I have investigated the ice nucleation behavior of a common plant pathogen, *Pseudomonas syringae*, to observe this catalyzing ability. This phenomenon could possibly affect the environment by causing changes to precipitation patterns. Using the ice nucleation assay, I have tested a range of microplastics for their ability to catalyze the formation of ice and will present these results.

Acknowledgements: Markus Dieser, Christine Foreman, Undergraduate Scholars Program (USP)

Jack Vanderbeek: Electrical & Computer Engineering

Mentor: Joseph Shaw, Michael Roddewig – Electrical and Computer Engineering

Researching Liquid Crystals for Electronic Polarization Control in FMCW Lidar

In recent years, lidar has become a powerful laser-based remote sensing tool. Conventional lidar systems primarily measure the range to a given object, so introducing methods of polarization detection would enhance the capabilities of a lidar system for identifying types of materials and other object properties. The Optical Remote Sensors Laboratory at Montana State University is exploring the use of Liquid Crystal Variable Retarders (LCVRs) for creating a fully polarimetric lidar system that can transmit and receive light with different polarization states. This presentation reports research being conducted to characterize LCVRs with fast axis orientations of 45 degrees and 22.5 degrees to recover the top and diagonal elements of the Mueller Matrix that represents the polarization-dependent scattering of a material. Work is in progress to test the timing of the voltage control on the LCVRs to ensure that the LCVRs can provide lidar polarization agility with the required speed.

Acknowledgements: Undergraduate Scholars Program (USP)

Xingzi Xu: Electrical & Computer Engineering

Mentor: Dominique Zosso – Mathematical Sciences

Graph-based Geometric Data Analysis

A fundamental premise of data science is that high-dimensional datasets contain simple underlying geometric structure. Such geometric information is useful in fields like disease diagnosis, pattern recognition, and more. We are interested in studying the *shape of data* in the form of point clouds: a collection of individual samples represented as points in a high-dimensional space.

Prior, we have successfully developed an algorithm realizing geometric inferences about integro-geometric properties (such as perimeter, surface area, mean width) of a union of virtual balls placed around each of the data points in the cloud. Estimating these features for a wide range of ball-radii informs us about the evolution of geometric properties across scales as a proxy to learn more about the geometry of the structure from which the points were sampled.

At the heart of our implementation, we need to repeatedly compute intersection volumes between multiple virtual balls, which is extremely time consuming. To identify relevant computations more quickly, we have utilized an induction method to efficiently calculate the Vietoris–Rips complex of the point cloud as a preliminary data representation [1]. Along this line of work, for each simplex degree, we now train a neural network to learn the intersection volumes of multiple virtual balls, just based off relative ball distances and radii. We can then use the trained networks instead of tedious computations to estimate the integro-geometric properties of the point cloud. We have also demonstrated the algorithm's ability in applications like classifying leaves from different species.

Acknowledgements: Undergraduate Scholars Program (USP)

COLLEGE OF LETTERS & SCIENCE

Habib Alabdullatif: Physics

Mentor: Aleks Rebane – Physics

3D-Fluorescence spectroscopy of Protonation Responsive Coumarins

Coumarins are organic dyes that often used as molecular in fluorescent-based microscopic because they show bright visible emission upon 1-photon and 2-photons excitation. There is ongoing effort to design and characterize functional coumarins that change their absorptions and emission proportion in response to change local environments. In this work, we aim to perform measurements on a series of Coumarins C-151, C-2 dissolved in organic solvents to study the dependence of the emission and absorption spectra on the protonation state of the fluorophore. This measurement can be done by prepare dye solutions to measure one photon absorption spectra by using Elemer Lambda 950 Spectrophotometer. As well, measuring 3D- fluorescence excitation and emission of one-photon spectra by using Perkin Elmer Fluorimeter LS50B. We get the protonation form of coumarins by adding HCl to the solution and remeasuring emission and absorption spectra to compare it with neutral form.

Klara Aspelin: Microbiology & Immunology

Mentor: Mari Eggers – Microbiology & Immunology

Statistical Analysis of Water Quality Data in the State of Montana

Contaminated drinking water can pose a significant threat to human health. Arsenic, nitrate, and manganese are compounds commonly found in drinking water wells that can increase the risk of conditions like blue baby syndrome, cancer, and cardiovascular disease. But testing for these and many other water contaminants in home wells can be expensive and difficult. The state of Montana has a database with measurements of these contaminants at ground- and surface-water sites across the state called Montana GWIC (Ground Water Information Center). This data is publicly available but has yet to be summarised from large datasets into easily accessible information. My project aims to use Excel and the statistical programming software R to identify the foremost water contaminants per watershed using data from GWIC. Under the assumption that the non-drinking water sites sampled for GWIC share similar contamination compositions, my summarized data will alert communities about what contaminants are of most concern in their area and what they should prioritize testing for in their own wells.

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

Sydney Austad: Chemistry & Biochemistry

Mentor: Patrik Callis – Chemistry and Biochemistry

Fundamental Physical Chemistry of the Serine Protease

The occurrence of nearly all biochemical reactions in living systems is owed to the dramatic catalytic action of enzymes, yet we are challenged in accurately predicting and verifying such reaction mechanisms. A textbook example is the hydrolysis of peptide bonds by the infamous serine protease: it is hypothesized that a coordinated proton transfer occurs across conserved serine, histidine and aspartate residues of the “catalytic triad”, allowing for nucleophilic attack to the peptide substrate. The Callis Lab seeks unbiased representations of catalytic events using objective Quantum Mechanics (QM) and Molecular Dynamics (MD)-based models to produce stepwise mathematical predictions of atomic behavior and electrostatics within the serine protease. In the hopes of observing one or several complete reaction steps in simulation, we have isolated crystal structures of chymotrypsin co-crystallized with a highly reactive N-acetyl-D,L-phenylalanyl trifluoromethyl inhibitor (APF). We created novel force field parameters in Gromacs for APF, allowing for MD-based modelling of the protein complex

to predict protein confirmation states. From 10 ns of MD trajectories (approximately 1000 frames), we choose optimized active site conformations that appear prone to proton transfer and nucleophilic attack. These selected frames are subject to Atom-Centered Density Matrix QM calculations of electron configurations across potential energy landscapes. We have observed a coerced lengthening of the serine O—H and His N—H bonds, configurations that we believe represent the reaction pathway, but no full proton transfers. We are also exploring the mechanistic contribution of channels of aligned water molecules nearby the triad residues in the active site.

Acknowledgements: Undergraduate Scholars Program (USP)

Tanya Baker: Chemistry & Biochemistry

Mentor: Mary Cloninger – Chemistry

Synthesis of A Multivalent Tether to Template Oligomerization of Galectin-3

An organic synthesis project. The goal of this project is to synthesize a multivalent tether that templates the protein galectin-3 oligomerization pattern. Galectin-3 is a specific carbohydrate-binding protein with an intrinsically disordered N-terminal tail. The protein aggregates are found over-expressed in cancer development. We do not know how the tails join together to form different aggregates. This novel tether molecule will bind multiple galectin-3 proteins simultaneously via multivalent interactions and allow us to study its structure.

Acknowledgements: Undergraduate Scholars Program (USP)

Quincy Balius: History & Philosophy

Mentor: Amanda Hendrix-Komoto – History & Philosophy

Respectability Beyond Reproach: The Racial Construction of Western Womanhood

The project investigated the construction of Western womanhood concerning race in post-Reconstruction era Montana. Though current historiography details Black women's experiences, few studies probe the social construction of Black womanhood in Montana. I utilized feminist intersectionality theory and social-historical frameworks to comprehend how Black women's experiences in Montana differed from those of white women. I focused on the four pillars of Victorian "true womanhood," which include domesticity, purity, piety, and submissiveness, and the racial constraints and obstacles that affected Black women's adherence to these ideals. I utilized vertical files, archival information, genealogical data, books, letters, newspaper articles, organizational records, and oral histories to construct a complex narrative of Black women's experiences with "true womanhood" in the American West. The final paper places the lives of notable Montana women Sarah Gammon Bickford, Mattie Bost Castner, and Mary Fields within the context of both Victorian "true womanhood" and post-Reconstruction racial identity. It argues that though many Black women in Montana earned respect within their communities, their ability to claim the title of "true woman" was impacted by segregation, social prejudice, economic necessity, and racism. Ultimately, this paper aims to contribute to diversifying the history of the American West.

Acknowledgements: Undergraduate Scholars Program (USP)

Seth Bassetti: Earth Sciences

Mentor: Brittany Fasy, David Millman – Computer Science

Enhancing Accessibility in Topological Data Analysis

Topological Data Analysis (TDA) is a field at the intersection of mathematics and computer science that involves analyzing large datasets using applied techniques in topology. Persistent homology is a method within TDA that is used for computing and determining certain topological features of a given space. Specifically, persistent homology represents spaces as simplicial complexes and computes a "filtration sequence" using a distance function on these simplicial complexes. My work focused on creating a visualization tool to construct persistence diagrams from given simplicial complexes in two and three dimensions. This tool was built for the purpose of discovering

certain classes of shapes that could be represented by a limited number of persistence diagrams, ideally some constant number. The visualization tool was successful, allowing different shapes to be represented as persistence diagrams in both two and three dimensions. While the visualization tool is currently being expanded on to include an Euler Characteristic Curve (ECC) representation, further use of this tool is necessary to discover certain classes of shapes.

Acknowledgements: Undergraduate Scholars Program (USP)

Amber Berry: Microbiology & Immunology

Mentor: Seth Walk, Paul van Erp – Microbiology and Immunology

MS2 Quantifying SARS-CoV Detection in Waste Water Protocol

A novel coronavirus, (SARS-CoV-2) recently became an unpredicted pandemic that not only affects large populated areas, but also small, rural towns and villages. Scientists have begun studying this emerging virus in an attempt to learn how to monitor the spread of the virus in people and in the environment. Such efforts help to slow viral transmissions and predict which group or groups of individuals are at the greatest risk of infection. The Walk Lab at MSU is currently studying SARS-CoV-2 in wastewater, and this project proposes to improve testing protocols with the addition of an internal bacteriophage control. I hypothesize that the bacteriophage, MS2, can be used as an internal control to spike into waste water samples. Results generated during this project will allow scientist to address the extent to which current protocols accidentally lose viruses during sample processing steps, such as waste water filtration, sample concentration and RNA extraction.

Acknowledgements: Undergraduate Scholars Program (USP)

Jaedyn Birchmier: Microbiology & Immunology

Mentor: Cara Palmer – Psychology

The Effect of Sleep Quality on Mental Health in Rural Montana Adolescents

Mental health difficulties are a growing public health concern among rural areas of the United States. The rural suicide epidemic has been linked to a number of factors including a shortage of mental healthcare professionals, social isolation, lack of anonymity, and stigma against mental healthcare. Sleep problems have been found to predict the onset of mental health issues and treatment for sleep issues has been associated with better mental health outcomes. The adolescent years are when many mental health disorders onset, and as many as 90% of teens do not obtain adequate sleep. Girls in particular might be most at risk for both mental health and sleep problems. This study aims to better understand mental health symptoms and sleep patterns in a population of rural adolescent youth in Montana, and to explore how and why rates may differ by gender. Adolescent participants and their caregivers were given questionnaires and diagnostic interviews that assess sleep, stage of pubertal development, mental health disorders and symptoms. Participants complete one week of diaries and actigraphy to assess sleep. Daily cortisol samples are collected twice daily in two consecutive days upon waking and prior to bedtime. The research aims to provide better sleep intervention strategies that can be implemented to improve the mental health of adolescents living in rural areas.

Acknowledgements: IDeA Network for Biomedical Research Excellence (INBRE)

Terrin Buchanan: Physics

Mentor: Sachiko Tsuruta – Physics

Thermonuclear Heating and Cooling of 2019 SAX J1808 Burst

Ever since the first observation of neutron stars by Jocelyn Bell Burnell and Anthony Hewish in 1967 Astrophysicists have sought to understand neutron star structure and temperature changes with each X-ray burst. Here, we sought to determine if the low mass x-ray binary (LMXB) system SAX J1808.4-3658 can be used as a standard for

other millisecond pulsars for a standard heating and cooling model. On August 20th 2019, SAX J1808.4-3658 had produced the brightest X-ray burst observed so far by the Neutron Star Interior Composition Explorer (NICER), which is aboard the international space station. We gathered long-term data from around the burst in order to analyze the burst evolution, from outburst to quiescence.

Jenaya Burns: Psychology

Mentor: Monica Skewes, Julie Gameon – Psychology

Self-compassion and mental health issues among college students with a history of trauma

Self-compassion is common in Buddhist philosophy and teachings, which is conceptualized as an orientation towards self-care in which individuals regard themselves with kindness, patience, and non-judgmental understanding. Self-compassion research is a relatively new study area in psychology. Self-compassion research examines the extent to which individuals engage in the three distinct dimensions of self-compassion: self-kindness vs. self-judgment, common humanity vs. isolation, and mindfulness vs. over-identification. Self-compassion is related to greater life satisfaction and buffers against psychological stress in everyday life. The current study aimed to examine the relationship between self-compassion, mental health, substance use problems, and past experiences with trauma among college students. Participants were 577 college students; 38.3% (n = 221) reported having a past trauma experience. Self-compassion was negatively correlated with depressive symptoms, anxiety symptoms, PTSD symptoms, and past traumatic experiences. Independent sample t-tests revealed that people with a history of trauma had significantly lower overall self-compassion scores and higher scores on the negative subscales included in the self-compassion measure. There was no statistically significant difference for the positive subscales when comparing people with a history of trauma and those without a trauma history. With self-compassion awareness individuals with a history of trauma can start to identify triggers and that they are not alone with their experiences. Overall, self-compassion appears to be a protective factor for mental health problems such as depression, anxiety, and substance use.

Acknowledgements: Julie Gameon, McNair Scholars Program

Owen Burroughs: Microbiology & Immunology

Mentor: Jovanka Voyich – Microbiology & Immunology

Potential Signaling Mechanisms for the SaeR/S Two-Component System in Staphylococcus aureus

Staphylococcus aureus (*S. aureus*) is a common human pathogen and a significant cause of morbidity and mortality in the United States each year. Successful *S. aureus* infection relies on the bacterium's ability to detect and evade host neutrophils. To do this, *S. aureus* uses a variety of two-component systems to sense neutrophils and respond through the up-regulation of virulence factors. One such system, the SaeR/S two-component system, is particularly important for effective evasion of the host's immune response. SaeR/S is comprised of SaeS, a trans-membrane histidine kinase, and SaeR, a response regulator. Upon activation by neutrophil components, SaeS phosphorylates the Asp51 residue of SaeR, allowing the protein to up-regulate numerous virulence factors. This research looks to address the mechanism with which SaeS phosphorylates SaeR by measuring the virulence of mutant *S. aureus* strains. We have shown the His132 residue of SaeS to be the active site for the phosphorylation of SaeR—replacing this residue with alanine results in a significant decrease in virulence. In strains lacking both the catalytically active histidine and SaeP/Q, two accessory proteins in the Sae complex, the bacterium regains a virulent phenotype. Taken together, this implies a complex signaling mechanism involving SaeS and the accessory proteins SaeP/Q. This project addresses this hypothesis using sheep's blood hemolysis assays and Phos-tag gel electrophoresis. A better understanding of the mechanisms that regulate the interaction of SaeS with SaeR may lead to the development of novel therapeutics to treat *S. aureus* infection.

Acknowledgements: Undergraduate Scholars Program (USP), IDeA Network for Biomedical Research Excellence (INBRE), Federal funding through research mentor (NSF, NIH, NASA, DOE, etc.)

Eamon Carmichael: Physics

Mentor: Anne Lohfink – Physics

Studying the tori of Polar-scattered Seyfert 1 galaxies in the Infrared

Active Galactic Nuclei (AGN) are the extremely luminous centers of galaxies. AGN unification models postulate the presence of a dusty circum-nuclear obscuring structure, referred to as the ‘torus’. The orientation of this torus, initially believed to be a homogenous toroid, to the line of sight explains most of the observational differences between Seyfert 1 and 2 galaxies in these models. These Seyfert classifications are based respectively on the presence, or absence, of broad line spectrums when observing the AGN. However, these models could not explain the presence of intermediate Seyfert galaxies, in which the Broad Line Region of the AGN is still visible, but scattered. Recent developments have hinted towards the presence of a clumpy torus, composed of separate clouds of matter spaced apart from each other, instead of the traditional "donut" torus as a solution. A good understanding of these nonhomogeneous tori is still lacking, especially for the less-obscured Seyfert 1 galaxies. We present first results from a study of the torus structure in Polar-scattered Seyfert 1 galaxies, a sub-group of Seyfert 1s, using archival IR data, including those from Wide-field Infrared Survey Explorer (WISE). To obtain insight into the torus structure, we analyze the data using the “CLUMPY” torus model. We discuss our modeling results in the context of other torus studies. We also present results from a study through IR-data from Herschel on how star formation influences the IR spectrum, in order to account for contributions other than the AGN in the spectrum we analyze.

Acknowledgements: Chalise Sulov, Undergraduate Scholars Program (USP)

Michael Colgrove: Physics

Mentor: Nicholas Borys – Physics

Quantification of the Enhancement of the Optical Properties of Alloyed 2D Semiconductors

Layered 2D semiconductors are a new class of materials that are only a few atomic layers thick yet are fully functional semiconductors with a plethora of unique properties. As these materials reach single-layer thicknesses, single-photon emission phenomena emerge which could meet critical needs for new quantum information science technologies. Thus, understanding single-photon emission and how it is influenced by the introduction of defects is critical for developing new technologies based on 2D materials. Numerous theories regarding the roles of defects on single-photon emission have been developed, however there is limited experimental data to test how these theories apply to 2D semiconductors. In this project, we are investigating how alloying affects defect-enabled light-emission in 2D semiconductors. In particular we are investigating $\text{Mo}_x\text{W}_{1-x}\text{S}_2$ semiconductors where the relative concentrations of Mo and W are systematically tuned between unalloyed MoS_2 and WS_2 . We have isolated single atomic layers of several alloys and characterized their optical and structural properties through photoluminescence spectroscopy and atomic force microscopy (AFM), respectively. The next steps in our research involve further processing the 2D samples with thermal annealing and superacid treatments. These processes are predicted to enhance the optical properties of the material, making it possible to characterize low-temperature defect emissions and shed light on the influence of the band structure on defect-induced emission. Such investigations of the low-temperature optoelectronic properties of alloyed materials will lend key insight into how composition affects defect-enabled phenomena in 2D materials, such as single-photon emission processes.

Acknowledgements: Undergraduate Scholars Program (USP)

Strother Cooper: Physics

Mentor: Shannon Willoughby – Physics

Initial Statistical Analysis of the Conceptual Survey of Electricity and Magnetism

The Conceptual Survey of Electricity and Magnetism (CSEM) is a multiple-choice introductory college-level test designed to assess a student’s knowledge and understanding of electricity and magnetism. This test is commonly

used in Physics Education Research but little is known about how it functions psychometrically. However, by examining statistics generated from Classical test theory (CTT) a preliminary understanding of the effectiveness of the CSEM as an assessment was found. In this initial analysis, it is evident that this test performs well as a gauge for student progress in electricity and magnetism from pre to post-instruction. Nevertheless, more robust statistical tools such as Item response theory (IRT) and Multi Trait Item Response Theory (MIRT) may be needed to further explore student misconceptions as well as potentially malfunctioning questions.

Acknowledgements: Phillip Eaton, Barrett Frank, McNair Scholars Program

Morgan Craig: History & Philosophy

Mentor: Molly Todd – History and Philosophy

Stories and Solidarity: A Public History Exhibit

In this historical research project I combined independent research with digitized photographs and documents from The Project Solidarity Archive at Montana State University to create an online exhibit about the history of solidarity in El Salvador. This project focuses on the relationship between the United States and El Salvador beginning with the El Salvador Civil War and continuing into solidarity work in the present day. This research is in collaboration with a nonprofit solidarity organization, US El Salvador Sister Cities (USESSC) as well as a graduate student in history. The project will provide the USESSC organization with educational material for their outreach and work both in the United States and El Salvador. Through this project I am cultivating historical research skills, curation skills, and technological skills by building an exhibit with a digital exhibit platform. This project has a significant impact on a large community. It applies historical thinking by connecting past stories with the present outside of a traditional academic setting. The work also shares photographs and historical documents with the public. Photographers and members of USESSC donated these materials with the hope that they could contribute to educating a larger community. The focus of my presentation will be the process of researching, curating, and presenting an online public history exhibit as well as the transnational collaboration of the project. Overall, the exhibit intends to contextualize the events of the El Salvador Civil War and the role of solidarity with the intention of showcasing the power of public history.

Acknowledgements: Undergraduate Scholars Program (USP)

Ryan Ducolon: Physics

Mentor: Jiong Qiu – Department of Physics

Determining Heating Energy in Solar Flare Phenomena

The energy in a solar flare is not just supplied to the heating of the flare, but instead supplies energy to heating, magnetic energy, and the system loses energy to radiation. However, the heating of the solar flare is critical in classifying and categorizing the solar flare event, so we seek a more accurate model to describe how much energy is heating. To do this, we take measurements from satellites to give us emission rates from these flares around certain wavelengths, and through a mixture of thermal and atomic physics we find the heating rate of the solar flare. Though this is well understood, the methods by which we do this is different for different flare events, we seek a more general method by which to model flare events, in turn deepening our understanding of these phenomena.

Connor Flanery: Physics

Mentor: Nicholas Borys – Physics

Z-Polarized Raman spectroscopy of single- and multi-layer 2D materials

Two-dimensional materials such as graphene and monolayer MoS₂ are atomic sheets that are only a few atomic layers thick and have potential to revolutionize technologies in areas ranging from clean energy to quantum information science. These 2D atomically thin systems have structural properties that are intimately connected to

their optical, electrical, and magnetic properties, providing new ways to achieve novel functionalities. Raman spectroscopy optically probes the vibrational states of the atoms in a material and provides a straightforward and nondestructive way to study the structural properties of 2D materials. Importantly, Raman spectroscopy is sensitive to the polarization state of the optical probe being used. Most studies to date have used an in-plane polarization which is not as sensitive to interlayer effects. In this project, thickness-dependent structural, optical, and electronic properties of 2D MoS₂ are investigated using Raman spectroscopy in a novel polarization configuration that is uniquely sensitive to interlayer effects in stacked assemblies of 2D materials. We have fabricated multiple samples of few-layer MoS₂ and have performed initial characterization of their thickness-dependent properties using combined optical, Raman, and AFM techniques. Building on these initial studies, we are now designing an optical system to establish the novel out-of-plane polarization Raman technique to study the interlayer properties of the MoS₂ samples. By establishing an experimental technique using the out-of-plane polarization, we plan to extend these proof-of-concept studies to 2D heterostructures and magnetic materials, establishing a new foundation to probe interlayer effects that are crucial for understanding exotic multilayer architectures of 2D materials.

Acknowledgements: Federal funding through research mentor (NSF, NIH, NASA, DOE, etc.)

Erika Fox: Mathematical Sciences

Mentor: Tomas Gedeon, Bree Cummins – Mathematics

Modeling transport terms in the p53-Mdm2 gene regulatory network

The study of gene regulatory networks is limited by the capacity to compute behavior for systems with a large number of species and associated parameters. The goal of the software Dynamic Signatures Generated by Regulatory Networks (DSGRN) is to provide a means to efficiently compute the dynamics of such networks. The current DSGRN framework is limited to computing the dynamics of systems containing only transcriptional regulation terms. We are interested in expanding this framework to account for systems which contain transport terms, i.e. systems in which one protein regulates the transport of another through the nuclear or cellular membrane. To this end, we investigate the p53-Mdm2 network, which plays a central role in the control of proliferation of potentially cancerous cells. This network contains one such transport term and enables us to develop a systematic approach to analyzing networks of this type.

Acknowledgements: William Duncan, Undergraduate Scholars Program (USP), IDeA Network for Biomedical Research Excellence (INBRE)

Julian Fox: Mathematical Sciences

Mentor: Bree Cummins – Mathematical Sciences

Dynamical behavior in network models of the yeast cell-cycle transcriptional program

I am investigating the dynamics behind the regulation of the yeast cell-cycle transcriptional program utilizing a computational tool called Dynamic Signatures Generated by Regulatory Networks (DSGRN). The yeast cell-cycle transcriptional program is a network of genes, proteins, and complexes which interact to regulate the production of yeast through cell division. The software DSGRN utilizes graph theory and differential equations to predict the dynamics of a proposed biological network across many different conditions. Specifically, DSGRN can determine the dynamics, or change in gene expression over long times, for the proposed network across all the parametrizations of the underlying differential equations. Researchers at the Haase lab at Duke University have proposed a network that models the yeast cell-cycle transcriptional program. I have identified a specific set of dynamics that have been seen in the biological data and have found, qualitatively, that the proposed network has the ability to exhibit the dynamics observed in the biological literature.

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

Makenna Gales: Chemistry & Biochemistry
Mentor: Anja Kunze – Electrical & Computer Engineering
Neuronal Cell Growth Behavior Under the Effect of Microgravity

Microgravity describes the state of weightlessness, most commonly associated with being at a space station. To better understand the influence of microgravity on the human body at low-cost without putting cells and tissues on a space flight, microgravitational systems have been developed based on rotation, or magnetic field levitation. These systems have already provided insight into the function and growth of cells. However, less is known about brain cells. In this project, we are seeking to determine the effects that microgravity based on magnetic levitation has on neuronal cells. In particular, research was done on how the growth of hippocampus cells (E18, rat) exposed to microgravity differed from neurons growing under normal culture conditions. For this proof-of-concept, we imaged neuronal growth every day over 5 days. One set of neuronal cells were placed on the microgravity platform and the other kept under sham condition. Grown neurites were traced using the Simple Neurite Tracer (SNT) in ImageJ and the neurite length was exported and compared. Although neurite length within the levitating magnetic field appeared slightly shorter, we found no statistically significant difference between the mean neurite length of 250 traced neurites.

Acknowledgements: Zeynep Malkoc, IDeA Network for Biomedical Research Excellence (INBRE)

Kaitlin Garman: Chemistry & Biochemistry
Mentor: Nicholas Stadie – Chemistry
Toward the Synthesis of Nano-Zeolite-Templated Carbons

Zeolite-templated carbons (ZTCs) are carbon framework materials with short-range disorder and long-range pore-to-pore order with many interesting properties. ZTCs are typically synthesized by impregnating a micron-scale, commercially available, faujasite-type zeolite template with furfuryl alcohol, pyrolyzing the material at high temperatures, and removing the template in acid. The resulting materials are locally amorphous and carbon packing is lower than predicted by pore-filling, indicating imperfect carbon templating. Instead, the synthesis and templating of nano-sized zeolites could yield zeolite-templated carbons with more accurate templating as a result of shorter diffusion pathways between pores, resulting in more homogenous precursor filling and less pore-blocking leading to undesirable outer particle graphitic deposition. Herein, we demonstrate the synthesis and characterization of monodisperse zeolite nanoparticles and subsequent synthesis of nanoscale ZTC.

Acknowledgements: Erin E. Taylor, Undergraduate Scholars Program (USP), Federal funding through research mentor (NSF, NIH, NASA, DOE, etc.)

Spencer Granville: Psychology
Mentor: Frank Marchak – Psychology
Mission Expectations Not Matching Combat Outcomes Indicate Predisposal For PTSD

The genres of horror and comedy use the unexpected to produce a desired emotional effect of fright and laughter. If expectations created by framing make an impactful response found in these scenarios, the same psychology may apply to posttraumatic stress disorder. Trauma can be theorized as being much in the same to how comedy and horror work psychologically as being funny or scary to some and not others, just as some soldiers develop lasting effects from combat while others do not. Many researchers have identified how the psychology of humor and fear work, while few have investigated further into how traumatic events and outcomes are correlated. This study used previous research on the psychology of comedy and horror to construct a survey to determine if a difference in pre-deployment expectations existed between groups of veterans with and without posttraumatic stress disorder. It appears output from both groups indicates a relationship of expectations matching combat provides results in fewer cases of PTSD regardless of the variability of the event.

Acknowledgements: Undergraduate Scholars Program (USP)

Laina Hall: Microbiology & Immunology

Mentor: Blake Wiedenheft – Microbiology

Characterizing the cyclic oligonucleotide signaling pathway of the Type III CRISPR-Cas system from *Thermus thermophilus*

Like humans, bacteria and archaea get infected by viruses. Although these viral infections are often overlooked, bacterial and archaeal viruses are the most abundant and diverse biological agents on the planet, causing roughly 10^{23} infections per second. In response to persistent viral predation, bacteria and archaea have evolved sophisticated immune systems. The discovery and characterization of one of these immune systems, clustered regularly interspaced short palindromic repeats (CRISPR) recently earned the first all-female team a Nobel Prize in chemistry. By understanding CRISPR systems and specifically how the Type II CRISPR protein Cas9 works in nature, Drs. Doudna and Charpentier creatively repurposed this system to cut DNA in any organism by design. However, CRISPR systems are phylogenetically and functionally diverse. Unlike Type II systems which target DNA, Type III CRISPR systems target RNA using a crRNA guided complex composed of five different “Csm” proteins. RNA recognition by the Csm complex results in cleavage of the target RNA and activates polymerase activity in one of the associated subunits (i.e., Cas10), which generates cyclic oligoadenylates (cA). The cA molecules then activate nonspecific Cas-nucleases. The goal of my work has been to better understand the mechanisms of interference by the Type III CRISPR system from *Thermus thermophilus* (Tt) and to apply this understanding to develop a CRISPR-based viral diagnostic.

Acknowledgements: Andrew Santiagos-Frangos, Ava Graham, IDeA Network for Biomedical Research Excellence (INBRE)

Zakarai Hannebaum: Earth Sciences

Mentor: David Varricchio – Earth Sciences

A study of *Orodromeus* Taphonomy at Egg Mountain, part of the Late Cretaceous Two Medicine Formation near Choteau, MT

The Egg Mountain Quarry is a paleontologically significant fossil locality that's part of the Two Medicine Formation, west of Choteau, MT. The fossils from this site are unique in that they preserve primarily dinosaur eggs, embryonic material, and evidence of nesting; however, dinosaur skeletal material is rare. One of the dinosaurs found at Egg Mountain, *Orodromeus makelai*, is unusual because it is exclusively known from fossil bone material.

Recent work (2010-2016) has found that many of the vertebrate and invertebrate fossils represent burrowing activity including burial of dinosaur eggs, denning underground of mammals, and insect pupation and dwelling chambers. To test whether *Orodromeus* remains also provide evidence of burrowing behavior we use methods of chemical preparation to preserve articulation and surface features of bone material.

Two large accumulations of *Orodromeus* elements have been collected which have been interpreted as possibly preserving *Orodromeus* burrow structure. Three articulated caudal vertebrae have been recovered from the largest accumulation. This articulation is important as it could be due to either rapid preservation, or slow burial with little disturbance, such as would be found in a burrow structure.

If *Orodromeus makelai* was in fact constructing, and living in burrow structures at Egg Mountain, this would make it only the second known burrowing dinosaur. The first known burrowing dinosaur being *Oryctodromeus cubicularis* which is also known from Montana. This would also add to the case that Egg Mountain was a site ecologically beneficial to bioturbation.

Acknowledgements: Undergraduate Scholars Program (USP)

Ashlyn Hemmah: Ecology**Mentor: Dana Skorupa – Chemical and Biological Engineering*****Eliminating Plastic Wastes: Using Thermophiles in the Bioconversion of Pre-Treated Plastics***

Plastics are one of the most prevalent pollutants on the planet, with most landfilled or incinerated after use. Finding a plausible plastic recycling system is a pertinent issue in our modern world. Currently large-scale recycling only exists for plastic materials classified as type #1 or type #2, leaving types #3 through #7 largely untouched. Plastics are often linear carbon polymers that range from 10,000 to 100,000 carbons in length, making them strong and hard to break down. Recently several species of bacteria and fungi have been found to convert short-chain carbon substrates into either polyhydroxyalkanoates (PHAs), or dicarboxylic acids (DCAs). These value-added products can be directly incorporated into biofuel, bioplastics, and industrial chemicals. By pairing these high-production strains with a microorganism capable of breaking down long-chain oxidized waxes (heat degraded plastic polymers) into shorter, readily digestible carbon compounds, one could create a viable recycling system for #3-7 plastics. Work here sought to cultivate thermophiles capable of metabolizing long-chain (>C28) oxidized waxes as a primary carbon and energy source. Thermophilic enrichment cultures were established from water samples collected from a variety of high temperature hot springs in the Heart Lake Geyser Basin region of Yellowstone National Park. Samples were grown up in a media with C28 as the sole carbon source and promising cultures were imaged using SYBR Gold and CARD-FISH staining techniques.

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

Zach Hurt: Microbiology & Immunology**Mentor: Christa Merzdorf – Microbiology & Immunology*****Calcium Signaling in the Neural Plate and its Relationship to Aquaporin 3b Inhibition***

A critical component of embryonic development is the construction of the central nervous system; the neural plate is one of the first tissues formed in this process. Without proper formation of the neural tube, neural tube birth defects result, such as anencephaly and spina bifida. Apical constriction (AC), a principal mechanism that drives neural tube closure, requires the presence of aquaporin 3b (aqp3b) to close properly. The cells that comprise the neural plate do not apically constrict in the absence of Aqp3b despite the protein only being expressed neural fold cells at the outer edge of the neural plate. My research focuses on the mechanism associated with Aqp3b communication to the neural plate cells that do not express the protein. Calcium is a common intracellular signaling molecule, which has been shown to be required for apical constriction. Since calcium is able to pass through gap junctions, we hypothesized that calcium ions may allow Aqp3b to act from the edge of the neural plate to affect all neural plate cells. By injecting *Xenopus* embryos with GCaMP6 RNA, I am able to use NIS-Elements software to image calcium waves both in space and in time. A morpholino oligonucleotide is co-injected to inhibit aqp3b expression. I have predominantly used time lapse imaging to compare control groups and aqp3b inhibited groups; the comparison of the calcium events (by observing wave function characteristics) should tell me whether or not the inhibition of aqp3b is associated with changed calcium wave characteristics in neural plate cells.

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

Thomas Jackson: Microbiology & Immunology**Mentor: Seth Walk, Qian Wang – Microbiology and Immunology*****Aerobic and Anaerobic Methane Production in the Human Gut***

Methane production in the human gut is an under-researched area of human health that may be a factor in obesity. This research aimed to characterize the microbiome associated with both anaerobic and aerobic methane production. Anaerobic media was inoculated with fecal slurries from one of six individuals (P121, P420, P721, JM, SW, P103) in an anaerobic chamber. These fecal slurries were also used to aerobically inoculate SAR media

containing either methylphosphonate (MPn) or methylamine (MeA) as the sole source of either phosphate or nitrogen, respectively. Gas chromatography was used to evaluate methane production in each culture. All of the anaerobic cultures produced methane, with P121, P420, and P721 producing the most methane. Fecal slurries P721, P103, SW, and JM, cultured in SAR+MPn media, produced methane. Slurries P721, P420, P121, and P103, cultured in SAR+MeA media, produced methane. *Klebsiella* sp., *Escherichia* sp., and *Leuconostoc* sp. were sequenced from isolates of aerobic cultures (38 from MPn cultures, 27 from MeA cultures). *Collinsella aerofaciens*, *Escherichia* sp., *Shigella* sp., *Salmonella* sp., and *Methanoculleus*, sp. were sequenced from the anaerobic cultures. Aerobic methane production runs contrary to the prevailing body of literature showing exclusively anaerobic methane production, especially from human fecal samples.

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

Olivia Jakobosky: Ecology

Mentor: Lance McNew – Animal & Range Sciences

Anthropogenic Effects on Grouse Detection and Abundance Based Upon Road and Trail Characteristics in Western Montana

Anthropogenic structures, such as constructed roads and trails, and human use may affect space use, demography, and other wildlife population parameters. Alternately, human infrastructure and activity may result in perceived population responses by influencing the ability of biologists to detect individuals during standard population surveys. The evaluation of spatio-temporal factors correlates in detection probabilities and local abundances, which is necessary for proper population management. To evaluate the effects of human use on mountain grouse populations, we developed and conducted replicated surveys throughout western Montana during 2020. Biologists and volunteers collected count data for dusky, ruffed, and spruce grouse during 582 surveys along 291 survey transects located throughout FWP Regions 1-5. Survey transects occurred along two types of human infrastructure: U.S. Forest Service Trails and unimproved roads close to highway vehicle use during the survey period. As a first step, we compared count data for road and trail transect surveys for each species of grouse. Overall, raw counts of dusky grouse were higher for transects located along trails ($0.59 \pm 1.07SD$ grouse per transect) than unimproved roads ($0.33 \pm 0.91SD$). Raw counts of ruffed grouse were similar for transects located along trails ($0.75 \pm 1.42SD$) and unimproved roads ($0.69 \pm 1.55SD$). Sample sizes for spruce grouse precluded comparison. In the next phase, we will use hierarchical models to evaluate whether the apparent effect of trail type on raw counts is manifested through effects on local abundance or the probability of detection, and consider the effects of other human-use and habitat characteristics.

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Madison Kadrmas: Physics

Mentor: David Nidever – Physics

Determining the Orientation of the Large Magellanic Cloud's Stellar Disk Using Gaia Parallax

Observations of the Large Magellanic Cloud (LMC) indicate that it has a slightly elliptical stellar disk and is set at an angle relative to the plane of the Milky Way described by line of nodes and inclination. All previous measurements of these parameters rely on photometry of stellar population that make assumptions about the distribution of stellar age, stellar metallicity, and dust which could bias the results. Utilizing Gaia EDR3 parallax measurements removes these assumptions and inherent biases by relying on purely geometrical information. LMC stars were selected by applying restrictions based on color, magnitude, proper motion, and individual parallax. While the uncertainty in a parallax measurement for a single LMC star is high, accurate distance information was obtained by averaging over thousands of LMC stars at a time. The orientation parameters of the stellar disk were measured directly from our best-fit LMC stellar disk distance model yielding a line of nodes position angle of $168.6 \text{ deg} \pm 2.23 \text{ deg}$ and an inclination angle of $60.7 \text{ deg} \pm 0.61 \text{ deg}$, with uncertainties derived from a Monte Carlo simulation. Our best-fit value for the line of nodes position angle is well within the range of previously determined

values for this parameter. However, previously reported inclination angles for the LMC fall significantly below our best-fit value. This is thought to be due in part to crowding in the central region of the stellar disk where our results show a clump of stars behind the plane of the stellar disk.

Lauren Kaiser-Jackson: Mathematical Sciences

Mentor: Stephan Warnat – Mechanical and Industrial Engineering

Impedance Spectroscopy for Detecting Microbial Presence in Ice

Electrochemical impedance spectroscopy (EIS) has been shown to be a noninvasive method for detecting microorganisms in both aqueous and icy environments. Here, we report data using microfabricated impedance spectroscopy sensors in parallel with the LTS420 temperature-controlled cryo-stage to simulate sub-zero environments containing microorganisms. By integrating microfabricated impedance sensors with the temperature-controlled stage, experimental conditions enabled a closer investigation of simulated icy matrices. The impedance of conductivity solution with fluorescent beads was investigated at a range of sub-zero temperatures from -10 to -30. Results showed that the presence of beads and ice veins at varying temperatures gave distinct impedance spectra. It was also shown that the fluorescent beads closely model the behavior of microorganisms in ice by migrating to the liquid grain boundaries inside of the ice crystals. These results have promising astrobiological implications, as cryophilic organisms are a topic of interest when considering extraterrestrial life within our solar system. Microfabricated impedance spectroscopy sensors may have potential method for detecting microbial presence in extraterrestrial sub-zero environments such as those on Mars.

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Taylor Kampf: Psychology

Mentor: Neha John-Henderson – Psychology

Historical Loss: Implications for Health of American Indians in the Blackfeet Community

Background: Historical loss in American Indians (AIs) is believed to contribute to high incidence of mental health disorders. Purpose: To investigate whether frequency of thought about historical loss predicts risk factors for chronic physical health conditions in an AI community. Methods: Using Community Based Participatory research (CBPR) and Ecological Momentary Assessment (EMA), we measured frequency of thoughts about historical loss in 100 AI adults residing on the Blackfeet reservation. Participants completed a one-week monitoring period, during which ambulatory blood pressure and daily levels of psychological stress were measured. At the end of the week, we collected a dried blood spot sample for measurement of C-reactive protein (CRP). Results: In a hierarchical linear regression controlling for demographics and depressive symptoms, greater frequency of thoughts about historical loss predicted higher average daily psychological stress ($B = .49$, $t = 4.87$, $p < .001$, $\Delta R^2 = .24$), and higher average ambulatory systolic and diastolic blood pressure ($B = .37$ $t = 3.36$, $p < .001$, $\Delta R^2 = .14$ and $(B = .38$ $t = 3.38$, $p < .001$, $\Delta R^2 = .14$ respectively). In a separate hierarchical linear regression controlling for the same covariates as well as Body Mass Index (BMI), greater frequency of thought about historical loss predicted higher levels of CRP ($B = .37$ $t = 3.41$, $p < .001$, $\Delta R^2 = .13$). Conclusions: Interventions which positively affect historical loss may help to reduce risk for common chronic diseases on the Blackfeet reservation including diabetes and CVD.

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Lauren Keller: Earth Sciences

Mentor: David Varricchio – Earth Sciences

New Azhdarchid Pterosaur Material from the Campanian Two Medicine Formation of Northwestern Montana

Pterosaurs were an incredibly successful group of flying reptiles that existed on Earth for 150 million years. One group of pterosaurs, the azhdarchids, first evolved in the Cretaceous and are arguably the most remarkable and ecologically distinct group. They are largely recognized for their enormous size, with the wingspans of some taxa reaching over ten meters in length. Azhdarchid fossils are known globally and are unique amongst pterosaurs due to their frequent occurrence in terrestrial deposits. This unfortunately contributes to less-than-ideal fossilization conditions as incredibly fragile bones are frequently crushed or destroyed. In 1979, multiple large pterosaur elements, including a humerus, radius, and carpals, were discovered at the Pterosaur Hill locality in the Campanian Two Medicine Formation in northwestern Montana. These elements were identified as belonging to an indeterminate azhdarchid. Additional elements, including a large metacarpal IV, were surface collected in subsequent summers but never described. In 2019 quarrying at the site was undertaken, yielding nine new elements, including two identifiable wing-digit phalanges and a partial metacarpal. Though they have undergone minor taphonomic crushing, many of the elements are three dimensionally preserved. These new elements place this specimen among the largest and most complete of the North American azhdarchids, and includes elements not previously described for this group. This specimen predates the Maastrichtian Quetzalcoatlus and may pertain the large Campanian azhdarchid Cryodrakon; however, comparative analysis of the distal end of metacarpal IV shows significant morphological disparity, suggesting that the Pterosaur Hill material may pertain to a new taxon.

Acknowledgements: Undergraduate Scholars Program (USP)

Conner Killeen: Microbiology & Immunology

Mentor: Anja Kunze – Electrical and Computer Engineering

Quantifying Organoid Morphology via Brightfield Microscopy Image Analysis

Stem cells have great potential to differentiate themselves into a variety of tissues and structures. Stem cells can form clusters called spheroids, and some of these clusters manage to differentiate into organoids. When these organoids are placed in an extracellular scaffold (e.g., matrigel), the cells can self-organize through cell migration, differentiation, and spatially restricted lineage commitment like in vivo. Organoids can also replicate some specific organ tissue functions (e.g., excretion of metabolites, filtration of biomolecules, neural communication, and tissue contraction). The issue is that it is less understood how organoids' morphology relates to tissue function and its maturity behaving like its original organ. The Bimczok lab provided brightfield microscopy images of EDTA spheroid bat cells (stomach, proximal, and distal) to quantify the morphological traits of eccentricity and cross-sectional area using an image processing program called organoSeg. We found morphological trends that showed common variability among passage five and six for all tissue types and a consistent increase in eccentricity across all passages except for passage five. This project should prove useful to understanding variability in morphology changes over time with brightfield microscopy image analysis.

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Pushya Krishna: Microbiology & Immunology

Mentor: Blake Wiedenheft – Microbiology and Immunology

Phase-Dependent CRISPR Evolution

Clustered Regularly Interspersed Short Palindromic Repeats (CRISPR) and associated genes (cas) are essential components of diverse adaptive immune systems that defend bacteria and archaea from viral and plasmid infection. Upon viral challenge, CRISPR loci evolve by preferentially integrating short fragments of phage-derived DNA into one end of the CRISPR locus. Sequences directly upstream of the CRISPR locus, referred to as the CRISPR “leader”, are reported to contain a binding site for a DNA bending protein called Integration Host Factor (IHF). IHF

induced DNA bending kinks the leader of type I-E CRISPRs, recruiting an upstream sequence motif that helps dock Cas1-2 onto the first repeat of the CRISPR locus during spacer acquisition. To determine the prevalence of IHF-directed CRISPR adaptation, we analyzed 15,274 bacterial and archaeal CRISPR leaders. These experiments reveal multiple IHF binding sites and diverse upstream sequence motifs in a subset of the I-C, I-E, I-F and II-C CRISPR leaders. We identify subtype-specific motifs and show that the phase of these motifs is critical for CRISPR evolution. Collectively, this work clarifies the prevalence and mechanism(s) of IHF-dependent CRISPR evolution and suggests that leader sequences and adaptation proteins may coevolve under the selective pressures of phage predation.

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Nicholas Kuechel: Physics

Mentor: Sachiko Tsuruta – Physics

Cataloguing Decades of Timing Results From the Crab Pulsar in the X-ray Band

For decades the Crab Pulsar's spin has been monitored and studied by astrophysicists primarily in the radio band. With a plethora of collected observational data in all bands, getting a clear, overall picture of the Crab Pulsar's timing evolution is a bit of a daunting task. This is because terabytes of data would need to be analyzed and compiled together. By employing the Z^2 statistic, graphics processing unit (GPU) acceleration of computation, elementary machine learning optimization, and automation of this timing methodology, we present a collective catalogue of the Crab Pulsar's timing evolution from decades of observational data in the x-ray band. These results are compared to the *Jodrell Bank Crab Pulsar Timing Results, Monthly Ephemeris*, where we notice similar glitches relative to the radio band. By combining this catalogue with that of the radio band we nearly double the size of the total timing results for the Crab Pulsar to aid in the study of the neutron stars and pulsar timing evolution.

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Robert Kwapisz: Physics

Mentor: Rufus Cone, Charles Thiel – Physics

Quantitative Measurement of Oxygen Stoichiometry Defect Densities in Lithium Niobate Crystals

One of the most common types of defects present in ionic crystals is a deficiency or excess in the density of anions in the lattice. The resulting deviation from ideal chemical stoichiometry can lead to many undesirable effects, including optical absorption, paramagnetism, and even quantum decoherence. The density and type of these defects are strongly dependent on the growth process as well as material processing such as thermal annealing, but quantitatively measuring the corresponding absolute defect density is often extremely difficult, even with modern material characterization techniques. Most electron, x-ray, and mass spectroscopy techniques only probe a very thin layer below the surface, which can deviate significantly from the bulk of the material. Optical techniques that do probe the bulk of the material only provide qualitative results that cannot be used to determine absolute densities. We use a gravimetric technique (density measurement) to examine oxygen stoichiometry in lithium niobate (LiNbO₃) crystals. This method was effective in determining concentration of Y-Al antisite defects in Yttrium Aluminum Garnet (YAG). Further improvements are being made to enable density measurements of LiNbO₃. We will use Raman and infrared spectroscopy to determine the Li/Nb ratio for a crystal sample, and then use that information with our density measurements to obtain an estimate of the oxygen content of the sample. In later work, vapor processing methods will be used to vary the oxygen content of the crystals to correlate the change in oxygen defect density with properties such as the infrared absorption spectrum and quantum decoherence.

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Alexi Kyro: Microbiology & Immunology

Mentor: Suzanne Held – Health and Human Development

Development of a Transportation Program on the Apsáalooke Reservation through the Tribal Health Improvement Program

Messengers for Health (Messengers) is an Indigenous non-profit organization on the Apsáalooke (Crow) reservation that partners with MSU Bozeman faculty and students. Messengers is leading the implementation of a Medicaid-funded care coordination program called the Tribal Health Improvement Program (THIP). As part of the implementation of THIP, our partnership is developing a transportation program as community partners have shared that this is a significant barrier to healthcare and important to address at this time. To develop the program, we conducted a literature review and learned from the experiences of similar groups. To create program policies and procedures, this information was synthesized, and partners met weekly to develop the document. Our program will utilize Apsáalooke community members who are hired to serve as Drivers who will provide rides to health care appointments to THIP participants. Additionally, we will provide gas cards for participants who have the means for transportation but lack the funds. These two facets will be organized by our Driver Supervisor using an online software program, Daphne. This project focused on the creation of policies and procedures. We will determine program efficacy following program implementation.

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Madalynne LaLanne: Physics

Mentor: John Sample – Physics

Magnetically Levitated Attitude Control System Testing Apparatus

For many cube satellites, the experiments that they contain require the ability to keep the experiment probe facing a specific direction through the duration of its orbit. For this to happen, we need an attitude control system. Attitude controls for cube satellites come in many different forms and some of those can not be fully tested within vacuum before being sent into space. Current attitude testing is done through computer simulation which could present an issue by providing a potentially idealized setting for attitude adjustment and control. To help bolster the physical testing phase of a cube satellite attitude system, we need a way to observe the control system's corrections. In order to test this during environmental testing within a thermal vacuum chamber, we need a spinning table that is safe for vacuum conditions. We designed a low-drag, magnetically levitated turntable in order to safely and efficiently test ACS. Using this setup, we are able to add to our environmental testing abilities of cube satellites.

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Lindsay Lee: Microbiology & Immunology

Mentor: Raina Plowright – Microbiology and Immunology

Spatiotemporal variation of gastrointestinal parasites in black flying foxes (Pteropus Alecto) and their impact on bat health

In the winter months, there is a pattern of increased Hendra virus (HeV) shedding from the black flying fox (Pteropus alecto) population in eastern Australia. The zoonotic henipavirus can infect humans with high fatality rates thus holds the risk to public health. Flying foxes have been studied for their range of viral pathogens and ability to spread disease, but the effect parasites have on them is generally unknown. Habitat loss and increased deforestation have pushed flying foxes into urban areas, which may alter prevalence, seasonal infection, and types of infectious parasite genera discovered in flying fox populations with the increase of human-bat interactions. Gastrointestinal (GIT) parasites infect many wildlife species, few studies examine relationships between P. alecto health and their GIT parasites. This project's goal is to add insight into the prevalence of GIT parasites infecting P. alecto comparing space, time, and between sexes. DNA extractions from fecal samples from six P. alecto camps in

New South Wales and Queensland, Australia will be used to perform nested PCR to amplify the 18s rDNA and ITS genes, followed by nested PCR reactions to identify unique DNA bands of the *P. alecto* GIT parasite species. I will use statistical program R to implement Chi-squared tests to test for differences in proportions of bats with and without GIT parasites across seasons (summer vs. winter), sex (male vs female), and sites (n=2) these will allow me to present the prevalence of GIT parasites and their effect on *P. alecto* health.

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Nathaniel Lenhard: Earth Sciences

Mentor: Madison Myers – Earth Sciences

Cathodoluminescence Texture and Melt Embayment Relationships within Quartz Grains for the Oruanui Eruption of Tuapo, NZ

The Oruanui eruption, originating from the Tuapo Volcano in New Zealand, is the world's youngest volcanic super-eruption. To understand aspects of this major eruption such as magma storage and accumulation, analysis of crystal features called melt embayments can be used. Melt embayments can form either by growth due to undercooling or dissolution via volatile saturation. To determine how these melt embayments may have formed for the Oruanui eruption, cathodoluminescence (CL) imaging can be used to observe growth textures and their relationship to melt embayments within quartz grains. In the case that CL zoning patterns wrap around a melt embayment, it could be argued that this is an instance of a growth relationship between the two features, indicating an origin of undercooling and rapid crystal growth to form the melt embayment. In contrast, a melt embayment cross-cutting CL zoning would indicate an origin of dissolution from volatile saturation. By using the scanning electron microscope (SEM) at Montana Tech for CL imaging, the quartz grains and their reentrants are grouped into multiple populations of CL zoning features and the relationships they have with the melt embayments that are found within them. These zoning/embayment relationships are classified as a growth or cross-cutting and will provide insight into the state of the volcanic system and the processes that happened preceding the Oruanui eruption.

Acknowledgements: Megan Saalfeld, Undergraduate Scholars Program (USP)

Shasta Longo: Earth Sciences

Mentor: Madison Myers – Geology

The fits and starts of volcanic supereruptions: Evidence for a time gap preceding the eruption of the Huckleberry Ridge Tuff member C

Yellowstone is renowned for its history of destructive, explosive volcanic eruptions. Namely, within the last ~2.1 million years, Yellowstone has produced three caldera-forming eruptions. The largest of these—the Huckleberry Ridge eruption—occurred 2.08 Ma and produced ~2500 km³ of material. The deposits of this eruption—collectively known as the Huckleberry Ridge Tuff (HRT)—comprise three ignimbrite units (A, B, C) and two fall units, with field evidence suggesting a decades- to years-long hiatus between the eruption of HRT-B and -C. Quartz crystals examined within the HRT-C fall unit exhibit rounded and bipyramidal morphologies, indicative of different (i.e., fast vs. slow) crystal growth kinetics. To investigate the implications of these distinct quartz morphologies for the inferred time gap preceding the HRT-C eruption, rounded and bipyramidal crystals from five successive airfall subunits of the HRT-C were imaged using a scanning electron microscope interfaced with a cathodoluminescence (CL) detector. The zoning intensity in CL is a proxy for Ti concentration; we therefore apply a 1-D diffusion model for Ti-in-quartz across zoned boundaries in order to determine the timescales of quartz rim growth. We compare our diffusion modeling timescales to experimentally-determined quartz growth rates to test our hypothesis: that is, rounded quartz represent prolonged crystallization throughout the eruption hiatus, while bipyramidal quartz represent rapid, syneruptive crystallization. Our study introduces a quantitative framework in which to understand the intermittent behavior of supereruptions, and allows us to gain further insight into Yellowstone's complex history of volcanism.

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Zachary Mayne: Microbiology & Immunology

Mentor: Christa Merzdorf, Jennifer Forecki – Microbiology & Immunology

Determining the Role of Aquaglyceroporin-3b in Convergent Extension During Xenopus Gastrulation

The aqp3b gene codes for an aquaglyceroporin, a type of transmembrane channel which facilitates the permeability of cells to glycerol and other small, polar molecules in addition to water. This aquaglyceroporin plays key roles in gastrulation, when the ectoderm, mesoderm, and endoderm layers form, and in neurulation, when the neural tube forms. During early gastrulation, dorsal mesoderm cells on the embryo's exterior move interiorly and undergo convergent extension, whereby they form into a long, thin band of tissue. Injecting morpholino oligonucleotides to prevent Aqp3b protein translation in the dorsal mesoderm cells prevents convergent extension in gastrulation. In my experiments, I am assessing whether it is the water or polar-solute permeability of Aqp3b that is necessary for convergent extension. Preliminary data from control experiments, where dorsal mesoderm cells of *Xenopus* embryos were injected with morpholino oligonucleotides targeting aqp3b, have reconfirmed that Aqp3b expression is required for convergent extension. Exogenous mRNAs will be co-injected with morpholinos targeting aqp3b to replace it with alternative aquaglyceroporins, which are permeable to water and polar solutes, or strict aquaporins, which are permeable only to water. My hypothesis is that other aquaglyceroporins will rescue Aqp3b function while strict aquaporins will not, which would indicate that permeability to polar solutes such as glycerol is required for convergent extension. If this hypothesis proves true, further investigation will determine which polar solutes are required and what role they play in the molecular mechanisms of convergent extension.

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Madeline Metcalf: Agricultural Economics & Economics

Mentor: Sally Moyce – Nursing

A Health Fair for the Montana Latinx Population

The purpose of this project is to conduct a Spanish-language community health fair to assess the general health of the Latinx community in Gallatin County in the summer of 2021. During the health fair, prevalence measures will be collected regarding chronic disease rates, including body mass index (BMI), blood pressure, and diabetes. Additional data will be collected to assess the prevalence of mental health issues present in the Latinx population. Spanish-language educational materials will also be provided to health fair participants with general health information. The results from this project will provide valuable information concerning the overall health of the Latinx population in rural Montana that can be used to improve future public health services offered to this community. I am working directly with Dr. Sally Moyce, an INBRE-funded investigator and assistant professor in the College of Nursing. Throughout the spring 2021 semester, I have begun to organize, plan, and promote the health fair to be conducted in the summer of 2021. Upon completion of the health fair, I will have data and results that can be presented regarding the current health status of the Latinx population in Gallatin County. This project will equip me with fundamental research skills and experience in the field of public health. I also believe that this research is important for the state of Montana to determine how its public health systems can better serve Montana citizens of all backgrounds.

Acknowledgements: Undergraduate Scholars Program (USP)

Curren Mezak: Earth Sciences

Mentor: David Varricchio – Earth Science, Paleontology

Fossil Egg Identification From Niger, Africa

In the country of Niger, Africa a fossilized egg of an unknown origin has been found in the Tiouraren Formation which dates to the mid Jurassic period. The discovery of this fossil is significant because fossil eggs are extremely

rare in Africa. Our goal was to identify the taxonomic species that this egg might belong to. The identification of this egg is of great importance because it will help give a better understanding of the prehistoric ecosystem at this location during the Jurassic period. Additionally it gives us the possibility of this egg having the potential for being the oldest and one of the only known turtles, dinosaurs, crocodiles, geckos, or even bird eggs that is found in Africa. To find the identification of this egg is by the usage of Electron backscatter diffraction (EBSD). This is necessary in order to be able to answer the question of what kind of animal species this egg comes from. Looking ahead of this research, our hypothesis is that this egg is from a turtle species within this location. This is due to the appearance of aragonite structures throughout the eggshell microstructure, in which turtles are the only known vertebrate species to contain this. This identification gives intell that this egg is the oldest and fourth turtle egg from Africa. It as well tells the wide range of species that lived within the Tiouraren Formation's ecosystem which would include dinosaurs, a wide variety of fish and invertebrate species, and now turtles.

Acknowledgements: Seung Choi, Undergraduate Scholars Program (USP)

Maya Moody: Chemistry & Biochemistry

Mentor: Chelsea Heveran – Mechanical and Industrial Engineering

Gut Microbiome Influence on Bone Remodeling and Osteocyte Viability

The gut microbiome monitors immune activity and cellular energy metabolism, influencing bone tissue. In studies investigating gut microbiome disruption and bone health, bone mineral density was increased. Other studies have shown that gut microbiome disruption decreases bone mineral density and bone strength. Bone tissue also responds to sex hormone signals. Understanding the interaction of sex and gut microbiome on bone health could allow therapies for bone diseases to be tailored to a patient's sex and gut microbiome.

The Germ-Free (GF) mouse study at Montana State University seeks to understand how gut microbiome absence and sex inform the material properties and microarchitecture of bone tissue. Results have shown an increase in bone strength in GF males and females and alterations in bone cellular energy metabolism. For the GF study, the role of the osteocyte, the most prevalent bone cell, is being investigated to determine the correlation between GF gut microbiome and osteocyte remodeling activity. Bone remodeling can take place through the coordination of osteoblasts/osteoclasts and osteocytes. The increased strength of GF bone could result from decreased bone resorption by osteoclasts and increased bone deposition by osteocytes. A decrease in osteocyte viability could also result in decreased osteoclast and osteocyte resorption activity.

TUNEL histological staining is being used to understand osteocyte viability. Quantitative histomorphometry will be used observe bone deposition and resorption by osteoclasts, osteoblasts, and osteocytes. Using this data, bone remodeling activity and osteocyte viability will be correlated with the increased bone strength observed in GF mice.

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Zoe Noble: Physics

Mentor: Rufus Cone, Charles Thiel – Physics

Investigating transitions of transition-metal-doped materials at wavelengths close to 1550nm

Emerging applications in Quantum Information Science (QIS), such as photonic signal processing and quantum memories, require materials that provide optical and spin transitions with long lifetimes, narrow linewidths, and ultra-low quantum decoherence. In order to be compatible with existing infrastructure, these materials should ideally have transitions at 1550nm, aka the telecom wavelength. Due to their well-established performance and relatively simple theoretical model, research over the past 4 decades has focused on crystals doped with rare-earth, with a particular focus on Er^{3+} and its predicable transitions in the 1550nm range.

However, due to several factors, including erbium's paramagnetism, these traditional materials are often incompatible with existing technological infrastructure. In order to address these discrepancies, there is a need for materials that operate at the 1.5-micron wavelengths and that are based on established semi-conductor materials. This study conducted a large-scale spectroscopic investigation of the optical transitions of transition metal ions in an assortment of host materials. Absorption and fluorescence spectroscopy methods were used to investigate materials such as Fe:LiNbO₃ in order to identify promising transition metal and host material combinations with narrow linewidths in the 1550nm range. Several such combinations were identified, thus demonstrating that some of these unexplored ions can offer transitions in technologically important wavelength ranges.

Acknowledgements: Undergraduate Scholars Program (USP), Federal funding through research mentor (NSF, NIH, NASA, DOE, etc.)

Hunter Olson: Earth Sciences

Mentor: David Varricchio – Earth Sciences

Fauna of the Meagher Limestone at Nixon Gulch

The Meagher Limestone is a middle Cambrian (Wuliuan stage ~509-504.5mya) formation that is exposed throughout southwestern and central Montana. Compared to other formations in the northwest, very little is known about the Cambrian fauna in southwestern Montana. The formation is part of the Sauk transgression sequence in Montana. The lower and upper members of the formation consist of shale and limestone and were deposited within the inner detrital belt. The middle member is a massive limestone which was deposited in the carbonate belt. The lower member is the most fossiliferous unit, preserving trilobites, brachiopods, and a soft bodied biota. Here I describe a sample of fossils at the Museum of the Rockies (MOR) which were collected from the lower Meagher Limestone, in Nixon Gulch, about 37 km northwest of Bozeman, Montana. Many of the taxa are undescribed from the formation and represent new occurrences in the state, including two new species of trilobites. This unit also represents a new Burgess Shale type deposit, with the occurrence of the exceptionally preserved soft-bodied vermiform and Porifera fossils. Comparing faunas to laterally adjacent faunas from Lakeview Limestone and Pentagon Formation contribute to a better understanding of the distribution of taxa along the western margin of the North American craton.

Acknowledgements: Undergraduate Scholars Program (USP)

Rowen Oswald: Physics

Mentor: Nicholas Borys – Physics

Integration of a Hanbury Brown Twiss Interferometer onto a Nano-Optical Microscope

In quantum optics, an ideal source of single photon emission has not been developed. Such an ideal source would release a photon if and only if a control signal is inputted, would release only a single photon with a constant polarization state and energy level, would allow for large scale production, and could be integrated into microchip photonic architecture. In order to identify potential candidates for such an ideal source, one must have the capability to characterize the photon emission statistics of semiconductor nano-structures. This can be achieved by the design and implementation of a Hanbury Brown Twiss interferometer incorporated into an existing nano-optical microscope. This style of interferometer would allow for the measurement of photon antibunching behavior of any candidate semiconductors, such as various tetrapod nanocrystals. To create a useful working interferometer, I designed and constructed an apparatus and demonstrated its effectiveness. The antibunching behavior of Cadmium selenide is well understood, so the apparatus can be calibrated via test analysis of CdSe crystals. Using model data sets of previously performed measurements of the antibunching behavior of CdSe, I analyzed and recorded the behavior of the custom interferometer, providing a proof of concept of the apparatus's effectiveness. Then, utilizing python, I constructed an interactive user interface that converts raw data into human

readable formats. This can lead to future work in controlling single photon emission by systematically applying strain to semiconducting tetrapod structures.

Jack Pearson: English

Mentor: Christine Foreman, Markus Dieser – Chemical and Biological Engineering, Center for Biofilm Engineering
Procedural Development and Utilization of Phenotype MicroArrays for Microbial Cells

Phenotype MicroArrays, a technology created by Biolog Inc., allow the phenotypic characterization of isolated microbes through the testing of growth on many different media at once. My research is in pioneering a use for this tool in studying cold-loving bacteria taken from Antarctic environments and identifying isolates that produce biosurfactants, which would then be useful for bioremediation or other biotechnological applications. The microarrays consist of twenty types of plates, each with 96 wells containing a different substance, these range from carbon and nitrogen sources to chemical sensitivities. If the bacteria deposited in a well can grow in the given conditions their respiration and activity activates a dye present within the plates. Currently, the data of two microarrays, run with five separate organisms, is being analyzed by graphing the growth in different media and determining which types of carbon sources the organisms use. Separately, the organisms' genomes have been sequenced to be examined in conjunction with the phenotypic expression. Long-term applications of such work are the easy utilization of Phenotypic Microplates to describe phenotypes and the discovery of new molecular pathways to breakdown carbon sources. Both of these entail combining Biolog's phenotypic tools with genetic sequencing for a holistic understanding of bacteria new to science.

Acknowledgements: Undergraduate Scholars Program (USP)

Ian Powell-Palm: English

Mentor: Gretchen Minton – English

Henry V goes to Iraq: Contemporary reflections on Shakespeare's Henry V in American leadership and foreign policy

This presentation focuses on the ways in which Shakespeare's historical play Henry V has impacted and informed modern American understandings of foreign policy, as well as expectations concerning the role of an American president. I will first examine the rhetoric and actions of three U.S. Presidents (John F. Kennedy, George W. Bush, and Donald J. Trump) through the lens of the Machiavellian principles of archetypal self-construction and systematic deflection of blame in military campaigning, and demonstrate how these same principles shaped the character of Shakespeare's King Henry V. I will then discuss how these Machiavellian compulsions dominated the presidency of John F. Kennedy, and remained dominant while both evolving and distorting en route to the presidency of Donald J. Trump, despite the significant changes in the nature of American warfare from the Cold War to the "forever wars" of the Middle East. The role of the medieval notions of divine right and "just war", which heavily motivated King Henry V's military campaign against France, will be examined in the motivations of contemporary American foreign conflict, the celebration of the warrior-king trope, and the aggrandizement of the American military. I will examine how both King Henry V and the aforementioned Presidents have used war and faith interchangeably to foster jingoistic support for their endeavors, and finally analyze Henry V through a Presentist framework in search of clues as to how American society might navigate out of the Machiavellian traps of endless warfare, chameleonic leadership, and the conflation of faith and governance.

Acknowledgements: Undergraduate Scholars Program (USP)

Rylan Rowsey: Chemistry & Biochemistry

Mentor: Robert Szilagyi, Nicholas Stadie – Chemistry & Biochemistry

Methane Interactions with Heteroatom-Doped Carbon Surfaces

Methane storage by physisorption on a carbon-based surface is a well-established strategy but the effect of heteroatom inclusions, specifically boron and nitrogen, within the carbon surface remains unexplored. In this work we employ computational chemistry to investigate both structural and energetic effects on the approach of a methane molecule to the surface of a polyaromatic hydrocarbon molecule: 1-methylidenephenalene (MPH). This molecule is selected for its aromaticity, low computational cost, and radial symmetry around a central atom that can be occupied by boron, carbon, or nitrogen. A suite of ab initio methods have been utilized herein, including density functional theory (MN15 functional) and wave function theory (MP2 and CCSD(T) correlated post-Hartree-Fock methods). Lowest energy structures of MPH and heteroatom-doped MPH have been achieved using the MN15 functional. Then, interaction energies between methane and the optimized MPH molecules have been assessed as a function of approach distance, angle, and location using MP2 along with CCSD(T) methods, the most robust methods known for the treatment of London dispersion forces. This work motivates important future synthetic strategies to substitutionally modify porous carbon adsorbent materials by heteroatom doping (especially by nitrogen) in order to strengthen methane binding and increase methane storage capacity at near room temperature.

Acknowledgements: Erin Taylor, Stephan Irle, Undergraduate Scholars Program (USP), Federal funding through research mentor (NSF, NIH, NASA, DOE, etc.), XSEDE

Raymond Salazar: Earth Sciences

Mentor: Madison Myers – Earth Sciences

A Petrographic and Geochemical Analysis of New Members of the Lava Creek Tuff, Yellowstone National Park

The Lava Creek Tuff (LCT) is the youngest caldera-forming eruption of the Yellowstone volcanic system. Around 630 ka this eruption disgorged over 1000 km³ of material in the form of two main ignimbrites, A and B, with the distinction that Member A contains amphibole (Christiansen, 2001). However, recent age dating on multiple ignimbrites in the Sour Creek Dome region of Yellowstone, originally mapped as part of the older (2.08 Ma) Huckleberry Ridge Tuff, yielded ages (~658 ka and 634 ka) similar to the younger LCT (Rivera et al., 2014; Wilson et al., 2018). This revelation suggests the LCT eruption is more complicated than currently assumed, posing several questions, including: a) are there additional unrecognized ignimbrite units which were produced by the LCT eruption, b) what is the volume and spatial distribution of these units, and c) what do they tell us about the progression of the LCT eruption? In this study we aim to characterize previously collected samples of the newly recognized LCT ignimbrite and determine if they are part of Member A, B, or if they are part of undescribed Members. This work will have significant impacts on how we currently understand the dynamics of the Lava Creek supereruption, with additional implications for the boundary of the Yellowstone Caldera.

Acknowledgements: Stacy Henderson, Madison Myers, Undergraduate Scholars Program (USP)

Emma Sihler: Microbiology & Immunology

Mentor: Vanessa Simonds – Community Health

Co-research, Citizen Science, and Water Quality: Adapting the Guardians of the Living Water Program

The Guardians of the Living Water project was started in 2014 as a way to address issues of water quality in the Apsáalooke (Crow Indian) community. The program focuses on educating 5th and 6th-grade children about the science and cultural importance of water. The goal of the program is for children to then take what they learn and act as agents of change, spreading knowledge and promoting safe practices throughout the community. One method the program has used to promote an interest in water quality science is to train these youth to be co-researchers investigating water quality topics of interest. To determine the most effective ways to engage youth

as co-researchers, we conducted a literature review comparing and contrasting youth as co-researchers vs. youth as citizen scientists. The results from the literature review were used to develop a facilitator guide for engaging Indigenous youth in research at the Guardians of the Living Water summer camp. Adults have an important role in guiding youth research projects, however, that guidance must be balanced with ample opportunity for authentic youth engagement so that youth may feel ownership and investment in the project.

Acknowledgements: Christine Martin, Yuhuan Xie, IDeA Network for Biomedical Research Excellence (INBRE), Federal funding through research mentor (NSF, NIH, NASA, DOE, etc.)

Griffin Smith: Mathematical Sciences

Mentor: Dominique Zosso, Scott McCalla – Mathematical Sciences

Group Formation and Cohesion of Janus Particles

Why do some species of birds fly in flocks? Similarly, why do some species of fish swim in schools? More generally, what underlying rules govern swarming and clustering behavior, and why do simple rules lead to complex dynamics? This project seeks to develop some of these questions.

We concern ourselves with orientable Janus Particles. We limit these particles perception of their surroundings to a "cone of vision" which is centered around the particles orientation. Should a particle sense enough of its peers it moves forward. It has been experimentally shown that Brownian motion and active forward drift controlled by quorum sensing is sufficient to produce clustering behavior in orientable Janus particles. This project explores the group formation and cohesion of Janus particles using both an agent-based computer model and an advection-diffusion partial differential equation (PDE) model.

The particles follow simple rules, so we program a computer to keep track of simulated particles position, orientation, activation-status and more. This model works well, and it agrees with the experimental results mentioned above. If we allow the number of particles in the agent based model approach infinity, we can no longer track individual particles, so we consider particle density as function of space and time: this is our PDE model. Our PDE model can recreate the behavior from both physical experimentation and computer simulations. Additionally, the PDE model highlights an annular structure which was not apparent in prior work.

Acknowledgements: Nathan Stouffer, Undergraduate Scholars Program (USP), IDeA Network for Biomedical Research Excellence (INBRE)

Uve Strautmanis: Microbiology & Immunology

Mentor: Heidi Smith – Microbiology and Immunology

Investigation of Complete Groundwater Denitrification Utilizing an Environmentally Relevant Bacterial Co-culture

Primary motivations for studying the subsurface are to expand the knowledge of Earth's microbial diversity and the subsurface microorganisms under low nutrient conditions that significantly impact C, S, N, P and mineral cycles. One such biogeochemical cycle of importance to groundwater systems is microbial denitrification, the reduction of nitrate (NO_3^-) from organic and inorganic sources back to atmospheric nitrogen (N_2). However, little is known about the extent of microbially-mediated denitrification in groundwater environments. The key to harnessing microbial potential is to find the optimal set of parameters that promotes enhanced rates of denitrification. In anaerobic environments, oxygen is not readily available for respiration, therefore microbes must use alternative electron acceptors such as NO_3^- to respire, reducing NO_3^- to N_2 . To investigate the environmental parameters that influence denitrification this work uses a co-culture of *Rhodanobacter* sp. R12 and *Acidovorax* sp. 3H11 that when grown together, can complete full biotic denitrification. Batch experiments mimicking field conditions were run using the *Rhodanobacter* sp. R12 and *Acidovorax* sp. 3H11 co-culture under varying pH values, dissolved oxygen concentrations, carbon sources, and amino acids. Samples were analyzed for growth performance, nitrate reduction, and single cell analysis including the integration of stable isotope probing with Raman

Microspectroscopy and the identification of individual microbial cells and fluorescent in-situ hybridization (FISH). This will quantitatively track the abundance of individual organisms across treatments. Higher rates of denitrification are expected to occur when the organisms are grown together and in anaerobic conditions at a pH of 7.

Acknowledgements: Sara Altenburg, Matthew Fields, Undergraduate Scholars Program (USP)

Annie Waldum: Chemistry & Biochemistry

Mentor: Valérie Copié – Chemistry and Biochemistry

Understanding the impact of neurodegeneration on metabolism in Familial dysautonomia

Crosstalks between cellular networks intersecting the gut-brain-liver axis have emerged as critical elements of neurodegenerative diseases, and new insights into the complexity of this axis could unravel routes for potential clinical interventions. Of great interest is the incurable neurodegenerative disease Familial dysautonomia (FD) that originates from a point mutation in the IKBKAP/ELP1 gene leading to tissue-specific reductions of the ELP1 protein, which affects both the peripheral and central nervous systems. Prominent features of the disease, observed in both patients and FD mouse models, include major impairments of central metabolism and severe gastrointestinal dysmotility. These observations are supported by our findings that FD mice and patients struggle to maintain a normal weight and display significantly altered gut microbiomes. We postulate that neuronal innervation deficits modulated by ELP1- neurodegeneration initiates a feedback loop whereby the gut microbiome becomes dysbiotic, contributing to impaired metabolism and an increase in neuronal mitochondrial stress, which further promotes neurodegeneration. To better understand the molecular networks regulating the gut microbiome, liver metabolism, and neuronal health, a multidisciplinary approach has been undertaken to identify and interrogate the molecular mechanisms at the source of the neuropathy observed in FD. We have conducted a detailed 1H NMR metabolomics analysis of liver samples obtained from FD mouse models, comparing them to the profiles of healthy, age-matched control mice. Here, we present our latest NMR metabolomics findings including a presentation of specific metabolic pathways found to be altered in our FD mouse models.

Acknowledgements: Undergraduate Scholars Program (USP), IDeA Network for Biomedical Research Excellence (INBRE), Federal funding through research mentor (NSF, NIH, NASA, DOE, etc.)

Connie Watt: Chemistry & Biochemistry

Mentor: Seth Pincus, Tami Peters – Chemistry and Biochemistry

Development of a Pseudovirus Assay to Measure SARS-CoV-2 Infection of Target Cells in Biosafety Level 2 Laboratories

The spike protein, used by SARS-CoV-2 to enter and infect human cells, is composed of two subunits, S1 and S2. The S1 subunit contains a receptor binding domain (RBD) that attaches to the human cell receptor angiotensin converting enzyme 2 (ACE-2) with the S2 subunit mediating the union between viral and host cell membranes. Traditional methods of studying infection by SARS-CoV-2 require live virus assays in biosafety level three facilities. Here we have simplified the study of SARS by pseudotyping the spike protein onto a non-replicative virus composed of human immunodeficiency virus (HIV)-based lentiviral particles encoding luciferase. The virulence of the resulting biosafety level two “pseudovirus” was evaluated by infecting 293T cells expressing the ACE-2 receptor. Chemiluminescence was used to detect infection by variants of viral entry protein sequences, codon-optimized, delta 21, and delta 21 D614G. Out of the three pseudotyped variants of the spike protein, Delta 21 D614G was the most efficient in the infection of 293T ACE-2 when compared to the other entry proteins. Using these pseudovirus, neutralization assays will serve as an alternative to live virus assays in assessing neutralizing antibodies against SARS-CoV-2.

Acknowledgements: Matthew Evans, IDeA Network for Biomedical Research Excellence (INBRE), Federal funding through research mentor (NSF, NIH, NASA, DOE, etc.)

Michael Winslow: Physics

Mentor: Shannon Willoughby – Physics

The Interrelatedness of Two General Forms of Reasoning

There has been minimal qualitative research into the reasoning methods used by physics students. What research there has been was focused primarily on qualitatively categorizing the specific research strategies taken by individual students. As opposed to previous studies which were qualitative, the research presented here focuses on a combined quantitative and qualitative approach to problem solving strategies to understand conceptual and mathematical reasoning. Specifically, how are these reasoning methods used by upper level students and if they are distinct categories. By analyzing responses to three counterintuitive physics problems, preliminary results indicate little to no difference between these categories and that mathematical and conceptual reasoning were used identically.

Joseph Wishart: Physics

Mentor: John Sample – Physics

X-Ray Detector Calibration for Impulsive Phase Rapid Energetic Solar Spectrometry (IMPRESS)

Solar flares occur during massive magnetic reconnection events on the outer reaches of the sun's atmosphere. These events are well known to release tremendous amounts of energy in the form of nonthermal accelerating electrons. These particles produce characteristic fluctuations in temporal x-ray flux, the details of which can give clues about the mechanisms that govern such electron acceleration. Previous studies have revealed fast ($\leq 2s$) time variations in x-ray flux (Kiplinger et al 1984, Qiu et al 2012), but issues of pulse detection pileup and inadequate temporal resolution have left many unanswered questions about acceleration timescales, magnetic field structures, and oscillatory behaviors. To continue the study of these phenomena in an attempt to address some of these outstanding inquiries, a collaborative x-ray detection project between four American universities has been planned and given the name IMPRESS: Impulsive Phase Rapid Energetic Solar Spectrometer. The content of this paper will outline in detail the testing of various detectors to be used on the satellite. Energetic and temporal dependencies of a variety of scintillating crystals, x-ray detectors, and software commands will be discussed. We find that through a variety of calibration routines using radioactive sources and direct software implementation, we are able refine the detector system to optimize energetic and temporal resolutions of acquired data.

Claire Zuetell: Microbiology & Immunology

Mentor: Mensur Dlakic – Microbiology and Immunology

Cloning Sso7d and PFU Together to Make a More Efficient DNA Polymerase

The goal of this project was to combine DNA-binding protein 7d (Sso7d) from the *Saccharolobus solfataricus* organism and PFU DNA polymerase from *Pyrococcus furiosus* archaea to make a more efficient polymerase. PFU is known to work well for PCR. However, it is slow and inefficient for larger constructs. Sso7d is a non-specific binding protein that compacts DNA, so when combined with PFU, it could hold PFU tighter to the DNA it is replicating to provide a better grip, so PFU could then move faster along longer strands of DNA. It is hypothesized that Sso7d combined with PFU will create a polymerase that, when used in PCR, will make the reaction more efficient for larger DNA constructs. The PFU used to make this construct was already made in the lab and used for prior PCRs. SSo7d was made synthetically using overlap PCR. The synthetic Sso7d was combined with the PFU again using overlap. The combined sso7d-PFU was cloned using gateway technology into PDEST-14 plasmid in BL-21 competent cells.

Acknowledgements: Undergraduate Scholars Program (USP)

Student, Mentor, Project	Presentation Time	Room No.	Page No.
Alabdullatif, Habib: Physics Aleks Rebane – Physics <i>3D-Fluorescence spectroscopy of Protonation Responsive Coumarins</i>	2-3PM	14	26
Angyus, Michael: Chemical & Biological Engineering Blake Wiedenheft, Robin Gerlach – Microbiology & Immunology, Chemical & Biological Engineering <i>New High pH High Alkaline Adapted Microalgae for Biofuel Production</i>	1-2PM	10	12
Aspelin, Klara: Microbiology & Immunology Mari Eggers – Microbiology & Immunology <i>Statistical Analysis of Water Quality Data in the State of Montana</i>	noon-1PM	7	26
Austad, Sydney: Chemistry & Biochemistry Patrik Callis – Chemistry and Biochemistry <i>Fundamental Physical Chemistry of the Serine Protease</i>	noon-1PM	5	26
Baker, Tanya: Chemistry & Biochemistry Mary Cloninger – Chemistry <i>Synthesis of A Multivalent Tether to Template Oligomerization of Galectin-3</i>	noon-1PM	5	27
Baker, William: Microbiology & Immunology Susy Kohout – Cell Biology and Neuroscience <i>New Discoveries About Voltage-Sensing Phosphatase Through Voltage Clamp Fluorimetry</i>	noon-1PM	7	4
Balius, Quincy: History & Philosophy Amanda Hendrix-Komoto – History & Philosophy <i>Respectability Beyond Reproach: The Racial Construction of Western Womanhood</i>	noon-1PM	6	27
Bassetti, Seth: Earth Sciences Brittany Fasy, David Millman – Computer Science <i>Enhancing Accessibility in Topological Data Analysis</i>	11AM-noon	2	27
Bauer, Catherine: Chemical & Biological Engineering Brent Peyton – Chemical Engineering <i>Method Development for Measuring Bacterial Growth in Iron-Precipitate Containing Cultures & Growth Comparisons for Nitrate Dependent Fe(II) Oxidation</i>	11AM-noon	1	12
Berghoff, Jade: Land Resources & Environmental Sciences Danielle Ulrich – Ecology <i>Comparing the Crown Architecture of Whitebark and Limber Pine Seedlings</i>	11AM-noon	3	4

Student, Mentor, Project	Presentation Time	Room No.	Page No.
Berry, Amber: Microbiology & Immunology Seth Walk, Paul van Erp – Microbiology and Immunology <i>MS2 Quantifying SARS-CoV Detection in Waste Water Protocol</i>	2-3PM	12	28
Birchmier, Jaedyn: Microbiology & Immunology Cara Palmer – Psychology <i>The Effect of Sleep Quality on Mental Health in Rural Montana Adolescents</i>	2-3PM	13	28
Boyd, Isaac: Electrical & Computer Engineering Bradley Whitaker, David Hedges – Electrical & Computer Engineering <i>Predicting the Spread of COVID-19 with Neural Networks</i>	noon-1PM	7	12
Buchanan, Terrin: Physics Sachiko Tsuruta – Physics <i>Thermonuclear Heating and Cooling of 2019 SAX J1808 Burst</i>	2-3PM	14	28
Burns, Jenaya: Psychology Monica Skewes, Julie Gameon – Psychology <i>Self-compassion and mental health issues among college students with a history of trauma</i>	2-3PM	15	29
Burroughs, Owen: Microbiology & Immunology Jovanka Voyich – Microbiology & Immunology <i>Potential Signaling Mechanisms for the SaeR/S Two-Component System in Staphylococcus aureus</i>	noon-1PM	7	29
Burton, Havilah: Health & Human Development Wan-Yuan Kuo – Food Product Development Lab <i>What role does food sovereignty play in bringing an invasive fish species to market? A collaborative study with the Confederated Salish and Kootenai Tribes</i>	2-3PM	15	10
Carmichael, Eamon: Physics Anne Lohfink – Physics <i>Studying the tori of Polar-scattered Seyfert 1 galaxies in the Infrared</i>	2-3PM	14	30
Colgrove, Michael: Physics Nicholas Borys – Physics <i>Quantification of the Enhancement of the Optical Properties of Alloyed 2D Semiconductors</i>	11AM-noon	4	30
Cooper, Strother: Physics Shannon Willoughby – Physics <i>Initial Statistical Analysis of the Conceptual Survey of Electricity and Magnetism</i>	2-3PM	14	30

Student, Mentor, Project	Presentation Time	Room No.	Page No.
Craig, Morgan: History & Philosophy Molly Todd – History and Philosophy <i>Stories and Solidarity: A Public History Exhibit</i>	noon-1PM	6	31
Denny, Christina: Center for Biofilm Engineering Ellen Lauchnor, Chistopher Allen – Civil and Environmental Engineering <i>Observations of Carbon and Nitrogen Removal in Treatment Wetlands</i>	1-2PM	9	13
Dreesbach, Hannah: Microbiology & Immunology Matthew Fields – Microbiology and Immunology <i>Determining the Effects of Flow Rate on Microbial Localization and Metabolism in a Simulated in situ Terrestrial Subsurface Environment</i>	2-3PM	13	4
Du, Martina: Chemical & Biological Engineering Ross Carlson – Chemical and Biological Engineering <i>Optimizing Exchange Economics in Synthetic Microbial Ecology Systems</i>	11AM-noon	1	13
DuBois, Camryn: Mechanical & Industrial Engineering Scott Monfort – Mechanical & Industrial Engineering <i>Influence of Multitasking Ability and Changes of Sensory Information on Walking Stability</i>	1-2PM	11	14
Ducolon, Ryan: Physics Jiong Qiu – Physics <i>Determining Heating Energy in Solar Flare Phenomena</i>	11AM-noon	4	31
Dupuis, Payton: Chemical & Biological Engineering L. Keith Henry – Biomedical Sciences <i>Toward identifying a novel binding site on the human serotonin transporter through computational docking of VK03-51.</i>	1-2PM	9	14
Eriksson, Austen & Kammerzell, Takumi: Mechanical & Industrial Engineering Mark Owkes, Phil Stewart – Mechanical & Industrial Engineering, Chemical & Biological Engineering <i>Biofilm Modeling</i>	1-2PM	11	14
Espinal, Michael: Mechanical & Industrial Engineering Chelsea Heveran, Adrienne Phillips – Mechanical & Industrial Engineering, Civil engineering <i>Evaluation of the Interfacial Bond Between OPC Mortar and Biomineralized Waste Plastic</i>	1-2PM	11	15

Student, Mentor, Project	Presentation Time	Room No.	Page No.
Flanery, Connor: Physics Nicholas Borys – Physics <i>Z-Polarized Raman spectroscopy of single- and multi-layer 2D materials</i>	11AM-noon	4	31
Fox, Erika: Mathematical Sciences Tomas Gedeon, Bree Cummins – Mathematics <i>Modeling transport terms in the p53-Mdm2 gene regulatory network</i>	1-2PM	11	32
Fox, Julian: Mathematical Sciences Bree Cummins – Mathematical Sciences <i>Dynamical behavior in network models of the yeast cell-cycle transcriptional program</i>	1-2PM	11	32
Gales, Makenna: Chemistry & Biochemistry Anja Kunze – Electrical & Computer Engineering <i>Neuronal Cell Growth Behavior Under the Effect of Microgravity</i>	noon-1PM	5	33
Garman, Kaitlin: Chemistry & Biochemistry Nicholas Stadie – Chemistry <i>Toward the Synthesis of Nano-Zeolite-Templated Carbons</i>	11AM-noon	1	33
Glanville, Natalee: Animal & Range Sciences Carl Yeoman – Animal and Range Sciences <i>Bacterial Immune Modulation of Neonatal Ruminants</i>	1-2PM	9	5
Granville, Spencer: Psychology Frank Marchak – Psychology <i>Mission Expectations Not Matching Combat Outcomes Indicate Predisposal For PTSD</i>	2-3PM	15	33
Grimm, Sophie: Land Resources & Environmental Sciences Jack Brookshire – Land Resources and Environmental Science <i>Quantifying Carbon Sequestration from Recent Woody Plant Expansion Across the Northern Great Plains</i>	11AM-noon	3	5
Hall, Samantha: Chemical & Biological Engineering Ryan Anderson – Chemical & Biological Engineering <i>Development of a Fully Coupled Three-Dimensional Computational Fluid Dynamics Model of a Reversible Solid Oxide Fuel Cell for Analysis of Flow Maldistribution and Performance</i>	1-2PM	10	34
Hall, Laina: Microbiology & Immunology Blake Wiedenheft – Microbiology <i>Characterizing the cyclic oligonucleotide signaling pathway of the Type III CRISPR-Cas system from Thermus thermophilus</i>	2-3PM	12	15

Student, Mentor, Project	Presentation Time	Room No.	Page No.
Hannebaum, Zakarai: Earth Sciences David Varricchio – Earth Sciences <i>A study of Orodromeus Taphonomy at Egg Mountain, part of the Late Cretaceous Two Medicine Formation near Choteau, MT</i>	11AM-noon	2	34
Hemmah, Ashlyn: Ecology Dana Skorupa – Chemical and Biological Engineering <i>Eliminating Plastic Wastes: Using Thermophiles in the Bioconversion of Pre-Treated Plastics</i>	11AM-noon	3	35
Heskett, Emily: Environmental Engineering Adrienne Phillips – Civil Engineering <i>Impacts of Biomineralization Growth in Cold Temperatures</i>	11AM-noon	3	16
Heys, Lillian: Microbiology & Immunology Shawna Pratt – Chemical engineering <i>Comparing growth rates of Pseudomonas aeruginosa and Staphylococcus aureus in single-cell and bulk cultivation approaches</i>	noon-1PM	7	6
Hurt, Zach: Microbiology & Immunology Christa Merzdorf – Microbiology & Immunology <i>Calcium Signaling in the Neural Plate and its Relationship to Aquaporin 3b Inhibition</i>	2-3PM	13	35
Jackson, Thomas: Microbiology & Immunology Seth Walk, Qian Wang – Microbiology and Immunology <i>Aerobic and Anaerobic Methane Production in the Human Gut</i>	2-3PM	13	35
Jakabosky, Olivia: Ecology Lance McNew – Animal & Range Sciences <i>Anthropogenic Effects on Grouse Detection and Abundance Based Upon Road and Trail Characteristics in Western Montana</i>	11AM-noon	3	36
Kadriu, Darien: Chemical & Biological Engineering Carl Yeoman – Animal and Range Sciences <i>The effects of Biogenic Amines in the biofilm formation and density of Gardnerella vaginalis.</i>	1-2PM	10	16
Kadmas, Madison: Physics David Nidever – Physics <i>Determining the Orientation of the Large Magellanic Cloud's Stellar Disk Using Gaia Parallax</i>	11AM-noon	4	36
Kaiser-Jackson, Lauren: Mathematical Sciences Stephan Warnat – Mechanical and Industrial Engineering <i>Impedance Spectroscopy for Detecting Microbial Presence in Ice</i>	1-2PM	11	37

Student, Mentor, Project	Presentation Time	Room No.	Page No.
Kampf, Taylor: Psychology Neha John-Henderson – Psychology <i>Historical Loss: Implications for Health of American Indians in the Blackfeet Community</i>	2-3PM	15	37
Kelderman, Samantha: Chemical & Biological Engineering Dana Skorupa, Brent Peyton – Center for Biofilm Engineering, Chemical and Biological Engineering <i>Thermophilic bioconversion of oxidized plastics to value-added products</i>	11AM-noon	1	17
Keller, Lauren: Earth Sciences David Varricchio – Earth Sciences <i>New Azhdarchid Pterosaur Material from the Campanian Two Medicine Formation of Northwestern Montana</i>	11AM-noon	2	38
Killeen, Conner: Microbiology & Immunology Anja Kunze – Electrical and Computer Engineering Department <i>Quantifying Organoid Morphology via Brightfield Microscopy Image Analysis</i>	2-3PM	13	38
Kluth, Janessa: Animal & Range Sciences Timothy DelCurto, Megan Van Emon – Animal & Range Science <i>The use of ruminal temperature probes to estimate water intake and water intake behavior of beef cattle</i>	1-2PM	9	6
Kozisek, Kayla: Chemical & Biological Engineering Robin Gerlach – Chemical and Biological Engineering <i>Enzyme Degradation of Algal Cell Walls</i>	1-2PM	10	17
Krishna, Pushya: Microbiology & Immunology Blake Wiedenheft – Microbiology and Immunology <i>Phase-Dependent CRISPR Evolution</i>	2-3PM	13	38
Kristiansen, Anna: Health & Human Development Mary Miles – Health & Human Development <i>Changes in Insulin Resistance after 12 Weeks of Lentil Consumption</i>	2-3PM	15	10
Kuechel, Nicholas: Physics Sachiko Tsuruta – Physics <i>Cataloguing Decades of Timing Results From the Crab Pulsar in the X-ray Band</i>	2-3PM	14	39
Kwapisz, Robert: Physics Rufus Cone, Charles Thiel – Physics <i>Quantitative Measurement of Oxygen Stoichiometry Defect Densities in Lithium Niobate Crystals</i>	2-3PM	14	39

Student, Mentor, Project	Presentation Time	Room No.	Page No.
Kyro, Alexi: Microbiology & Immunology Suzanne Held – Health and Human Development <i>Development of a Transportation Program on the Apsáalooke Reservation through the Tribal Health Improvement Program</i>	2-3PM	12	40
LaLanne, Madalynne: Physics John Sample – Physics <i>Magnetically Levitated Attitude Control System Testing Apparatus</i>	11AM-noon	4	40
Lee, Lindsay: Microbiology & Immunology Raina Plowright – Microbiology and Immunology <i>Spatiotemporal variation of gastrointestinal parasites in black flying foxes (Pteropus Alecto) and their impact on bat health</i>	noon-1PM	7	40
Lenhard, Nathaniel: Earth Sciences Madison Myers – Earth Sciences <i>Cathodoluminescence Texture and Melt Embayment Relationships within Quartz Grains for the Oruanui Eruption of Tuapo, NZ</i>	11AM-noon	2	41
Longo, Shasta: Earth Sciences Madison Myers – Geology <i>The fits and starts of volcanic supereruptions: Evidence for a time gap preceding the eruption of the Huckleberry Ridge Tuff member C</i>	11AM-noon	2	41
Magoon, Matthew & Lam, Kenedee: Chemical & Biological Engineering Stephanie McCalla – Chemical & Biological Engineering <i>Developing an Aptamer Against Acetaminophen to Detect Acetaminophen Toxicity at the Point of Care</i>	1-2PM	9	18
Martin, Evan: Chemical & Biological Engineering Connie Chang – Chemical and Biological Engineering <i>Optical barcoding of bacterial cells in single-cell drop-based microfluidics</i>	1-2PM	10	18
Mayne, Zachary: Microbiology & Immunology Christa Merzdorf, Jennifer Forecki – Microbiology & Immunology <i>Determining the Role of Aquaglyceroporin-3b in Convergent Extension During Xenopus Gastrulation</i>	2-3PM	12	42
McCoy, Quintin: Chemical & Biological Engineering Mentor: Christine Foreman, Markus Dieser – Chemical & Biological Engineering, Center for Biofilm Engineering <i>Reduction of Biofilm Formation in Metal Working Fluids Through Introduction of Organic Quorum Sensing Inhibiting Molecules</i>	1-2PM	10	18

Student, Mentor, Project	Presentation Time	Room No.	Page No.
Mclean, Rory: Computer Science Jim Becker – Electrical and Computer Engineering <i>Identifying Misconceptions in Student Essay Responses Using Natural Language Processing Algorithms</i>	noon-1PM	8	19
Metcalf, Madeline: Agricultural Economics & Economics Sally Moyce – Nursing <i>A Health Fair for the Montana Latinx Population</i>	noon-1PM	6	42
Mezak, Curren: Earth Sciences David Varricchio – Earth Science, Paleontology <i>Fossil Egg Identification From Niger, Africa</i>	11AM-noon	2	42
Moody, Maya: Chemistry & Biochemistry Chelsea Heveran – Mechanical and Industrial Engineering <i>Gut Microbiome Influence on Bone Remodeling and Osteocyte Viability</i>	noon-1PM	5	43
Myer, Rory: Computer Science Brock LaMeres – Computer and Electrical Engineering <i>Protecting our Nation's Critical Infrastructure from Cyber Attacks</i>	noon-1PM	8	19
Nessan, Sydney & Toole, Faina: Microbiology & Immunology Steve Stowers – Microbiology and Immunology <i>Dual Neurotransmission Circuitry and Mechanisms Underlying Regulation of Aggressive Behavior</i>	2-3PM	12	7
Noble, Zoe: Physics Rufus Cone, Charles Thiel – Physics <i>Investigating transitions of transition-metal-doped materials at wavelengths close to 1550nm</i>	11AM-noon	4	43
Olson, Hunter: Earth Sciences David Varricchio – Earth Sciences <i>Fauna of the Meagher Limestone at Nixon Gulch</i>	11AM-noon	2	44
Oswald, Rowen: Physics Nicholas Borys – Physics <i>Integration of a Hanbury Brown Twiss Interferometer onto a Nano-Optical Microscope</i>	2-3PM	14	44
Pearson, Jack: English Christine Foreman, Markus Dieser – Department of Chemical and Biological Engineering, Center for Biofilm Engineering <i>Procedural Development and Utilization of Phenotype MicroArrays for Microbial Cells</i>	noon-1PM	7	45

Student, Mentor, Project	Presentation Time	Room No.	Page No.
Pirtz, Matalin: Chemical & Biological Engineering Connie Chang – Chemical and Biological Engineering <i>Encapsulation and Growth of Gastrointestinal Organoids in Matrigel</i>	1-2PM	9	20
Poty, Lauren: Chemical & Biological Engineering Joseph Seymour – Chemical & Biological Engineering <i>Characterization of Newtonian Fluids Using Rheology</i>	11AM-noon	1	20
Powell-Palm, Ian: English Gretchen Minton – Department of English <i>Henry V goes to Iraq: Contemporary reflections on Shakespeare's Henry V in American leadership and foreign policy</i>	noon-1PM	6	45
Pryor, Elliott: Computer Science John Sheppard – Computer Science <i>Finding Factor Architectures Using Maximum Spanning Trees for Factored Evolutionary Algorithms</i>	noon-1PM	8	20
Rector, Jesse: Electrical & Computer Engineering Anja Kunze – Electrical and Computer Engineering <i>Developing an ImageJ plugin for automated magnetic force estimations from particle tracking velocimetry</i>	noon-1PM	8	21
Redfield, Naomi: Animal & Range Sciences Shelly Hogan – McNair Scholars Program <i>Oral Micro-mineral Treatment in Yearling Beef Cattle to Decrease Morbidity and Increase Performance</i>	1-2PM	9	7
Rizzo, Gabrielle: Microbiology & Immunology Edward Schmidt – Microbiology & Immunology <i>Induction of an Antioxidant Response System by Genetic and Biochemical Manipulation of Keap1-Nrf2 Interaction</i>	2-3PM	13	7
Robbins, Rachael: Land Resources & Environmental Sciences Danielle Ulrich – Ecology <i>Variation in Seedling Stomatal Traits among 3 High Elevation Pine Species</i>	11AM-noon	3	8
Ross, Sydney: Chemical & Biological Engineering James Wilking – Chemical & Biological Engineering <i>Culturing "Unculturable" Bacteria</i>	1-2PM	10	21
Rowsey, Rylan: Chemistry & Biochemistry Robert Szilagyi, Nicholas Stadie – Chemistry & Biochemistry <i>Methane Interactions with Heteroatom-Doped Carbon Surfaces</i>	11AM-noon	1	46

Student, Mentor, Project	Presentation Time	Room No.	Page No.
Rux, Kylee: Civil Engineering Chelsea Heveran – Mechanical & Industrial Engineering <i>Does Oil-Contaminated Plastic Impair the Compressive Strength of Biomineralized Cement?</i>	1-2PM	9	22
Salazar, Raymond: Earth Sciences Madison Myers – Earth Sciences <i>A Petrographic and Geochemical Analysis of New Members of the Lava Creek Tuff, Yellowstone National Park</i>	11AM-noon	2	46
Shonka, Jack: Civil Engineering Anthony Hartshorn – Land Resources and Environmental Sciences <i>Are snow-mantled, burned slopes at greater risk of avalanching?</i>	2-3PM	14	22
Sihler, Emma: Microbiology & Immunology Vanessa Simonds – Community Health <i>Co-research, Citizen Science, and Water Quality: Adapting the Guardians of the Living Water Program</i>	2-3PM	12	46
Smith, Griffin: Mathematical Sciences Dominique Zosso, Scott McCalla – Mathematical Sciences <i>Group Formation and Cohesion of Janus Particles</i>	1-2PM	11	47
Stewart, Anna: Chemical & Biological Engineering Nicholas Stadie – Chemistry & Biochemistry <i>Synthesis of a Triply Periodic Minimal Surface Foam</i>	11AM-noon	1	23
Stouffer, Nathan: Computer Science Mike Wittie – Computer Science <i>Truncating Blockchains with Tangly Statistics</i>	noon-1PM	8	23
Strautmanis, Uve: Microbiology & Immunology Heidi Smith – Microbiology and Immunology <i>Investigation of Complete Groundwater Denitrification Utilizing an Environmentally Relevant Bacterial Co-culture</i>	2-3PM	13	47
Stroh, Bailey: Health & Human Development Cara Palmer – Psychology <i>Got Ghrelin?</i>	2-3PM	15	11
Tandberg, Madison: Computer Science Travis Peters – Computer Science <i>Analyzing Application-Layer Encryption in Bluetooth Devices: Auditing for Encryption</i>	noon-1PM	8	24

Student, Mentor, Project	Presentation Time	Room No.	Page No.
Taylor, Molly: Civil Engineering Huyen Bui – Center for Biofilm Engineering <i>Manipulation of Microbial Communities to Promote Algae Growth</i>	11AM-noon	3	24
Telford, Evan: Health & Human Development David Graham – Health and Human Development <i>The relationship between muscle contraction dynamics and balance recovery performance</i>	2-3PM	15	11
Teska, Christy: Chemical & Biological Engineering Christine Foreman, Markus Dieser – Chemical and Biological Engineering, Center for Biofilm Engineering <i>Investigation of Ice Nucleation Activity of Nano- and Microplastics in Snow and Rain</i>	1-2PM	10	24
Vanderbeek, Jack: Electrical & Computer Engineering Joseph Shaw, Michael Roddewig – Electrical and Computer Engineering <i>Researching Liquid Crystals for Electronic Polarization Control in FMCW Lidar</i>	noon-1PM	8	25
Waldum, Annie: Chemistry & Biochemistry Valérie Copié – Chemistry and Biochemistry <i>Understanding the impact of neurodegeneration on metabolism in Familial dysautonomia</i>	noon-1PM	5	48
Walsh, Susanna: Land Resources & Environmental Sciences Jack Brookshire – Land Resources & Environmental Sciences <i>Comparative analysis of root characteristics and soil microbial community dynamics across two bioenergy cropping systems on marginal land in SW Montana</i>	11AM-noon	3	8
Watt, Connie: Chemistry & Biochemistry Seth Pincus, Tami Peters – Chemistry and Biochemistry <i>Development of a Pseudovirus Assay to Measure SARS-CoV-2 Infection of Target Cells in Biosafety Level 2 Laboratories</i>	11AM-noon	1	48
Winslow, Michael: Physics Shannon Willoughby – Physics <i>The Interrelatedness of Two General Forms of Reasoning</i>	11AM-noon	4	49
Wishart, Joseph: Physics John Sample – Physics <i>X-Ray Detector Calibration for Impulsive Phase Rapid Energetic Solar Spectrometry (IMPRESS)</i>	11AM-noon	4	49

Student, Mentor, Project	Presentation Time	Room No.	Page No.
Xu, Xingzi: Electrical & Computer Engineering Dominique Zosso – Mathematical Sciences <i>Graph-based Geometric Data Analysis</i>	noon-1PM	8	25
Zuetell, Claire: Microbiology & Immunology Mensur Dlakic – Microbiology and Immunology <i>Cloning Sso7d and PFU Together to Make a More Efficient DNA Polymerase</i>	2-3PM	12	49