The Undergraduate Scholars Program and McNair Scholars Program Acknowledge the Following Sponsors and Partners for their Ongoing Support of Student Research:

American Indian Research Opportunities (AIRO)
Center for Biofilm Engineering
Montana INBRE Program
Montana Space Grant Consortium

College of Agriculture
College of Arts & Architecture
College of Business
College of Education, Health & Human Development
College of Engineering
College of Letters & Science
College of Nursing
Honors College

Office of the Provost
The Graduate School
Vice President for Research & Economic Development

MONTANA STATE UNIVERSITY
McNair Scholars Program

MONTANA STATE UNIVERSITY

MONTANA STATE UNIVERSITY
Undergraduate Scholars Program

Table of Contents

2021 Winter Student Research Celebration

Morning Poster Presentations

SUB Ballroom A

9:30AM – 12:30PM

Student, Mentor, Project	Poster Station
Kayla Kozisek: Chemical & Biological Engineering Mentor: Dr. Robin Gerlach – Chemical & Biological Engineering *Isolation of new algal and bacterial strains from high pH/high alkalinity habitats*	1
Payton Dupuis: Chemical & Biological Engineering Mentor: Cliff Rosen, Eben Estell – Chemistry & Biochemistry *Gene Set Enrichment Analysis of the Impact of Irisin on Osteoclast Function*	2
Jacob Michaletz: Chemical & Biological Engineering Mentor: Nicholas Stadie – Chemistry & Biochemistry *Real-time optical properties analysis for perovskite solar cell contact layer fabrication*	3
Jonathan Shikany: Chemical & Biological Engineering Mentor: Brent Peyton – Chemical & Biological Engineering *Enhancing growth rates and biodiesel potential in the diatom RGd-1*	4
Julian Fox: Chemical & Biological Engineering Mentor: Bree Cummins – Mathematical Sciences *Matching DSGRN network models to the Yeast Cell Cycle*	5
Lily Toussaint: Chemistry & Biochemistry Mentor: Valérie Copié – Chemistry & Biochemistry *Multi-Omics Data Integration and Multifactorial Analyses to Inform Selective Breeding of Cattle and Sheep*	6
Laina Hall: Chemistry & Biochemistry Mentor: Blake Wiedenheft – Microbiology & Immunology *CRISPR: how the bacterium Thermus thermophilus defends itself against infection*	7
Elijah Luciani: Mechanical & Industrial Engineering Mentor: Lewis Cox – Mechanical & Industrial Engineering *Stability, shelf-life, and properties of Two Stage Reactive Polymer Resins*	8

2021 Winter Student Research Celebration

Afternoon Poster Presentations

SUB Ballroom A

1:30 – 4:30PM

Student, Mentor, Project	Poster Station
Hanna Nyquist, Pushya Krishna: Chemical & Biological Engineering **Cell Biology and Neuroscience** Mentor: Blake Wiedenheft – Microbiology & Immunology *Extracellular cA3 Induced Bacterial Inhibition*	1
Rachel Anderson: Chemical & Biological Engineering Mentor: Ross Carlson – Chemical & Biological Engineering *Effects of Microbial Interactions on the Efficacy of Antimicrobial Agents*	2
Ryan Hinson: Chemical & Biological Engineering Mentor: Nicholas Stadie – Chemistry & Biochemistry *Gas Adsorption on Heteroatom Doped Porous Carbon Materials*	3
Tasnia Javin Nur: Chemistry & Biochemistry Mentor: Roberta Amendola, Douglas Cairns – Mechanical & Industrial Engineering *Design of a experimental fixture to measure ply-ply and tool-ply friction in carbon fiber reinforced thermoset prepregs*	4
Isabelle Gordon: Chemistry & Biochemistry Mentor: Nicholas Stadie – Chemistry & Biochemistry *Synthesis and Characterization of Phosphorus-Doped Silicon for Electrochemical Applications*	5
Kelli Ober: Chemistry & Biochemistry Mentor: Seth Pincus – Chemistry & Biochemistry *Measurement of the Antibody Response to Anti-HIV Immunoconjugates*	6
Connie Watt: Chemistry & Biochemistry Mentor: Seth Pincus, Tami Peters – Chemistry & Biochemistry *Development of a Pseudovirus Assay to Measure SARS-CoV-2 Infection of Target Cells in Biosafety Level 2 Laboratories*	7

2021 WINTER STUDENT RESEARCH CELEBRATION

GRADUATE ABSTRACTS

Sorted by Student Major

COLLEGE OF AGRICULTURE

Shishir Pandey, Noah Anderson: Microbiology & Immunology
Mentor: Blake Wiedenheft – Microbiology & Immunology
An Evolutionary Treatise Between CRISPR-mediated Defense and a Toxin-Antitoxin Addiction System

CRISPR (clustered regularly interspaced short palindromic repeats) and their associated proteins (Cas) are essential components of adaptive immune systems found in half of bacteria and most archaea. These immune systems rely on CRISPR RNA-guided nucleases to detect and destroy nucleic acids of invading mobile genetic elements, and thereby maintain genomic integrity. However, using profile hidden Markov models to query genomic and metagenomic databases, we identified a genetic fusion between Cas7, a core component of class 1 CRISPR systems, and an antitoxin called MntA. The MntA prevents the ribonuclease activity of an accompanying toxin (HepT) via AMPylation. The genetic fusion of Cas7 to MntA suggests a functional coupling between crRNA-guided target detection and MntA-HepT toxin-antitoxin (TA) systems. Here, we describe a series of experiments to determine the mechanism and evolutionary connection between CRISPR-Cas and the MntA-HepT TA systems.

Acknowledgements: NIH (1R35GM134867), M. J. Murdock Charitable Trust, Montana State University Agricultural Experiment Station (USDA NIFA).

COLLEGE OF ENGINEERING

Jubaer Ahmed: Mechanical & Industrial Engineering
Mentor: Nicholas Ward – Mechanical & Industrial Engineering
How Does Emotional Intelligence Predict Driving Behaviors Among Non-Commercial Drivers?

Dangerous driving behaviors have been found to be a leading contributor in vehicle crashes and fatalities with more than 2.7 million people injured and 36,560 people killed in the United States in 2018 (NHTSA, 2019). Drivers' emotions have been found to be among the leading contributors of dangerous driving behaviors. Emotions can be measured and understood through one's emotional intelligence (EI). Previous research has confirmed the relationship between EI and dangerous driving behaviors among general driving populations in limited scope. This study analyzed dangerous driving behaviors (e.g., aggressive driving) among non-commercial U.S. drivers. 615 U.S. drivers ages 18 to 65 (M=31.14, SD=11.15) with valid U.S. driver's licenses (non-commercial) participated in this study. Participants completed an online survey through Qualtrics that included the Trait Emotional Intelligence questionnaire (TEIQue-SF) to measure different dimensions of EI and the Dula Dangerous Driving Index (DDDI) and the Driving Behavior Questionnaire (DBQ) to measure dangerous driving behaviors. Furthermore, participants reported their demographic information including age, sex, and location. Correlation analysis revealed that significant associations exist between dangerous driving behaviors and EI. The emotionality component of EI was found to be the strongest predictor of dangerous driving behaviors. The findings conclude that participants with higher EI scores engaged in less risky driving behavior, resulting in fewer crashes and fatalities. Thus, promoting and improving EI may be useful in preventing risky driving among non-commercial drivers. Incorporating emotional intelligence education in driver's education, workplace training, and licensing procedure can be helpful to develop more safe drivers.

Acknowledgements: Jay Otto – CHSC, Annmarie McMahill – CHSC

Saptaparni Chanda: Mechanical & Industrial Engineering
Mentor: Dilpreet S Bajwa – Mechanical & Industrial Engineering
Silane Compatibilzation to Improve the Dispersion, Thermal and Mechanical Properties of Cellulose Nanocrystals in poly (ethylene oxide)

Cellulose nanocrystal (CNC) has excellent potential to be used as a reinforcement in polymeric composites because of their inherent biodegradability, universal accessibility, and superior mechanical properties. The most crucial challenge faced in the polymer composite production is to transfer the exceptional mechanical properties of the nanoparticles to the macroscale properties of the bulk composites and can be achieved by dispersing the nanoparticles effectively and uniformly in the polymer matrix. In this research, a safe, effective and ecofriendly surface modification technique was used to functionalize the surface hydroxyl groups of CNC via silane treatment. These modified CNCs were used as reinforcements to prepare poly (ethylene oxide) (PEO)/CNC composites. The composites were prepared using solvent casting method. The composite properties were evaluated using Fourier Transform Infrared Spectroscopy (FT-IR), Scanning Electron Microscopy (SEM), Thermo-Gravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC), and Dynamic Mechanical Analysis (DMA). The SEM micrographs demonstrated the improved dispersion behavior of the silane treated CNCs in the polymer matrix. Oxidative combustion of the composites containing silane treated CNCs showed enhanced thermal stability and promoted char formation. The (1:1) silane treated CNCs containing composites exhibited better crystallization ability, highest storage modulus, and lowest tan δ value compared to the other silane treated systems indicating improved dispersion of CNC. The polysiloxane network provided an efficient surface covering of the CNC molecules, imparting reduced surface polar characteristics and enhancing the overall mechanical properties of the composites.

Matthew Egloff: Mechanical & Industrial Engineering
Mentor: Roberta Amendola, Douglas Cairns– Mechanical & Industrial Engineering
Formability of Stretch-Broken Carbon Fiber

Supplanting ductile sheet metal with lighter and often stronger continuous carbon fiber composites has been inhibited by formability issues. Stretch-Broken Carbon Fiber (SBCF) addresses this by breaking continuous carbon fiber filaments into shorter segments. These segments slip in an uncured resin matrix, exhibiting pseudo-ductile deformation and, when cured, the strength of SBCF composites is comparable to continuous fiber. The deformation mechanism and techniques to control this process differ from those in sheet metal forming. Differences in the deformation mechanisms indicate the need for new methods and techniques to achieve forming and to develop predictive models. This research focused on the development of a new testing unit to evaluate carbon fiber reinforced polymers forming behavior based on established methodologies used for characterizing sheet metal forming. Data indicates that temperature, forming rate, mean fiber length, and state of stress have significant effects on forming. Results indicate that SBCF composite materials possess increased formability characteristics when compared to traditional continuous carbon fibers.

Acknowledgements: Dilpreet Bajwa – Mechanical & Industrial Engineering

Venkata Krisshna: Mechanical & Industrial Engineering
Mentor: Mark Owkes – Mechanical & Industrial Engineering
Simulating electrolyte jets in an electric field

An electrolyte (like sodium chloride) can conduct electricity when dissolved in water. The dissolved electrolyte forms ions that are positively and negatively charged and are uniformly dispersed in the solvent to render an electrically neutral solution. However, when placed in an electric field, the ions move to create a charge distribution. This charge distribution consisting of both positive and negative ions generates both repulsive and attractive electrical forces in the liquid. This phenomenon of ion migration plays an important role in the studies conducted by an experimental facility in the University of Washington where a neutral electrolytic solution is injected as a single slow moving jet through a grounded nozzle into a region with an electric field. Non-axisymmetric whipping instabilities characterized by large scale violent, chaotic and quick whips are observed in the jet. In this project, the system is numerically modeled using a multiphase electrohydrodynamic formulation that includes a model for ion transport (using the Poisson-Nernst-Planck equations) with an aim to investigate the origin and propagation of the instabilities in the jet. The physical process of ion migration, which is a challenging measurement to obtain experimentally, can be conveniently studied in real-time using the computer simulations. Computational studies of this process in such detail will help gain an in-depth insight into the complex physical phenomena that occur in electrolytic solutions.

Venkata Krisshna: Mechanical & Industrial Engineering
Mentor: Mark Owkes – Mechanical & Industrial Engineering
Simulating rotary atomization with electrohydrodynamic effects

Automotive paint shops have a significant impact on the process of manufacturing vehicles, accounting for up to 70% of the total energy costs, 50% of the electricity demand, and 80% of the environmental concerns in the manufacturing facility. Electrostatic rotary bell atomizers are extensively used as paint applicators in the automotive industry. The device atomizes paint, i.e., generates micrometer sized droplets, with the help of a nozzle that rotates at speeds of 20-80 kRPM. In most setups, the paint is electrically charged and a background electric field is applied between the nozzle and the target surface to increase the transfer efficiency. The atomization process affects the droplet size and droplet charge distributions which subsequently control the transfer efficiency of paint to the surface and surface finish quality. Optimal operating parameters are often

obtained from expensive trial-and-error methods. In this work, atomization is computationally simulated using solver that includes models for 1) incompressible fluid dynamics, 2) surface tension force for multiphase flows, 3) centrifugal and Coriolis forces due to the rotating nozzle, 4) electric forces due to the charging of paint and 5) gravity. This cost-effective method of simulating multiphase electrohydrodynamic atomization enables the extraction of post-atomization statistics such as the droplet size and droplet charge distribution which are otherwise challenging to obtain experimentally. This data can provide the initial conditions of position, size, velocity and charge density to a Lagrangian flow solver that predicts the motion of atomized droplets towards the target surface.

Dalton Nold: Mechanical & Industrial Engineering
Mentor: Dilpreet Bajwa – Mechanical & Industrial Engineering
Stretch Broken Carbon Fiber

Continuous carbon fiber is a remarkable engineered material known for its strength, stiffness, and lightweight nature. A major problem with continuous carbon fiber is that it is not versatile in forming deep drawn geometries, which require a lot more convoluted manufacturing technique. To combat this issue, a discontinuous carbon fiber type called stretch broken carbon fiber (SBCF), is able to form under complex geometries while maintaining similar strengths and stiffness to that of continuous fiber. Montana State University has been able to design a novel process to manufacture their own version of SBCF. Currently, research is being conducted to determine how a single carbon fiber tow that has been impregnated with resin reacts to forming loads at high and low temperatures. The data obtained from this study is being compared to that of continuous fiber as well as SBCF manufactured by Hexcel Corporation.

Acknowledgements: Douglas Cairns – Mechanical & Industrial Engineering, Roberta Amendola – Mechanical & Industrial Engineering, Cecily Ryan – Mechanical & Industrial Engineering

Riad Morshed Rezaul: Mechanical & Industrial Engineering
Mentor: Cecily Ryan – Mechanical & Industrial Engineering
Stretch Broken Carbon Fiber for Primary Aircraft Structure

Carbon fiber reinforced polymer composites have been used extensively in aerospace due to their outstanding strength-to-weight ratios and stiffness-to-weight ratios. Both continuous and discontinuous carbon fibers are used in the composite manufacturing process. When manufacturing components with a complex geometry, discontinuous carbon fibers can offer superior formability compared to continuous carbon fibers. Stretch broken carbon fiber (SBCF) is a type of discontinuous carbon fiber generated by stretch breaking fibers at their natural flaws, resulting in fibers with a shorter length than continuous fibers. Since an SBCF tow contains little to no continuous fibers, overall tow tenacity is reduced. In this project, a thin homogeneous coating (sizing) is applied to increase the tenacity of the SBCF tows to improve handleability and processing. Sizing is commonly applied to carbon fiber tows; in this application, it is expected to provide increased back-tension ability and improved formability to the SBCF tows. Montana State University has been successful in manufacturing sized SBCF (MSU SBCF) tows. To evaluate the back-tension ability and formability of the MSU SBCF tows, a temperature-controlled tenacity test setup has been designed and fabricated. SBCF tow tenacity data at room and elevated temperatures were compared to continuous carbon fiber and previously produced SBCF with a longer mean fiber length (Hexcel Corporation).

Acknowledgements: Roberta Amendola – Mechanical & Industrial Engineering, Dilpreet Bajwa – Mechanical & Industrial Engineering

Yoni Shchemelinin: Mechanical & Industrial Engineering
Mentor: Amendola Roberta – Mechanical & Industrial Engineering
Hydraulic bulge testing to compare formability of continuous and stretch broken carbon fiber prepreg laminates

Demand for high-performance, low-density materials is leading to an increase in the use of carbon fiber reinforced polymers (CFRPs). Continuous fiber composite possesses a high strength-to-weight ratio, but the low formability of this material limits its wider adoption. By comparison, Stretch Broken Carbon Fiber (SBCF) is a form of carbon fiber characterized by the randomized breaking of aligned fibers at inherent flaw points in a tow. This manufacturing form of collimated carbon fiber fragments creates a material that can exhibit pseudo-plastic deformation by allowing fibers to slide past one another. This can potentially allow for the use of traditional forming such as the low-cost, well established manufacturing techniques of stamping and press forming commonly used for sheet metals. To investigate the formability of SBCF and compare it to continuous fiber, a hydraulic bulge tester was used to form uncured carbon fiber prepreg using continuous and SBCF Hexcel IM-7 fiber in a Huntsman RDM 2019-053 resin matrix. Initial results show greater formability with SBCF, with larger strains at lower peak pressures compared to continuous fiber. In addition, strain in SBCF demonstrated axis-symmetry with a failure mode at the bulge apex, whereas continuous fiber showed dissymmetry in the strain behavior with boundary clamped area slippage failure.

Acknowledgements: Jared Nelson – Keene State College

COLLEGE OF LETTERS & SCIENCE

Isabelle Gordon: Chemistry & Biochemistry
Mentor: Nicholas Stadie – Chemistry & Biochemistry
Synthesis and Characterization of Phosphorus-Doped Silicon for Electrochemical Applications

Phosphorus-doped silicon has been reported to exhibit improved cycling stability and/or higher capacity retention than pure silicon as the anode in lithium-ion batteries. However, crystallite size and particle morphology are difficult to decouple from compositional tuning during chemical modification. In this work, we explore direct solid-state routes to phosphorus doping of silicon powders relevant to electrochemical applications. A wide range of compositions are assessed, from 0.01-3.0 at% P, as well as a wide range of silicon starting materials of varying crystallinity, particle size, and particle morphology. Successful incorporation of phosphorus into the silicon lattice is best confirmed by X-ray diffraction; the Si (111) reflection shifts to higher angles roughly consistent with the known lattice contraction of 0.002 Å per 1 at% phosphorus. The addition of phosphorus to Si nanoparticles (50-100 nm) in the high doping regime causes grain coarsening and catalyzes an increase in crystallinity. On the other hand, dilute doping of phosphorus can be carried out without a great alteration of the nanoparticulate morphology. The opposite effect occurs for very large microparticles (>10 μm) whereby doping is concomitant with a disruption of the crystal lattice and reduction of crystallite size. These effects are borne out in both the electrochemical stability over long-term cycling in a lithium-ion half-cell as well as in the thermal stability under high-temperature decomposition. By comparison across a wide range of pure and P-doped materials of varying particle and crystallite size, the independent effects of doping and structure on thermal and electrochemical stability are decoupled.

Acknowledgements: Richard Jow – U.S. Army Research Laboratory

Tasnia Javin Nur: Chemistry & Biochemistry
Mentor: Roberta Amendola, Douglas Cairns – Mechanical & Industrial Engineering
Design of a experimental fixture to measure ply-ply and tool-ply friction in carbon fiber reinforced thermoset prepregs

There exist many challenges in the design and manufacture of complex geometries using carbon fiber reinforced composite prepregs. Frictional phenomena occur between the tool and the heated laminate and also between subsequent prepreg plies within a laminate during forming stage of these composite parts. Research has reported that the constrains imposed by friction during forming generates major defects, which later translates into the final component. As a result, characterization of tool/ply and ply/ply friction during composite forming is significant to achieve optimum quality and manufacturing process of complex shapes. Since there is no ASTM test standard available for frictional measurement of composites, most of the research are based on different custom built test fixtures and non-standard test methods. An experimental fixture has been designed at MSU and currently under construction to measure inter-ply and tool-ply friction of both continuous vs. stretch broken carbon fiber composite prepregs. The test fixture is designed to be fitted in Mark-10 universal test machine and the test method has been developed based on preliminary experimental observations. Both the material properties (e.g. fiber orientation, resin architecture, resin viscosity) and the forming process parameters (e.g. temperature, forming rate and normal pressure) were taken into account to accurately simulate the frictional phenomena that the material under study encounters during an actual forming operation. The fixture is expected to enable accurate quantification of frictional properties and thus provide improved knowledge in the area of composite friction.

2021 WINTER STUDENT RESEARCH CELEBRATION

UNDERGRADUATE ABSTRACTS

Sorted by Student Major

COLLEGE OF AGRICULTURE

Alison Fitzpatrick: Microbiology & Immunology
Mentor: Ed Schmidt – Microbiology & Immunology
Polysome Profiling – How Translation is Altered to Accommodate Metabolic Methionine Use

This research aims to determine whether protein synthesis is altered in mouse livers lacking both thioredoxin reductase-1 and glutathione reductase ("TR/GR-null") to re-prioritize Methionine (Met) and Cysteine (Cys) for their abnormal requirement of Met for critical homeostatic pathways.
To analyze protein synthesis rates, liver cytosol was spun down into equal-volume fractions by density (the denser RNA fractions having more attached ribosomes). RNA was isolated and run on a gel, from which overall concentration of RNA per fraction was determined.
Then, to analyze the differences in translation rates between Met+Cys high and low (1-2 amino acids) mRNAs, fitting genes were identified, primer pairs were designed, and cDNA was made from the isolated RNA fractions and ran in rtPCR. This rtPCR data will then be analyzed to identify whether/how the polysome curve differs between WT and TR/GR-null livers with Met/Cys high and low genes.
Understanding whether and how translation is altered to accommodate metabolic use of Met fits within the Schmidt lab's overall goal of understanding how TR/GR-null mice survive without enzymes thought to provide the only source of disulfide reducing power. This can inform therapeutic approaches for combatting related clinical pathologies such as inflammatory diseases, cancers, and toxic exposures.

Acknowledgements: Justin Prigge – Microbiology and Immunology, Undergraduate Scholars Program (USP)

Ava Graham: Microbiology & Immunology
Mentor: Blake Wiedenheft – Microbiology & Immunology
Secondary Regulation of Type III CRISPR Systems by Cyclic Oligonucleotide Interactions via Riboswitches

Immunity in organisms does not arise from a uniform system; rather immunity is complex and varies greatly across species. In prokaryotes, the CRISPR (Clusters of Regularly Interspaced Short Palindromic Repeats) adaptive immune system protects the host cell against invading viruses. The genomes of these organisms contain spacers of nucleotide sequences from past viral infections which serves as a memory of previous invaders and a template for the defense against them. Upon transcription of these spacer sequences, the binding of CRISPR-derived RNA (crRNA) with CRISPR associated (Cas) proteins produces a functional complex able to target complementary viral RNA sequences for degradation. Binding of the CRISPR-Cas complex with target RNA results in the production of cyclic nucleotide signal molecules that further activate the ribonuclease activity of associated proteins. It is hypothesized that the cyclic oligonucleotide signal molecules synthesized during CRISPR-Cas interference are also involved in a secondary pathway to directly regulate RNA in the cell via riboswitches. An electrophoretic mobility shift assay (EMSA) following the reaction of radioactive-labelled cyclic oligoadenylates with RNA from human cells, mouse brain cells, and prokaryote cells allows for the analysis of riboswitch activity. For future use in the EMSA assay, prokaryotic RNA from Thermus thermophilus and Sulfolobus solfataricus, thermophiles known to contain cyclic oligoadenylate producing-Type III CRISPR systems, was extracted from cultures grown up to log phase using

phenol-chloroform RNA extraction methods. Results gathered will provide an increased understanding of how the regulatory functions of cyclic oligonucleotides contribute to CRISPR immunity.

Acknowledgements: Laina Hall – Microbiology & Cell Biology

Emory Hoelscher-Hull: Microbiology & Immunology
Mentor: Mari Eggers – Microbiology & Immunology
Identifying Groundwater contaminants in the Belt Watershed

The aim of this project was to identify the prevalence of water contaminants in wells, streams and springs in the Belt watershed (10030105) in Cascade county, Montana in order to educate residents of contaminants of concern. The Safe Drinking Water act and related regulations do not apply to private drinking water, meaning there is no federal or municipal oversight of these resources. There are many sources of groundwater contamination in Montana, including natural geologic features and anthropogenic contamination from mining and agriculture. Well and stream water quality data were downloaded for the Belt watershed (at the Hydrologic Unit Code 8 level) from the Montana Ground Water Information Center. Cumulative risk for lifetime consumption was calculated for each water source by summing the risk quotients of contaminants with health standards. Excel was used for all calculations; R Studio was used to generate graphs. The groundwater contaminants of main concern in the Belt watershed (10030105) are manganese, nitrate, arsenic, strontium and TDS. The average cumulative risk in the Belt watershed is 2.487. Cumulative risk values above 1.00 represent unacceptable risk for lifetime consumption, 58% of wells in the belt watershed exceed this standard, meaning most wells in the region are unsafe for lifetime consumption. These contaminants can cause elevated risk of health conditions including memory loss, bone diseases, circulatory issues, and some types of cancer. Conveying this information to the public will help emphasize the importance of testing private drinking water and inform residents of the risks associated with common groundwater contaminants.

Kelsay Jensen: Microbiology & Immunology
Mentor: Margaret Eggers – Microbiology & Immunology
Contaminant Levels and Cumulative Risk in The Upper Missouri Dearborne Watershed Sub-Basin

Water is a precious and dwindling resource. This research investigates the water quality of wells and streams in the Upper Missouri Dearborne watershed sub-basin to assess contaminant levels in comparison to health standards, and calculate cumulative health risk from lifetime consumption. This watershed sub-basin is part of the Missouri Sun Smith Watershed that is located in Cascade County in Montana. Well and stream data was downloaded for the Upper Missouri Dearborne watershed (at the Hydrologic Unit Code 8 level) from the Montana Ground Water Information Center. Poor data, including the ½ values of the "non-detect" values that were greater than 10% of the applicable health standard, and data that was collected for lead, beryllium, and thallium were removed. Cumulative risk for lifetime consumption was calculated for each water source by summing the risk quotients of contaminants with health standards. Excel was used for all calculations. R Studio was used to generate graphs based on the quality data. It was found that there were high levels of primary drinking water contaminants manganese, strontium, cadmium, and nitrates in the water. The high levels of these contaminants pose health risks. There were also high levels of secondary contaminants, including total dissolved solids, sulfates, and iron. This research will be available on the Montana State University Well Educated program, and will hopefully be used as a resource for residents of this watershed, so they know what to test their well water for and are aware of potential health risks from consuming contaminated groundwater.

Pushya Krishna: Microbiology & Immunology
Mentor: Blake Wiedenheft – Microbiology & Immunology
Identification of Subtype- and Taxonomy-specific CRISPR leader motifs

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, resulting in a chronological record of previously encountered foreign genetic elements. The Doudna lab showed that in the type I-E CRISPR locus of Escherichia coli (K12), the Integration Host Factor (IHF) binds to and kinks the "leader" end of the CRISPR, creating a horseshoe-shaped structure that stabilizes the Cas1-2 integrase complex. IHF-induced kinking of the "leader" DNA facilitates polarized evolution by trapping the Cas1-2 integration complex in the curve of the horseshoe. Additionally, DNA kinking recruits an upstream-sequence motif (UM) that specifically interacts with residues on one lobe of the Cas1-2 integration complex. A recent bioinformatics analysis performed by a team of scientists in Dr. Wiedenheft's lab demonstrated that IHF-dependent CRISPR integration mechanisms are found within subsets of I-E as well as I-F, I-C and II-C leaders. Furthermore, the composition of IHF-associated UM's was found to vary significantly across subtypes. Importantly however, approximately 65% of leaders analyzed do not possess an IHF binding site. This lead to the hypothesis that leaders that do not display evidence of an IHF-mediated mechanism possess alternate, conserved motifs that facilitate polarized spacer integration. To test this hypothesis, I repurposed previously established bioinformatic pipelines to identify novel CRISPR leader motifs.

Acknowledgements: Murat Buyukyoruk – Microbiology and Immunology, Andrew Santiago-Frangos – Microbiology and Immunology, Undergraduate Scholars Program (USP)

Zachary Mayne: Microbiology & Immunology
Mentor: Christa Merzdorf – Microbiology & Immunology
Heightened Glycerol Permeability in the Dorsal Mesoderm is Required for Convergent Extension in Notochord Formation

The apq3b gene codes for an aquaglyceroporin, a transmembrane channel which facilitates the permeability of cells to glycerol 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 involute and undergo convergent extension, whereby they form into a long, thin band of tissue known as the notochord. Injecting morpholino oligonucleotides to knock down Aqp3b protein translation in the dorsal mesoderm cells interferes with convergent extension. My experiments are designed to assess whether it is the water or glycerol permeability of Aqp3b that is necessary for convergent extension. To that end, I inject the dorsal mesoderm cells of Xenopus laevis embryos with morpholino oligonucleotides targeting aqp3b plus exogenous mRNAs to replace aqp3b. I then cut out the dorsal marginal zone at early gastrula stage 10.5 and assess convergent extension in the resulting explants. I have hypothesized that it is the glycerol-permeability function of aqp3b rather than the water-permeability function which is necessary for convergent extension. My data show that aqp9, another aquaglyceroporin, rescued convergent extension after aqp3b was knocked down, while aqp1, a strict aquaporin (permeable only to water), did not. These results are consistent with my hypothesis. I will continue to collect convergent-extension data on alternative aquaglyceroporins and strict aquaporins to solidify this finding.

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

Cecelia McAfee: Land Resources & Environmental Sciences
Mentor: Barbara Keith, William Dyer – Land Resources & Environmental Sciences, Plant Sciences & Plant Pathology
Transcriptomic Research of Multiple Herbicide Resistant Lines of Avena fatua L.

Avena fatua L., commonly referred to as wild oat, is a common grass weed that thrives among cereal grains, decreasing yields and crop quality. In 1990, triallate resistant wild oats were identified after almost two decades of annual treatment on the Fairfield Bench, Montana. In 2006 and 2018, these plants also showed resistance to difenzoquat, each generation developing resistance to more herbicides (Keith et al. 2014). These generations of wild oat are now resistant to at least five additional modes of action, including glyphosate. Years of collaborative study have identified multiple genes as factors of herbicide resistance in several grass weeds. Glutathione S-transferases (GSTs) play an important role in plant stress response. Plants can respond to chronic stress by overexpressing GSTs, and that is exactly what multiple herbicide resistant (MHR) wild oats showed in comparison to sensitive controls (HS1), even in absence of herbicide treatment (Keith et al. 2017). The transcriptome study also identified a number of other stress-induced genes that are differentially expressed between MHR and HS1, indicating that MHR plants are 'primed' to respond to many biotic and abiotic challenges, likely conferring resistance to multiple herbicide families. Using virus induced gene silencing (VIGs) technology, my research will work to knock down or knock out transcripts of genes differentially expressed between MHR and HS1, and then assess these plants for changes in herbicide efficacy. I will be assessing these plants for changes in herbicide efficacy to assist future study pertaining to the management and treatment of persistent invasive plants.

Acknowledgements: Undergraduate Scholars Program (USP)

Gwendolyn Mueller: Microbiology & Immunology
Mentor: Susy Kohout – Microbiology & Immunology
Breaking Voltage-Sensing Phosphatase Dimers

The voltage sensing phosphatase (VSP) is an enzyme which performs catalytic activity in response to changes in membrane potential. It is the only known enzyme to have a direct link between voltage and catalytic activity. VSP is conserved in many organisms, and has the ability to change intracellular phosphatidylinositol phosphate (PIP) concentrations (Murata et al., 2005), which have a wide array of physiological effects such as cell growth and synaptic regulation. The Kohout lab found that VSP dimerizes in a concentration dependent manner (Rayaprolu et al., 2018). However, the functional relevance of VSP dimerization is still unknown. In order to explore this, VSP was altered using mutagenesis. Then, the mutated VSPs are tested using coimmunoprecipitation (coIP) and Western blots to determine if the alteration has broken the protein interaction, resulting in two VSP monomers, or if the interaction is intact and VSP remains in dimer form. This is accomplished through the use of two different epitope tags on either VSP subunit, allowing for the selection and identification of either subunit. The dimers and monomers can be used in subsequent experiments to further explore the functional difference between VSP monomers and dimers.

Acknowledgements: Heini Miettinen-Granger – Microbiology & Immunology, Undergraduate Scholars Program (USP)

Reed Noyd: Microbiology & Immunology
Mentor: Colin Miller – Microbiology & Immunology
Investigating the role of Thioredoxin Reductase-1 on liver health in a surgical model of cholestatic liver disease

The Schmidt laboratory studies the redox biology of the nicotinamide adenine dinucleotide phosphate (NADPH) – dependent disulfide reductases, thioredoxin reductase-1 (TrxR1) and glutathione reductase (Gsr). The reducing power they provide is critical for maintaining the reduced intracellular environment and for synthesizing DNA precursors. The lab has created mice that lack the gene for thioredoxin reductase 1 (TrxR1), glutathione reductase (Gsr), and thioredoxin 1 (Txn1) in hepatocytes, which constitute ~95% of the mass of the liver. The lab uses different combinations of these alleles as genetic models for understanding the physiological role of the disulfide reductase systems in health and disease. The first objective of this project is to use a cholestatic liver disease model, bile duct ligation (BDL) injury, to determine how these systems influence the degree of pathology in mice.

Mice undergo a BDL surgery, which mimics conditions of cholestatic liver disease. The mice are harvested and quantification of resilience to cholestatic liver disease will be assessed. Based on my previous investigations in the lab, mice with TrxR1-null livers demonstrate resistance to BDL-injury, suggesting that the absence of TrxR1 could decrease morbidity in cholestatic liver disease. In addition, it has been observed that mice lacking Trx1 and TrxR1 in hepatocytes have increased resistance to a BDL surgery. To further investigate the genetic basis of this protection, combinations of the TrxR1-, Trx1-, and Gsr-null alleles will continue be tested in livers with BDL injury. I hypothesize that TrxR and Trx1 promote a more damaging inflammatory response to cholestatic conditions.

Acknowledgements: Undergraduate Scholars Program (USP)

Lyra Reynolds: Land Resources & Environmental Sciences
Mentor: Jean Dixon – Earth Sciences
Post-Fire Fallout: Measuring Fallout Radionuclides to Understand Soil Erosion in a Burn Scar

The 2020 Bridger Foothills Fire raged for over a month, burning > 8,000 acres just 15 miles outside the city of Bozeman. A year later, the landscape is still torched, yet with sprouts of green across the soil. Wildfire is widely recognized to change erosion dynamics, especially in mountain landscapes, and the purpose of this investigation was to quantify soil transport one year following the Bridger fire. I used topographic analysis, field observations, and isotopic tracers of sediment movement to compare erosion on slopes that experienced high-burn intensity or were unburnt. Isotopic measurements focused on Fallout Radionuclides (FRNs, Cs-136 and Pb-210), isotopes with known decay rates that accumulate in surface soils and thus relate to soil age and disturbance to the surface. I hypothesize that the areas of high burn intensity will have higher erosion, characterized by lower fallout radionuclide inventories, as compared to the unburnt soils. To measure the erosion, the top 12.5 centimeters of soil were collected across three high intensity sites and one unburnt site. Samples were dried and analyzed in Broad Energy Germanium Detectors that record the natural gamma radiation in the samples. I found that FRN inventories in the high-intensity burn, were not consistently lower than the unburnt area as hypothesized. However, high-intensity soils showed significantly greater variance in Cs-137 inventories at each site, consistent with greater local disturbances.

Acknowledgements: Undergraduate Scholars Program (USP)

Sonja Ring: Microbiology & Immunology
Mentor: Margaret Eggers – Microbiology & Immunology
Montana Risk Category Study

Risk categories are the key component into organizing restaurants based off of their food processes. This study goes over Montana Risk Categories by looking at the difference/similarities between counties, across restaurants, in license subtypes across Montana, and across risk categories (1,2,3, and 4), with 4 being the highest risk for food safety issues. The study was designed to help the Food and Consumer Safety in the Montana Department of Public Health and Human Services in determining which counties need help and how they can best provide assistance. All of the data were collected from the Montana public license, looking specifically at food establishments with licenses up until May 2021. The results showed that most of the county sanitarians were not adding the risk category information onto the licensing website. The largest license subtype was the retail restaurant food establishments; for example, McDonald's or McKenzie River Pizza fall into this category. The largest risk categories were 2 and 3 (16%) with 1 (14%) following right behind. Lastly, the smallest category, to be expected, is risk category 4: establishments serving a highly susceptible population, such as a hospital food service. Given the limitation that not all counties entered the risk category information into the licensing website, it was difficult to make conclusions. After investigating with a few of the counties, it looked like they have a different risk category data base while some do not have the time to correctly enter this information. More risk category information is

critical to establish where all the food establishments are grouped, determine the largest category in license subtypes, which counties need help, and how the Food and Consumer Safety Division can help.

Edward Shaw: Land Resources & Environmental Sciences
Mentor: Wan-Yuan Kuo – Health & Human Development
Senegalese Indigenous Farm to School System: Establishing a food manufacturing protocol and assessing participatory action teaching approaches

In the 2020 Senegal Annual Country Report, the World Food Program called for "School feeding interventions to enhance access to education, nutrition activities to fight malnutrition and micronutrient deficiencies, and strengthening of smallholder farmers' resilience and partners' capacities to tackle the root causes of food insecurity and malnutrition" Team Promoting Agricultural Transformation Holistically (PATH) has collaborated with smallholder women farmers and schools in Senegal to address these goals. Since 2018, team PATH and the women farmers in the community of Ndangane have co-developed and begun commercializing Bonbon Bouye, a children's nutrition bar utilizing Senegal's Indigenous fruit and local crops. As a continuation of previously conducted work, this study addresses the questions: (1) How to establish a manufacturing protocol for Indigenous value-added products that international food safety and quality standards, and (2) How to enhance student interest and support of local Indigenous foods? Since September of 2021, team PATH has collaborated with a team of Montana State Chemical Engineer students and the African Development Bank to co-develop a post-harvest processing and community center in collaborating community of Ndangane, Senegal. Additionally, the development of a facility-specific Hazards Analysis and Critical Control Points (HACCP) plan has been initiated, alongside the delivery of comprehensive surveys to assess the needs and concerns of collaborating communities. The outcomes of food safety risk assessment, processing facility design, and community development initiatives conducted since September 2021 will be reported in the presentation.

Acknowledgements: Olivia Schwintek – Department Health and Human Development, Sage Stevens – Microbiology and Immunology/ Ecology, Undergraduate Scholars Program (USP)

Sarah Warnke: Microbiology & Immunology
Mentor: Mari Eggers – Microbiology & Immunology
Cumulative Risk Assessment of Exposure to Well and Stream Water Contaminants, Sun River, Montana

Lifetime consumption of water with unsafe levels of certain contaminants can negatively impact one's health. The levels of these stream and groundwater contaminants in specific population areas are not commonly known. The goal of this research project is to assess and create awareness of the cumulative risk from consuming well and stream water in the Sun River watershed, Montana.
The water quality data were collected from multiple sources by the Ground Water Information Center (GWIC), which is managed by the Montana Bureau of Mines and Geology. Data downloaded from GWIC were analyzed using Excel and visualized using R Studio. The Centers for Disease Control's "ToxFAQs" reports were used to identify the health effects of the contaminants which had high levels in relation to health standards.
57.35% of the wells had cumulative risk values over the safe level for drinking water over a lifetime. Many contaminants were above the recommended safe level, such as: arsenic and nitrate. Exposure to these contaminants over an extended period can result in many negative health effects including higher rates of cancer, liver damage, diabetes, methemoglobinemia, etc.
Up to date and accessible information on the water quality is important to the health and wellbeing of a community. Knowing the health effects of water contaminants is essential to ensure a community is aware of any issues. Safe drinking water is essential to life and the contaminants in the Sun River watershed, Montana, are ones that are common throughout the state.

COLLEGE OF ARTS & ARCHITECTURE

Nicole Anderson: Music Education
Mentor: Gregory Young – Music
Between Music and Mental Health: A Look Into the Trauma of a Music Education Major

Participation in music is often thought of as a way of healing the human body, mind, and soul. Many use it as an escape from daily life. There have been many studies on engagement in music as a coping mechanism for depression, anxiety and trauma. The field of music therapy has played a large role in bringing to light the power of musical healing. Through my own experiences, including a major tragedy, I have begun to wonder how music practice and performance may be different for those who study music for a career or degree. Sometimes preparing music for performance worsens depression and sets the healing process back. I will create a written resource and a musical composition that encompass a wide variety of perspectives on the study of music for those who may be struggling with trauma and the resulting depression and anxiety.

Jenaya Burns: Music
Mentor: Greg Young – Music
Correlations between self-compassion and music : Finding ways to relieve stress in undergraduate music majors

Being a music major comes with its own level of stress. Music students are required to take the core music classes of music theory, aural perception, applied lessons, keyboard skills and ensembles. With other required classes, this can lead to a big workload causing a lot of stress for the student. The concept of self-compassion could help manage the stress that comes with being a music student. Self Compassion is a Buddhist philosophy that was conceptualized in Western Society by Kristian Neff. Self-compassion has six main aspects; three positive and three negative. The positive aspects are mindfulness, common humanity, and self-kindness; the negative aspects are overidentification, isolation, and self-judgement. Using the positive aspects of Self-Compassion can help music students deal with isolation and know that struggling with practicing or performing is normal. Using the negative aspects when practicing or performing could hinder the growth of the music student, while using the positive aspects may help students realize they can make mistakes and learn from them. My hypothesis is that students with greater self-compassion will have a better time managing stress when it comes to the many required music classes as well as practicing. A Qualtrics survey will be sent out to undergraduate Bachelor of Arts in Music and Bachelor of Music Education music students at a public university.

Acknowledgements: McNair Scholars Program

Caleb Carr: Business
Mentor: Greg Young – Music
The value of a BA Music degree: Evaluation of music industry careers using labor statistics

Attending college should be treated as an investment in higher paying employment opportunities. For those interested in studying music at Montana State University, three degrees are offered: Bachelor of Music Education (BME), Bachelor of Arts in Music Technology (BMT), and Bachelor of Arts in Music (BA). Music education and music technology prepare students with job-specific skills, but a problem that BA graduates may face is what to do with their degree. Performing, composing, and directing are three potential careers for a music major. To gain an understanding of these musical careers, a financial analysis will be done using data gathered from the Bureau of Labor Statistics (BLS). The BLS website has employment statistics and occupational outlook handbooks that forecast the status of these careers. A flaw with these statistics is that some data is missing. 38.5% of musicians and singers are self-employed, and 20% of composers and directors are self-employed, resulting in nonreporting to

BLS statistics. With these holes in the data, how accurate is BLS data and job outlook handbooks? The product of this research will be a handbook written to accurately forecast perspectives into musical careers. Insights into areas with the highest concentration of jobs and highest salaries will be provided, as well as suggestions for other careers and potential pairings of non-musical majors and minors. The goal is to assist those wanting to pursue a BA in Music with decisions about the value of this investment.

Samantha DeMars: Music Education
Mentor: Gregory Young – Music
Application of IEFA by Music Educators in the Bozeman

IEFA, or Indian Education for All, was implemented in Montana schools in 1999 with the declared policy "to recognize the distinct and unique cultural heritage of American Indians and to be committed in its educational goals to the preservation of their cultural heritage." However, it is unknown how many schools are actively incorporating this into their curriculum. In July 2021, the Yellow Kidney vs. Montana lawsuit was filed by eight tribes and eighteen individual student plaintiffs for Montana's failure to enforce IEFA in public schools. The purpose of this research is to find out how music educators in Bozeman are incorporating Native American education into their curriculum and gain insight into tribal members' perspectives and experiences. The responses will then be compiled to reflect the current status of IEFA application and address how educators can move forward to effectively and respectfully incorporate Native American education into their curriculum.

Laura Detrick: Music
Mentor: Greg Young, Eric Funk – Music
Eric Funk, Composer, Conductor, Producer, Professor—an Aural Biography

There resides within Montana a composer whose music and work are quite well known. Yet, not much is known about Eric Funk, the man himself: the experiences that lead to the music—how the music, in fact, expresses his life. The purpose of this study is to capture and make this information more readily available. In doing so, his music would gain listeners' greater understanding, clarifying communicated thought. For fellow composers and students, learning about the motivations and challenges in the compositional process is informative and encouraging. Interviews with Mr. Funk, the study of his music scores and recordings, surveying of artifacts connected with his life, and the review of research compiled by former MSU student Peter Pomajevich are all synthesized together to present a new form of biography, as told through musical description, bringing to light the life and times of Eric Funk. The resulting book (which may also become available digitally with links to samples of his music) is written with musicians and historians in mind, whether they already have some knowledge of his work or may benefit from the new discovery. The music of Eric Funk is both trailblazing and influential. Readers' lives and musical practices and perceptions may be enriched through an encounter with this story. The book would also serve as a sampler that would connect scholars to a deeper study Eric Funk's music.

Acknowledgements: Peter Pomajevich – School of Music

Megan Sheufelt: Music Education
Mentor: Greg Young – Music
Tlingit Music in the 21st Century

The Tlingit are the largest Native group of Southeast Alaska. Since the end of forced assimilation efforts in the late 20th century, many Tlingit people have worked to reclaim their heritage and traditional cultural practices, including music. The existing literature on Tlingit music focuses on the historical musical practices, and relies on accounts from early colonizers and an ethnographic study which collected recordings in the 1950s, which are radically different contexts than the revival of traditional music in the modern era. A common misunderstanding of

Native culture is that it is unchanging, or that it is only "authentic" if it is the same as in the past. I would like to examine the ways in which Tlingit music is changing and expanding, for example through new compositions and blending of musical styles. In this project I will explore the current practice of Tlingit music in its social and cultural contexts. Video recordings of musical performances and interviews with Tlingit musicians/dancers will be the primary sources of information.

Thomas Thomas: Music
Mentor: Greg Young – Music
Bozeman Arts—Live!

COVID-19 necessitated video capture of classical music performance on a scale never before seen. Bozeman Arts—Live! is a digital platform for Bozeman art—born of COVID—that provides production services and marketing for Bozeman artists and arts groups for whom vast digital presence would be out of reach. Questions arose over the use of video assets in music performance: liabilities/opportunities of spectacle and sexualization; audience reach without geographic boundaries; visual exploration of performance; differentiation for an array of digital platforms; and video program notes. This poster display will chronicle its rise and provide a critical analysis of its videography to date.

Ashlyn Varga: Music
Mentor: Gregory Young – Music
Practical Methods to Maintain Good Mental Health for Music Majors; A Perspective from Students at Montana State University

College can be a stressful time for many of our peers, but music programs often push the boundaries of getting a degree to an all-time high. In addition to course load, ensembles and/or bands, fitting practice into schedules, and amount of homework, students may have to use their time management skills if they have full-time or part-time jobs, extra-curricular activities, etc. Having different and engaging ways to aid students in their college experience has the potential to improve the way that music school affects the students. The purpose of this research is to help music students become proactive about their mental health early on in their musical careers to help manage the amount of work and dedication it takes to achieve a degree in music at the undergraduate level and beyond. The resulting booklet, made up of real-life scenarios and stories, can be used as a guide for future music students who may struggle with their mental health.

Naomi Vliet: Music Education
Mentor: Kristofer Olsen, Gregory Young – Education, Music
Blackface minstrel music in elementary school music curriculums

The American blackface minstrel show emerged in the 19th century as one of the most popular forms of American entertainment. These were variety shows, which evolved over time but typically contained multiple short musical and comedic acts. The characters were often played by white actors in blackface, portraying Black Americans in a racist and degrading manner. Due to the long-lasting popularity of such shows, many songs that originated in minstrelsy are still well-known today, although their past may not be universally recognized. One setting in which these songs can still be found is elementary music classrooms, which raises a number of questions on the appropriateness of teaching such songs to children. This project identifies songs in elementary music textbooks that were originally composed for blackface minstrel shows, including researching their particular histories and locating historical scores. The information discovered in this project will be made available on a website for teachers to reference. In the future, replacement song suggestions will be added to help teachers more easily remove and replace minstrel songs in their curriculum.

Acknowledgements: McNair Scholars Program

Madison Wambeke: Music
Mentor: Gregory Young – Music
Creating a culture that needs opera

Opera! Why don't more people go? The age-old question is "how do we expand the opera audience?" Everyone who says they love opera is either an opera singer, highly educated in opera, or has been positively impacted by opera. What is the culture of opera? Looking at this from a business perspective, one answer to "how do you fix this?" is to adapt to the audience and create something that people already need. However, if people don't want or need this then it truly is a dying art. Instead, a better question of how to expand the Bozeman audience for Intermountain Opera Company might be "how do you integrate opera into the culture?" In this project I will investigate the effects of opera integration into culture through young artist programs in high schools and collaboration with other organizations. There is power in coming together to maximize audience, impact, and potential. Results will be shared with arts organizations in the community.

COLLEGE OF ENGINEERING

Rachel Anderson: Chemical & Biological Engineering
Mentor: Ross Carlson – Chemical & Biological Engineering
Effects of Microbial Interactions on the Efficacy of Antimicrobial Agents

Chronic wounds are wounds that persist for 3+ months due to bacterial infections that affect over six-million people in the United States alone. Biofilms are ubiquitous bacterial consortia that exhibit unique growth and communication properties. When combined with patient wounds, these conglomerations present dangerous threats including amputation of infected areas. In this study, Staphylococcus aureus and Pseudomonas aeruginosa are two organisms of interest due to their frequent co-isolation from infection sites. S. aureus exhibits a classic carbon catabolite repression (cCCR) metabolism in which higher energy substrates (e.g., glucose) are selected first for catabolism. The reverse carbon catabolite repression (rCCR) strategy exhibited by P. aeruginosa is imperative to understanding its evolutionary role in chronic wounds, through which organic acids (e.g., lactate, acetate, succinate) are preferentially selected. The organization of planktonic culture experiments allowed for the collection of basic physiological data to inform the interpretation of biofilm data, which can be more complex to analyze due to substrate diffusion and nutrient gradients. The planktonic results quantified the growth rates of P. aeruginosa in a free-living environment to explore the relationships between substrate preference and associated growth rates. The biofilm samples were challenged with specific antibiotics to explore antibiotic tolerance in monocultures versus cocultures. This ongoing study hypothesizes that biofilm experimental setups will demonstrate emergent properties between P. aeruginosa and S. aureus and the division of labor when grown together. The study of metabolic patterns in simpler controlled systems will allow for the interpretation of interspecies properties in more complex natural biofilm consortia.

Acknowledgements: Lee McGill – Center for Biofilm Engineering, Undergraduate Scholars Program (USP)

Scott Ault: Mechanical & Industrial Engineering
Mentor: Lewis Cox – Mechanical & Industrial Engineering
Boundary Stress in Composite polymers

This project is designed to look at using digital image correlation (DIC) and atomic force microscopy (AFM) to create strain fields, and modulus maps of polymeric composites. Specifically the boundary created by polymerization in 2 stage photoreactive polymers(TSRPs). By using these polymers functionally graded materials can be created, and tested to better understand their properties. To do this TSRPs will be utilized to create simple stage 1 rubbery photo polymers that will then be exposed to UV light, causing it to harden into a glassy polymer. This glassy transformation can be controlled by limiting what portions of the sample are exposed to UV light by using a photo mask. Using these photo masks functionally graded material composites can be created. Following this the AFM will be utilized to create modulus maps for the composite. Next the sample will be dirtied using powdered sugar or silicon particulates, to create visible surface features. The DIC will then be utilized to generate strain fields in these materials. From this strain fields and modulus maps of these materials can be overlaid and utilized to create stress fields in these composite materials. It is expected that the strain fields created should be able to see and compare features on a micrometer scale. This should allow for better predictions in how the gradient in composites will fail and function.

Acknowledgements: Undergraduate Scholars Program (USP)

Malakai Coblentz: Mechanical & Industrial Engineering
Mentor: Mark Owkes, Phil Stewart – Mechanical & Industrial Engineering, Center for Biofilm Engineering
A Multispecies Biofilm Growth Model

Biofilms are colonies of bacteria adhered to a surface where they form a structure and propagate by dispersing plankton into the surrounding medium. In the study of bacteria, these structures are important because they develop a protective layer that provides some resistance to antibiotics and other attacks. Some of the applications of biofilm research include medicine, wastewater management, and material corrosion. The aim of this project is to produce a program to model the dynamics of a biofilm with multiple substrates and multiple biomass species. Substrates are nutrients present in the bulk liquid that promote or inhibit biofilm growth depending on the biomass species. Different biofilm species have unique maximum growth rates that are affected by the presence of substrates. This program would be used for instructional and research purposes in the Center for Biofilm Engineering. The program uses numerical methods including the Runge Kutta and finite difference schemes to solve growth equations for specified initial conditions and environmental conditions. The results from this model have been compared to test cases with known analytical solutions. The model has been shown to accurately predict biofilm growth in simplified cases where a solution is known. The program developed in this project is easier to use and more versatile than previous tools and can be used to get understand how a biofilm will grow with specified conditions and biomass species without the time-consuming process of cultivating biofilm colonies.

Acknowledgements: Undergraduate Scholars Program (USP)

Payton Dupuis: Chemical & Biological Engineering
Mentor: Cliff Rosen, Eben Estell – Chemistry & Biochemistry
Gene Set Enrichment Analysis of the Impact of Irisin on Osteoclast Function

Irisin is a novel signaling factor that is released from the surface of cells by enzymatic cleavage of its precursor, the transmembrane protein FNDC5. This protein is highly expressed is muscle cells, and irisin has been shown to be released in response to exercise, mediating crosstalk between muscle and other tissues, including bone1. Irisin signaling has been shown to modulate aspects of bone remodeling by its direct action on osteocytes1 and osteoblasts2. We have previously demonstrated that irisin also signals to osteoclasts, promoting differentiation and resorptive capacity3. The present study further explores the osteoclast gene pathways that irisin effects to potentiate these changes in function. These gene sets identify other possible effects of irisin previously unidentified by cellular assays or targeted gene expression. Moving forward, the project will focus on exploring other gene set data bases and examining specific genes within upregulated and downregulated pathways to more fully elucidate the transcription-level effects of irisin on the osteoclast.

Acknowledgements: McNair Scholars Program

Julian Fox: Chemical & Biological Engineering
Mentor: Bree Cummins – Mathematical Sciences
Matching DSGRN network models to the Yeast Cell Cycle

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 that 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. In addition, the dynamics determined by DSGRN can be matched to real biological data sets. 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)

Ryan Hinson: Chemical & Biological Engineering
Mentor: Nicholas Stadie – Chemistry & Biochemistry
Gas Adsorption on Heteroatom Doped Porous Carbon Materials

A sub-class of porous carbon materials, zeolite-templated carbons (ZTCs), has shown great promise as a medium for storing gases such as methane and hydrogen. Heteroatom doping of boron and nitrogen into carbonaceous surfaces has been suggested as a means of improving their ability to store such gases. To determine how heteroatom doping affects the complex interactions between adsorbent and adsorbate, a thorough computational study was performed using density functional theory (DFT). To study these interactions, a molecular maquette was extracted from the larger network of a ZTC model that is representative of the entire structure yet small enough for high-level DFT calculations. By performing heteroatom substitution and different modifications on this maquette (e.g., altering its symmetry), the effects on binding energy with methane and hydrogen gas were calculated across a diversity of environments. Specifically, the interaction of these gases with the edge of the representative maquette, as opposed to the more studied and understood surface interaction, was of great interest. The results indicate that nitrogen-doped models have a more favorable surface interaction with methane compared to boron-doped and pure carbon models. However, edge interactions appear relatively unaffected by the heteroatom dopant, and neither substitution significantly improves the interaction with hydrogen. Preliminary studies of other adsorbates, such as ammonia, borane, and water, are currently being undertaken to understand the complex relationship between adsorbate geometry and adsorption above the pi system of carbon surfaces. Initial results demonstrate that ZTCs are useful materials for storing or separating a wide variety of gaseous adsorbates.

Acknowledgements: Rylan Rowsey – Chemistry and Biochemistry, Robert Szilagyi – Chemistry and Biochemistry, Erin Taylor – Chemistry and Biochemistry, Undergraduate Scholars Program (USP)

Kayla Kozisek: Chemical & Biological Engineering
Mentor: Dr. Robin Gerlach – Chemical & Biological Engineering
Isolation of new algal and bacterial strains from high pH/high alkalinity habitats

As the world's population continues to rise there is an increasing urgency in finding an alternative to fossil fuels and a way to reduce atmospheric carbon. A promising solution to both these problems can be found in algae. Much of commercial algal cultivation is being attempted with axenic (free of other organisms) algal cultures, these cultures are prone to becoming contaminated by other microorganisms from the surrounding environment. In their natural setting algae grow in a complex network with other microorganisms including bacteria, other species of algae, or even protists like ciliates. This research provides further insights into the algal-bacterial interactions in high pH/high alkalinity conditions, which have been shown to support high biomass productivity for biofuel production. Water samples with visible algal growth were collected from several alkaline lakes in Soap Lake (WA, USA). Algae and their associated bacteria in these samples were enriched in the laboratory using Bold Basal Medium (BBM, for green algae), BBM with silica (Na2SiO3) (for diatoms), and Blue-Green 11 medium (for cyanobacteria). Individual algal and bacterial colonies were selected through three rounds of re-streaking before being reintroduced to liquid media. These isolates will be used in further research. They will be imaged and genetically sequenced for taxonomic identification. Once identified, their growth will be characterized by determining the growth rate in lag and log phase, as well as the maximum cell density. They will then be used to determine how algae interact with bacteria in high pH/high alkalinity conditions.

Acknowledgements: Huyen Bui – Center for Biofilm Engineering, Undergraduate Scholars Program (USP)

Elijah Luciani: Mechanical & Industrial Engineering
Mentor: Lewis Cox – Mechanical & Industrial Engineering
Stability, shelf-life, and properties of Two Stage Reactive Polymer Resins

This research studies the effects that post-processing swelling and cross-linking of two-stage reactive polymers have on network stability, shelf-life, and material properties of two-stage reactive polymers. This study specifically uses an off-stoichiometry formulation of a multifunctional acrylate and a multifunctional thiol to generate a cross-linked network with an excess of acrylate functional groups that can be subsequently photopolymerized to generate spatially resolved heterogeneity. After curing of the heterogeneous structure, a monofunctional thiol dissolved in acetone is used to swell the films to "cap" unbonded, high-energy acrylate groups.
To see the initial effect of swelling, three different concentrations of monofunctional thiol and acetone were used to swell films comprised entirely of the more compliant, "stage 1," material and a single sample of the more rigid, "stage 2," material. The stage 1 material contains unreacted acrylate functional groups, while all functional groups have been reacted in the stage 2 material. A control group of stage 1 and stage 2 films were also fabricated. All three stage 1 samples swelled with monofunctional thiols were then cured under UV light after comparing swelled stage 1 film stiffness to control stage 1 film stiffness.
Initial results showed swelled stage 1 films were mildly stiffer than control stage 1 film, but swelled stage 2 films showed no difference compared to control stage 2 films. However, Once swelled stage 1 films were cured, they remained noticeably rubbery compared to cured control stage 1 films which indicated monofunctional thiol diffused and "capped" significant portions of unbonded acrylate. The full effects on shelf-life network stability, shelf-life, and material properties are still unknown. It is hypothesized that capping stray, unconsumed functional groups within the films will increase material stability without significantly altering viscoelastic properties. Theoretically, increased material stability should increase material shelf-life.

Acknowledgements: Undergraduate Scholars Program (USP)

Jacob Michaletz: Chemical & Biological Engineering
Mentor: Nicholas Stadie – Chemistry & Biochemistry
Real-time optical properties analysis for perovskite solar cell contact layer fabrication

Hybrid organic-inorganic perovskites are one of the most promising light absorber materials for affordable and efficient near-future photovoltaics due to their relative ease of manufacturing and high power conversion efficiencies. Perovskite solar cell devices are made of a stack of thin films deposited on plastic or glass. The problem is that there are at least six unique layers in a solar cell device, all of which need to be optimized. We can accelerate this optimization by characterizing each layer during fabrication instead of waiting until the device is finished, assembled, and tested for electrical output. Herein, we use ellipsometry to characterize the thicknesses and optical properties of these layers, especially the important perovskite light absorbing and tin oxide (SnOx) conducting layers. To achieve this, each layer was independently synthesized, measured, and a model of its optical constants was developed. We then analyzed complete, multilayer perovskite cells and combined these models to measure the optical properties of all layers in the cell simultaneously. As an example application, we measured differences in the optical constants of tin oxide layers synthesized at different temperatures and conditions. Finally, the completed models were used with an in-situ setup which collects data throughout fabrication. This

allowed for real-time measurement of optical properties and layer thicknesses. This work will help to more rapidly improve the device fabrication process.

Acknowledgements: Samuel Johnson – University of Colorado Boulder, Axel Palmstrom – National Renewable Energy Laboratory, Steven Christensen – National Renewable Energy Laboratory

Hanna Nyquist, Pushya Krishna: Chemical & Biological Engineering, Cell Biology and Neuroscience
Mentor: Blake Wiedenheft – Microbiology & Immunology
Extracellular cA3 Induced Bacterial Inhibition

Bacteria are known for their unique immune systems which defend against viral infection. One immunologic defense mechanism utilizes an effector protein called NucC. When activated by a cyclic oligonucleotide known as cA3, NucC non-specifically cleaves bacterial DNA causing cell death. Recent work performed in the Wiedenheft lab indicated that extracellular exposure to cA3 in the SCV20265 strain of Pseudomonas Aerigunosa inhibits bacterial growth. My work tests the hypothesis that exposure to extracellular cA3 activates a NucC protein inside SCV20265, leading to DNA degradation and cell death.
This hypothesis was tested by exposing PA SCV20265 to various concentrations of extracellular cA3 in a 96-well plate. The plate was placed in a plate reader which collected OD600 measurements every 10 minutes to assess bacterial growth. The resulting data indicated that a cA3 concentration of 1 mM can completely halt bacterial growth between 10 and 16 hours. In a second growth experiment, this inhibited bacterial DNA was extracted and run on an agarose gel after 15 hours of growth. No additional bands or streaks were visualized on the resulting gel to indicate genome degradation. Future experimentation will attempt to determine if genome degradation is occurring by extracting bacterial RNA during inhibition to see if NucC is being expressed. If NucC expression is occurring, the bacterial genome will be sequenced.
Antibiotic-resistant SCV20265 is a common pathogen infecting cystic fibrosis patients. This work may provide a novel way to inhibit bacterial growth and serve as a valuable tool in fighting these deadly lung infections.

Acknowledgements: Undergraduate Scholars Program (USP)

Spencer Otis: Mechanical & Industrial Engineering
Mentor: Dilpreet Bajwa – Mechanical & Industrial Engineering
Fiber Board Research

The question researched was: Is Guayule a feasible replacement for Phenol Formaldehyde when used as a binder to create fiber boards? If so, what is the optimal weight ratio? After boards of different concentrations were made, testing in the forms of static bending and water solubility was performed. Guayule at the weight fractions tested was found to have a lower elastic modulus and modulus of rupture, as well as a higher water absorption. However, a mixture of Guayule and Phenol Formaldehyde was found to have the highest elastic and rupture moduli. The percent water absorbed is between plain Guayule and Phenol Formaldehyde. This implies that Guayule is not as promising as hoped for use with wood fibers. The next step, currently being taken, is to perform more tests utilizing wood flour instead of fiber.

Kadin Ritter: Mechanical & Industrial Engineering
Mentor: Stephan Warnat, Michael Nuebauer – Mechanical & Industrial Engineering
Electrical and Mechanical Characterization of AgPDMS for Integration into Microfluidic Devices

Dielectrophoresis (DEP) is an effective technique used in microparticle characterization and separation. Particles are polarized by dielectrophoresis and experience a force parallel to the gradient of an external electric field created by conducting electrodes. This effect can be used in microfluidic devices to sort cells. This project aims to

develop and characterize a polydimethylsiloxane (PDMS) based microfluidic device for sorting microparticles using AC DEP with sidewall electrodes. The composite will be made by mixing silver particles with PDMS gel and then integrated into the microfluidic device. The goal is to find the concentration of silver particles that will optimize the electrode composite's electrical conductivity and strength. The conductivity will be measured using a linear four-point probe connected to a Source Measurement Unit and the strength will be evaluated with a hardness tester. Results will be gathered before the presentation date and displayed in graphs showing the optimized concentration of silver particles. Ultimately the electrodes will be integrated with a PDMS part to make a complete microfluidic device that can be used to sort cells. If successful, this research will be implemented in biological research to sort environmentally sourced cell samples.

Acknowledgements: Undergraduate Scholars Program (USP)

Zachary Schallenberger: Computer Science
Mentor: John Paxton – Computer Science
Autonomous UAV Navigation in a GPS-Denied Outdoor Environment Using Discontinuous Visual Contact With Fiducial Markers

Autonomous navigation of Unmanned Aerial Vehicles (UAVs) has become an increasingly popular area of study as technology has advanced over the years. One technology that has been developed for use in the autonomous navigation of UAVs is fiducial markers. Fiducial markers are a type of physical tag that can be placed in an environment to assist with UAV localization, navigation, and landing. A UAV can identify and scan a fiducial marker with an onboard camera and take appropriate action based on the data received from the marker. Previous research using only fiducial markers and onboard sensors for UAV navigation in a GPS-denied environment requires the camera to have constant visual contact with at least one marker. This research explores the use of fiducial markers for outdoor UAV navigation in a GPS-denied environment without the restriction of constant visual contact with a marker. Both indoor and outdoor courses were constructed to evaluate the viability of the developed solutions and algorithms. Although autonomous UAV navigation was only partially achieved due to substantial UAV drift during flights, the results are promising. The UAV was able to detect and decode fiducial markers as navigational instructions during flights. Physical implementation and formal methods are used to study the performance and overall viability of this solution.

Acknowledgements: Nicholas Dunn – Columbus State University

Jonathan Shikany: Chemical & Biological Engineering
Mentor: Brent Peyton – Chemical & Biological Engineering
Enhancing growth rates and biodiesel potential in the diatom RGd-1

Traditional petroleum-based fossil fuels release carbon dioxide into the atmosphere and contribute to global warming. Algal biofuels represent a near carbon neutral alternative to petroleum-based fuels as algae produce lipids which can be converted to biodiesel. The alkalophilic diatom, RGd-1, cultivated from Yellowstone National Park, produces greater quantities of triacylglycerol (TAG) than other algal strains. For improving biomass and lipid productivities, ammonia can be used as a potential alternative to nitrate as the nitrogen source as it readily assimilates into the cell biomass. Thus, to increase cell concentrations and enhance growth rates, RGd-1 was grown in shaker flasks with Bold's 7.8 medium supplemented with nitrate and ammonium (0 – 2.941 mM) as nitrogen sources. TAG content and medium N concentrations were measured by Nile Red fluorescence, ammonia via 2-phenylphenol and nitrate using ion chromatography. The conditions with enhanced growth were grown in tubular photobioreactors with the addition of sodium bicarbonate (25 mM) as a TAG "trigger" near nitrogen depletion. Nitrogen depletion paired with sodium bicarbonate addition was shown to enhance intracellular TAG accumulation. RGd-1 supplementation with full ammonium exhibited a greater TAG concentration per cell

compared to cultures grown in the presence of nitrate (10.96 versus 7.00 arbitrary units/cell). However, cultures grown with ammonium did not have greater growth rates than those grown in nitrate. It was determined that RGd-1 produces greater intracellular TAG accumulation while grown in medium supplemented with ammonium and the addition of sodium bicarbonate at nitrogen depletion.

Acknowledgements: Muneeb Rathore – Chemical & Biological Engineering, Undergraduate Scholars Program (USP)

Veronica Soran: Mechanical & Industrial Engineering
Mentor: Corey Pew – Mechanical & Industrial Engineering
Physiological Effects of Running with a Jogging Stroller

Stroller running is a popular form of exercise, however limited research has been done on its physiological effects. The objective of this study was to assess metabolic intensity (COSMED K5 Unit) for increased stroller load. Participants performed running both indoors on a treadmill with a simulated stroller and outdoors with a real stroller at varying loads. We will analyze steady state heart rate, oxygen consumption (VO2), and energy expenditure (EE) data to assess the participants physical effort in response to the varying conditions. We hypothesize that all these metrics increase with increased loading in both indoor and outdoor trials. We expect to see a greater increase in these metrics in indoor trials than in outdoor trials for similar loading conditions. This is likely because the outdoor stroller can store its own momentum while the indoor simulated stroller requires the participant to constantly push the lateral load, requiring more effort. Overall, we hope to show that stroller running can be used as a method to increase metabolic intensity while running.

Acknowledgements: Nolan Black – Mechanical & Industrial Engineering,

Sam Weston: Mechanical & Industrial Engineering
Mentor: Mark Jankauski – Mechanical & Industrial Engineering
Simplified dynamic modeling of bee thorax during pre-flight warmup

Flying insects have been the subject of considerable research in engineering communities. Owing to their small size and low energy expenditures, they serve as model organisms in the development of small-scale micro-air vehicles. One aspect of insect flight that is still not well understood is the warm up period, during which the insect rapidly engages its flight muscles in order to elevate their temperature in preparation for flight. Prior research has shown that flight muscle oscillation frequency rises dramatically during this period, which may indicate a stiffening of these muscles in response to an increase in their temperature (assuming that the oscillations are happening at the natural frequency of the thorax). Our research aims to characterize the dynamics of the insect thorax during warm up through the use of a simplified dynamic model, in order to gain a better understanding of this behavior. Our model assumes the thorax can be approximated as an externally forced spring-mass-damper, where the spring stiffness (representative of the muscle stiffness) is modeled as a first-order system dependent on the time history of the thorax oscillations. We populated the model with experimental measurements from the Bumble bee Bombus centralis, then simulated the model numerically. The results of this simulation so far support the hypothesis that changes in muscle stiffness during the warmup period increase muscle oscillation and wingbeat frequency. Currently, we are focused on incorporating a more realistic forcing model to more accurately represent muscular forces.

COLLEGE OF LETTERS & SCIENCE

Franklin Alongi: Modern Languages & Literatures
Mentor: Peter Schweppe – Modern Languages & Literatures
Interspecific trait variability and local soil conditions modulate grassland model community responses to climate

High elevation grasslands provide critical services in agriculture and ecosystem stabilization. However, these ecosystems face elevated risks of disturbance due to predicted soil and climate changes. We experimentally exposed model grassland communities, comprised of three species grown on either local or reference soil, to varied climatic environments along an elevational gradient in the European Alps, measuring the effects on species and community traits. Although species-specific biomass varied across soil and climate, species' proportional contributions to community-level biomass production remained consistent. Where species experienced low survivorship, species-specific biomass production was maintained through increased production of surviving individuals. Species responded directionally to climatic variation, segregating differentially by plant traits (including height, reproduction, biomass, survival, leaf dry weight, and leaf area) across all sites. Local soil variation drove stochastic trait responses across all species. This soil variability obscured climate-driven responses: we recorded no directional trait responses driven by climate. Our species-based approach contributes to our understanding of grassland community stabilization and suggests that these communities show some stability under climatic variation.

Laina Hall: Chemistry & Biochemistry
Mentor: Blake Wiedenheft – Microbiology & Immunology
CRISPR: how the bacterium Thermus thermophilus defends itself against infection

Bacteria get infected by viruses and have evolved immune systems, including CRISPR (Clusters of Regularly Interspaced Short Palindromic Repeats), to fight off infectious agents. CRISPR systems utilize complexes of CRISPR-associated (Cas) proteins to target and cleave invading viral genetic material. In type III CRISPR systems, like the one found in Thermus thermophilus, viral infection and target binding lead to the production of cyclic oligoadenylate (cA) secondary messengers by the type III CRISPR surveillance complex (TtCsm Complex). Cyclic oligoadenylates subsequently activate ancillary ribonucleases (i.e. Csm6). This summer I quantified what cA secondary messengers the TtCsm complex creates. I next characterized three Csm6 ribonuclease proteins (TtCsm6 1, TtCsm6 2, and TtCsm6 3) in Thermus thermophilus by determining what cA secondary messengers they are activated by. The purpose of having three redundant ribonucleases remains unknown. Recently, it has been shown that a CRISPR RNA nuclease (Cas13) preferentially cleaves tRNAs. We hypothesize that similar activity of the TtCsm6's might explain their redundancy. The purpose of this project is to determine the RNA substrate preferences (i.e. tRNA, rRNA, mRNA) of these nucleases.

Acknowledgements: Joey Nichols – Microbiology, Andrew Santiagos-Frangos – Microbiology, IDeA Network for Biomedical Excellence (INBRE), Undergraduate Scholars Program (USP)

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

Orodromeus makelai was a small 2-meter-long herbivorous dinosaur well known from the Late Cretaceous Two Medicine Formation, and most notably from the Egg Mountain quarry west of Choteau, Montana. Egg Mountain is renowned for discoveries of exceptionally preserved eggs and clutches of the 2.5-meter-long carnivorous dinosaur Troodon formosus. Orodromeus fossils contrast by consisting only of skeletal material. This study seeks to

determine the ecologic and or taphonomic factors driving the preservation and dominance of Orodromeus skeletal remains at Egg Mountain. Recent discoveries there provide evidence of three hypotheses (not mutually exclusive) to explain this taphonomic bias: First, Orodromeus was a burrowing dinosaur, like the related Oryctodromeus, and burrows drive the preservation of Orodromeus material. Second, the abundance of Orodromeus fossils represent an Orodromeus breeding ground. Lastly, Orodromeus remains represent the remains of individuals preyed upon by Troodon.
The recent Orodromeus discoveries from Egg Mountain are being prepared using a method of chemical preparation, and a large skeletal aggregation is being prepared using traditional preparation methods, while also creating a 3D model of the aggregation using the software Blender. A survey of the Museum of the Rockies Orodromeus collection is assessing the size and hence ontogenetic age of specimens collected from Egg Mountain. This comparison of Egg Mountain Orodromeus specimens to specimens from the wider Two Medicine Formation reveals an abundance of very young juvenile to subadult animals at Egg Mountain. Articulation in the skeletal aggregation and elsewhere in the quarry hint at a possible unique taphonomic factor such as burrows.

Acknowledgements: Undergraduate Scholars Program (USP)

Ashlyn Hemmah: Ecology
Mentor: Dana Skorupa – Chemical & Biological Engineering
Survey for the Presence and Abundance of Naegleria fowleri in Southwest Montana

Naegleria fowleri is a thermophilic free-living amoeba that is found in both man made and natural environments. N. fowleri is an opportunistic pathogen that was first isolated in 1965 and is the causative agent of primary amoebic meningoencephalitis (PAM). PAM is a highly fatal disease, with a >95% mortality rate that is due to a combination of misdiagnosis and speed of infection. N. fowleri is found in many different natural environments, from hot springs to warm ponds and lakes. As global climates change and become warmer in many regions across the globe, N. fowleri is a potential emerging pathogen of concern. Increases in seasonal temperatures lead to not only warmer waters, but also cause variations in snowpack melt and worsening drought. Collectively, these conditions exaggerate the rate of temperature increase in a variety of water systems. Work here sought to survey for the presence of N. fowleri in southwest Montana. Samples were collected from several sites in the Heart Lake Geyer Basin region of Yellowstone National Park as well as two locations in Bozeman MT. DNA from the samples was extracted and amplified, then followed by downstream sequencing to determine if N. fowleri is present in the system.

Acknowledgements: Undergraduate Scholars Program (USP)

Beatrix Lever: Interdisciplinary Studies
Mentor: Sara Rushing – Political Science
The impact of cultural and linguistic differences on contemporary art in Quebec

There exists a long withstanding cultural clash embedded into Canadian society that has led to the recognition of Quebec as a separate nation within the country as outlined in the Canadian Charter of Rights and Freedoms. The assumed connection between Quebec nationalism and the desire to become an independent state are often confused by non-French speakers who see this behavior as problematic. The tension caused by linguistic distinctions has made for a thriving artistic community which will be used as a means of exploring the extent to which the Quebec identity is unique from that of Canada and has been shaped by its juxtaposition thereof. The focus of this research is on the impact of cultural differences resulting from the historical context upon which Quebec was founded on popular contemporary cinema, music, and literature.

Kelli Ober: Chemistry & Biochemistry
Mentor: Seth Pincus – Chemistry & Biochemistry
Measurement of the Antibody Response to Anti-HIV Immunoconjugates

We have been developing cytotoxic anti-HIV immunoconjugates to eliminate the persistent reservoir of HIV infection, the barrier to a cure. It was previously shown that in vivo treatment of macaques with an immunoconjugate lowered virus production. However, within two weeks of treatment, an immune response to the drug developed and the efficiency of the drug was decreased. The aim of this study is to modify conjugates in a way that would make them less immunogenic in the host. Thus far, 17 groups of eight mice, except one group with 12, were repeatedly injected with differently modified immunoconjugates, using an identical immunization schedule over 13 weeks. Clearance has been studied via a capture ELISA in which plates were coated with anti-human Ig to capture the immunoconjugate in the mouse plasma. Concentration of the immunogen was measured at 1, 2, 4, and 6 hours post injection. Clearance is much more rapid after the final injection at 11 weeks than after the first, presumably reflecting removal of the immunoconjugate by antibodies. We measured the development of the anti-immunoconjugate antibody response using an antigen-binding ELISA in which the immunoconjugate or components were used to coat the plate and anti-mouse Ig to detect binding. We have concluded that the addition of de-glycosylated ricin A chain (dgA) makes the antibody more immunogenic. It can also be shown that our antibody-drug conjugate (ADC) is less immunogenic than our immunotoxin (IT). Further analysis will determine if immunoconjugates can be used on a repetitive basis to treat HIV infection.

Acknowledgements: Tami Peters – Letters & Science, Tamera Marcotte – Animal Resource Center

Jacob Oppelt, Ethan Abrahamson: Physics
Mentor: Charles Kankelborg – Physics
Searching for Fast Variations of Soft X-Ray Flux in Solar Flares

Students at Montana State University are developing a high cadence (1kHz) soft x-ray radiometer (CAPRI-SUN) which will launch in 2024 as part of the High-resolution Coronal Flare Imager Campaign (Hi-C Flare). Previous measurements of x-ray flux in solar flares have been at a 2-3 second cadence using the GOES X-ray Sensor. It is unknown whether more rapid fluctuations exist, but a timescale of about 0.1-0.6 seconds can be inferred for events in the low corona based on the Alfven velocity and an upper limit on flare kernel size. This poster summarizes the scientific motivations for our high cadence measurement, describes the Hi-C Flare mission profile and the instrument we are developing. Finally, we use synthetic time series to demonstrate analysis methods to be used on CAPRI-SUN data.

Acknowledgements: Zachary Hull – Space Science & Engineering Laboratory (SSEL), Jacob Mann – Space Science & Engineering Laboratory (SSEL), Montana Space Grant Consortium (MSGC), Undergraduate Scholars Program (USP)

Kristina Otfinoski, Magdalen Kosciolek, Eli Boylan, Emma Christopher, Audrey Hood: Psychology
Mentor: Keith Hutchison, Brandon Scott – Psychology
Heart Rate Variability Biofeedback as a Potential Training Mechanism to Improve Attention Control Task Performance

Working memory capacity (WMC) refers to the ability to maintain information in the face of distractions. Individuals higher in WMC perform better on many attention control tasks compared to those lower in WMC (e.g., Engle, 2002). Our lab (Hood et al., in prep) recently found that higher WMC individuals also have greater resting-baseline heart rate variability (HRV; variation in time between successive heartbeats). In the current study, we are implementing an HRV biofeedback training, with the goal of increasing HRV, and in turn, attention control task performance. We are recruiting 150 undergraduates from MSU for a one-week study. Participants are randomly

assigned to either an HRV biofeedback or active control condition. Physiological measurements are being collected using electrocardiograph electrodes and BioNomadix receivers which transmit signals to a BioPac MP-150 System. At Session 1, participants first undergo a resting baseline period to assess their HRV and then complete two measures of WMC. They then complete three attention control tasks pre- and post-training. For the training, those in the HRV biofeedback condition undergo a breathing exercise, whereas those in the active control complete wordsearch puzzles. Participants are asked to practice the breathing/wordsearch exercises at home for one week. At Session 2, participants undergo a resting baseline physiological assessment followed by the three attention control tasks again. We expect to find: 1) HRV biofeedback will increase resting baseline HRV, 2) greater attention control task performance in the biofeedback condition, and 3) HRV biofeedback will enhance attention control more among those lower in WMC.

Eli Quist: Mathematical Sciences
Mentor: David Millman – Computer Science
A Probabilistic Approach to GPS Art

Matching and registration of polygonal curves is an important problem in fields ranging from computational geometry to molecular biology. One way to visualize this matching problem is through the idea of GPS Art: a popular hobby of cyclists and runners, where routes resemble shapes or text embedded in a street map from a bird's eye view. Here, the desired artwork is framed as a polygonal curve, and the street map as a network graph. We introduce a probabilistic method for computing the optimal route for a cyclist to follow that will embed the art on the road network. We sample edges from both the curve and network graph, and represent edges as four dimensional, abstract points. We then fit the two point sets together with an implementation of the Coherent Point Drift algorithm, and extract the most similar route from the road network. Importantly, this probabilistic approach allows for variance in scale, rotation, and translation of the polygonal curve throughout the matching process.

Acknowledgements: Undergraduate Scholars Program (USP)

Amanda Ruckey: Microbiology & Immunology
Mentor: Margaret Eggers – Microbiology & Immunology
2019 Baseline Foodborne Illness Risk Factor Study: Gallatin County, Montana

The purpose of this report was to determine the most common foodborne illness risk factor violations observed during retail food inspections performed throughout Gallatin County, Montana in 2019. Utilizing this report as a baseline study will allow for the Gallatin City-County Health Department (GCCHD) to measure the success of their retail food regulatory program and make changes where needed. This study will assist Gallatin County in achieving the criteria of Standard 9 of the Voluntary National Retail Food Regulatory Program. Reports from routine, retail food establishment inspections conducted in 2019 between January 1st and December 31st were used for this study. Data was collected from the GCCHD which maintained their data using a contracted service-provided database management system (DBMS). Collected data was analyzed to identify areas needing improvement throughout retail food establishments and the GCCHD's retail food regulatory program. Reports were organized into eight facility types to determine which facilities had the highest violations to observations ratio. The presence of a Certified Food Protection Manager (CFPM) was also evaluated to determine possible effects on the quantity of risk factor related violations. The results showed improvement needed in areas relating to Improper Holding/Time and Temperature and Contamination. Establishments lacking a CFPM during inspection showed a higher percentage of violations including risk factor violations. Healthcare and Combined Facilities had the highest violations to observations ratio. The results of this study recommend the continuation of CFPM requirements and a primary focus on reducing violations related to Improper Holding/Time and Temperature and Contamination.

Acknowledgements: McNair Scholars Program

Jack Tierney: Liberal Studies Degree
Mentor: Danielle Ulrich – Ecology
Quantifying the relative growth rates of alpine tree populations

The effects of the rapidly changing climate are becoming increasingly extreme and sporadic. In recent years, studies related to the current effects of climate change on global temperatures, precipitation levels, and weather variability have been published in droves. However, far less is known about the effect climate change has on organisms that are slow to respond to these changes such as alpine tree species. Species like these are long-lived, slow growing, and have long generation times, limiting our understanding of their response to climate change. In order to study these growth rates, stem height and stem diameter have been measured once a month from January 2021 to present and will continue through the end of this year. Data will be entered each month after measurements are made. Data will be analyzed in late November and early December.

Acknowledgements: Undergraduate Scholars Program (USP)

Sky Tillett: Sociology and Anthropology
Mentor: Mitchell Vaterlaus – Health & Human Development
Men's Perspectives on Household Labor, Childcare, and the COVID-19 Pandemic: Preliminary Results

The COVID-19 pandemic created a swift need for renegotiating the distribution of household and childcare tasks within two-parent families. Emerging research in the United States has found that working mothers in partnered relationships have had to bear the burden of reduced working hours and increased childcare responsibilities. Most research exploring work-life integration has relied on data collected from women, which leaves a gap in understanding men's perspectives regarding the navigation/negotiation of household and childcare responsibilities during the global health crisis of 2020. This cross-sectional qualitative case study aims to understand how men (n = 6) perceived the division of labor and childcare responsibilities within their partnered relationships before, during, and after the pandemic. Men in the United States who were in dual-income households with children under the age of 18 were recruited for this study. These are the preliminary results.

Acknowledgements: Mackenzie Sage – Health & Human Development, McNair Scholars Program, Undergraduate Scholars Program (USP)

Lily Toussaint: Chemistry & Biochemistry
Mentor: Valérie Copié – Chemistry & Biochemistry
Multi-Omics Data Integration and Multifactorial Analyses to Inform Selective Breeding of Cattle and Sheep

This project aims to use results from two highly comprehensive, data-intensive projects to streamline the selective breeding process by elucidating correlations between cattle and sheep metabolomics and transcriptomics data with desirable livestock traits such as high feed efficiency, carcass fatness, and condition scoring. In the first project, serum samples of 45 cattle fed to USDA quality grades and 45 sheep classified by fat ranking were taken at 0, 30 and 60 days before harvest, and liver tissue was collected for RNA-sequencing analysis. Using NMR spectroscopy, the changes in serum concentrations of 55 metabolites known to play significant roles in ovine and bovine metabolism were quantified. (n=122) The project now aims to develop R code that will allow for multi-omics incorporation of the RNA-seq and metabolomics data and to perform multifactorial analysis of the other metadata. In the second project, NMR was again used to generate a 55-metabolite cattle serum metabolomics dataset across timepoints with the intent to perform multivariate statistical analysis to investigate differences in

metabolism based on Ancestral Breed Group (ABG), BIF Guidelines Framescore (FS), cow or heifer classification, and timepoint differences. (n=341)

Connie Watt: Chemistry & Biochemistry
Mentor: Seth Pincus, Tami Peters – Chemistry & 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. 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, delta 21 D614G, as well as UK and South American strains. Of the pseudotyped variants of the spike protein, delta 21 D614G is the most efficient in the infection of 293T ACE-2 when compared to the other entry proteins. Additionally, this variant is most effectively neutralized by monoclonal antibodies against RBD. Neutralization by antibodies that bind RBD, S1, and S2 domains will be evaluated against all variants. Furthermore, antibodies will be applied in several combinations to measure any additive or synergistic properties. Using these pseudovirus variants, 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 Excellence (INBRE), Undergraduate Scholars Program (USP)

Shelby Wuertz, Donovan Olsen, Audrey Hood: Psychology
Mentor: Keith Hutchison, Brandon Scott – Psychology
Heart rate variability as a correlate of working memory capacity

Heart rate variability (HRV) refers to the changes in time between successive heartbeats and is thought to reflect the heart's ability to adapt and respond to varying circumstances by detecting and responding to unpredictable stimuli (Acharya et al., 2016). Although greater resting baseline vagally-mediated HRV has been shown to be associated with better cognitive task performance (Forte et al., 2019), no one has directly examined whether individuals higher in working memory capacity (WMC) have greater resting baseline HRV. Physiological measurements (heart rate and respiration) were collected with electrocardiograph (ECG) electrodes and BioNomadix receivers transmitting signals to a Biopac MP-150 system. Heart rate variability was calculated from the inter-beat and inter-breath intervals data. Participants first underwent a resting baseline period and then completed the shortened Automated Operation Span and Symmetry Span tasks as measures of WMC. Heart rate variability during a five-minute resting baseline period significantly and positively correlated with WMC, indicating that individuals higher in WMC have greater resting baseline vagally-mediated HRV.

2021 Student Research Celebration
December 10, 2021

Alphabetical Listing of Students

Samantha DeMars: Music Education Mentor: Gregory Young – Music *Application of IEFA by Music Educators in the Bozeman*	AM	35	24
Laura Detrick: Music Mentor: Greg Young, Eric Funk – Music *Eric Funk, Composer, Conductor, Producer, Professor—an Aural Biography*	PM	24	24
Payton Dupuis: Chemical & Biological Engineering Mentor: Cliff Rosen, Eben Estell – Chemistry & Biochemistry *Gene Set Enrichment Analysis of the Impact of Irisin on Osteoclast Function*	AM	2	28
Matthew Egloff: Mechanical & Industrial Engineering Mentor: Roberta Amendola, Douglas Cairns – Mechanical & Industrial Engineering *Formability of Stretch-Broken Carbon Fiber*	PM	10	13
Alison Fitzpatrick: Microbiology & Immunology Mentor: Ed Schmidt – Microbiology & Immunology *Polysome Profiling – How Translation is Altered to Accommodate Metabolic Methionine Use*	AM	28	17
Julian Fox: Chemical & Biological Engineering Mentor: Bree Cummins – Mathematical Sciences *Matching DSGRN network models to the Yeast Cell Cycle*	AM	5	28
Isabelle Gordon: Chemistry & Biochemistry Mentor: Nicholas Stadie – Chemistry & Biochemistry *Synthesis and Characterization of Phosphorus-Doped Silicon for Electrochemical Applications*	PM	5	16
Ava Graham: Microbiology & Immunology Mentor: Blake Wiedenheft – Microbiology & Immunology *Secondary Regulation of Type III CRISPR Systems by Cyclic Oligonucleotide Interactions via Riboswitches*	PM	16	17
Laina Hall: Chemistry & Biochemistry Mentor: Blake Wiedenheft – Microbiology & Immunology *CRISPR: how the bacterium Thermus thermophilus defends itself against infection*	AM	7	34
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*	AM	19	34
Ashlyn Hemmah: Ecology Mentor: Dana Skorupa – Chemical & Biological Engineering *Survey for the Presence and Abundance of Naegleria fowleri in Southwest Montana*	PM	22	35

Ryan Hinson: Chemical & Biological Engineering Mentor: Nicholas Stadie – Chemistry & Biochemistry *Gas Adsorption on Heteroatom Doped Porous Carbon Materials*	PM	3	29
Emory Hoelscher-Hull: Microbiology & Immunology Mentor: Mari Eggers – Microbiology & Immunology *Identifying Groundwater contaminants in the Belt Watershed*	AM	26	18
Kelsay Jensen: Microbiology & Immunology Mentor: Margaret Eggers – Microbiology & Immunology *Contaminant Levels and Cumulative Risk in The Upper Missouri Dearborne Watershed Sub-Basin*	PM	20	18
Kayla Kozisek: Chemical & Biological Engineering Mentor: Dr. Robin Gerlach – Chemical & Biological Engineering *Isolation of new algal and bacterial strains from high pH/high alkalinity habitats*	AM	1	29
Pushya Krishna: Microbiology & Immunology Mentor: Blake Wiedenheft – Microbiology & Immunology *Identification of Subtype- and Taxonomy-specific CRISPR leader motifs*	AM	27	18
Venkata Krisshna: Mechanical & Industrial Engineering Mentor: Mark Owkes – Mechanical & Industrial Engineering *Simulating rotary atomization with electrohydrodynamic effects*	AM	12	13
Venkata Krisshna: Mechanical & Industrial Engineering Mentor: Mark Owkes – Mechanical & Industrial Engineering *Simulating electrolyte jets in an electric field*	PM	14	13
Beatrix Lever: Interdisciplinary Studies Mentor: Sara Rushing – Political Sciece *The impact of cultural and linguistic differences on contemporary art in Quebec*	PM	29	35
Elijah Luciani: Mechanical & Industrial Engineering Mentor: Lewis Cox – Mechanical & Industrial Engineering *Stability, shelf-life, and properties of Two Stage Reactive Polymer Resins*	AM	8	30
Zachary Mayne: Microbiology & Immunology Mentor: Christa Merzdorf – Microbiology & Immunology *Heightened Glycerol Permeability in the Dorsal Mesoderm is Required for Convergent Extension in Notochord Formation*	AM	25	19
Cecelia McAfee: Land Resources & Environmental Sciences Mentor: Barbara Keith, William Dyer – Land Resources & Environmental Sciences, Plant Sciences & Plant Pathology *Transcriptomic Research of Multiple Herbicide Resistant Lines of Avena fatua L.*	AM	20	19

Jacob Michaletz: Chemical & Biological Engineering Mentor: Nicholas Stadie – Chemistry & Biochemistry *Real-time optical properties analysis for perovskite solar cell contact layer fabrication*	AM	3	30
Gwendolyn Mueller: Microbiology & Immunology Mentor: Susy Kohout – Microbiology & Immunology *Breaking Voltage-Sensing Phosphatase Dimers*	PM	18	20
Dalton Nold: Mechanical & Industrial Engineering Mentor: Dilpreet Bajwa – Mechanical & Industrial Engineering *Stretch Broken Carbon Fiber*	AM	15	14
Reed Noyd: Microbiology & Immunology Mentor: Colin Miller – Microbiology & Immunology *Investigating the role of Thioredoxin Reductase-1 on liver health in a surgical model of cholestatic liver disease*	PM	15	20
Tasnia Javin Nur: Chemistry & Biochemistry Mentor: Roberta Amendola, Douglas Cairns – Mechanical & Industrial Engineering *Design of a experimental fixture to measure ply-ply and tool-ply friction in carbon fiber reinforced thermoset prepregs*	PM	4	16
Hanna Nyquist, Pushya Krishna: Chemical & Biological Engineering Cell Biology and Neuroscience Mentor: Blake Wiedenheft – Microbiology & Immunology *Extracellular cA3 Induced Bacterial Inhibition*	PM	1	31
Kelli Ober: Chemistry & Biochemistry Mentor: Seth Pincus – Chemistry & Biochemistry *Measurement of the Antibody Response to Anti-HIV Immunoconjugates*	PM	6	36
Jacob Oppelt, Ethan Abrahamson: Physics Mentor: Charles Kankelborg – Physics *Searching for Fast Variations of Soft X-Ray Flux in Solar Flares*	AM	17	36
Kristina Otfinoski, Magdalen Kosciolek, Eli Boylan, Emma Christopher, Audrey Hood: Psychology Mentor: Keith Hutchison, Brandon Scott – Psychology *Heart Rate Variability Biofeedback as a Potential Training Mechanism to Improve Attention Control Task Performance*	PM	27	36
Spencer Otis: Mechanical & Industrial Engineering Mentor: Dilpreet Bajwa – Mechanical & Industrial Engineering *Fiber Board Research*	AM	9	31
Shishir Pandey: Microbiology & Immunology Mentor: Blake Wiedenheft – Microbiology & Immunology *An Evolutionary Treatise Between CRISPR-mediated Defense and Toxin-Antitoxin Addiction System*	AM	24	11

Eli Quist: Mathematical Sciences Mentor: David Millman – Computer Science *A Probabilistic Approach to GPS Art*	PM	8	37
Lyra Reynolds: Land Resources & Environmental Sciences Mentor: Jean Dixon – Earth Sciences *Post-Fire Fallout: Measuring Fallout Radionuclides to Understand Soil Erosion in a Burn Scar*	AM	21	21
Riad Morshed Rezaul: Mechanical & Industrial Engineering Mentor: Cecily Ryan – Mechanical & Industrial Engineering, *Stretch Broken Carbon Fiber for Primary Aircraft Structure*	AM	13	14
Sonja Ring: Microbiology & Immunology Mentor: Margaret Eggers – Microbiology & Immunology *Montana Risk Category Study*	PM	19	21
Kadin Ritter: Mechanical & Industrial Engineering Mentor: Stephan Warnat, Michael Nuebauer – Mechanical & Industrial Engineering *Electrical and Mechanical Characterization of AgPDMS for Integration into Microfluidic Devices*	PM	13	31
Amanda Ruckey: Microbiology & Immunology Mentor: Margaret Eggers – Microbiology & Immunology *2019 Baseline Foodborne Illness Risk Factor Study: Gallatin County, Montana*	PM	21	37
Zachary Schallenberger: Computer Science Mentor: John Paxton – Computer Science *Autonomous UAV Navigation in a GPS-Denied Outdoor Environment Using Discontinuous Visual Contact With Fiducial Markers*	AM	18	32
Edward Shaw: Land Resources & Environmental Sciences Mentor: Wan-Yuan Kuo – Health & Human Development *Senegalese Indigenous Farm to School System: Establishing a food manufacturing protocol and assessing participatory action teaching approaches*	AM	22	22
Yoni Shchemelinin: Mechanical & Industrial Engineering Mentor: Amendola Roberta – Mechanical & Industrial Engineering *Hydraulic bulge testing to compare formability of continuous and stretch broken carbon fiber prepreg laminates*	AM	16	15
Megan Sheufelt: Music Education Mentor: Greg Young – Music *Tlingit Music in the 21st Century*	PM	25	24
Jonathan Shikany: Chemical & Biological Engineering Mentor: Brent Peyton – Chemical & Biological Engineering *Enhancing growth rates and biodiesel potential in the diatom RGd-1*	AM	4	32

Veronica Soran: Mechanical & Industrial Engineering Mentor: Corey Pew – Mechanical & Industrial Engineering *Physiological Effects of Running with a Jogging Stroller*	AM	14	33
Thomas Thomas: Music Mentor: Greg Young – Music *Bozeman Arts—Live!*	AM	30	25
Jack Tierney: Liberal Studies Degree Mentor: Danielle Ulrich – Ecology *Quantifying the relative growth rates of alpine tree populations*	AM	23	38
Sky Tillett: Sociology and Anthropology Mentor: Mitchell Vaterlaus – Health & Human Development *Men's Perspectives on Household Labor, Childcare, and the COVID-19 Pandemic: Preliminary Results*	PM	28	38
Lily Toussaint: Chemistry & Biochemistry Mentor: Valérie Copié – Chemistry & Biochemistry *Multi-Omics Data Integration and Multifactorial Analyses to Inform Selective Breeding of Cattle and Sheep*	AM	6	38
Ashlyn Varga: Music Mentor: Gregory Young – Music *Practical Methods to Maintain Good Mental Health for Music Majors; A Perspective from Students at Montana State University*	AM	32	25
Naomi Vliet: Music Education Mentor: Kristofer Olsen, Gregory Young – Education, Music *Blackface minstrel music in elementary school music curriculums*	AM	34	25
Madison Wambeke: Music Mentor: Gregory Young – Music *Creating a culture that needs opera*	AM	31	26
Sarah Warnke: Microbiology & Immunology Mentor: Mari Eggers – Microbiology & Immunology *Cumulative Risk Assessment of Exposure to Well and Stream Water Contaminants, Sun River, Montana*	PM	17	22
Connie Watt: Chemistry & Biochemistry Mentor: Seth Pincus, Tami Peters – Chemistry & Biochemistry *Development of a Pseudovirus Assay to Measure SARS-CoV-2 Infection of Target Cells in Biosafety Level 2 Laboratories*	PM	7	39
Sam Weston: Mechanical & Industrial Engineering Mentor: Mark Jankauski – Mechanical & Industrial Engineering *Simplified dynamic modeling of bee thorax during pre-flight warmup*	PM	11	33
Shelby Wuertz, Donovan Olsen, Audrey Hood: Psychology Mentor: Keith Hutchison, Brandon Scott – Psychology *Heart rate variability as a correlate of working memory capacity*	PM	26	39