Higher Education Research Council
Undergraduate Research Supplemental Funding
Boise State University
Final Report

Academic Year 2019-2020

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Introduction

The Institute for STEM & Diversity Initiatives (ISDI) oversaw the HERC Undergraduate Research Fellowship at Boise State University Fall 2019, and Spring 2020. ISDI changed its office name to the Institute for Inclusive & Transformative Scholarship in the summer of 2020. HERC funds were used to support Boise State undergraduate students who had minimal research experience with a 10-week mentored research opportunity. Funds provided by the Higher Education Research Council supported a total of 27 students across 12 different STEM disciplines.

In addition, HERC funds made it possible to support 10 students with travel opportunities to attend professional STEM conferences in their field.

On behalf of the Institute for Inclusive & Transformative Scholarship, we thank the Higher Education Research Council for their generous support in helping build meaningful experiential learning experiences for Idaho students and supporting faculty research.

HERC Funding:

The Higher Education Research Council provided $55,000 in supplemental funding for STEM undergraduate research this year. Please see table below of how stipends and travel awards were dispersed.

Stipends	**Amount**
Boise State Research Stipends 17 students Majors: Anthropology, Applied Mathematics, Biology (2), Chemistry (4), Elementary Education – Earth Science, Geosciences (2), Health Sciences, Health Studies, Mathematics, Mechanical Engineering (3)	$51,805
Student Travel to Professional Conference	**Amount**
Molecular Beam Conference (1 student)	$440.22
2020 Pacific Sociological Association Conference (4 students)	$1, 559.60
Undergraduate Women in Physics Conference (4 students)	$688.44
Applied Anthropology Conference (1 students)	$506.12
Total	**$54,999.38**

Note: Travel less than normal due to COVID

Fall 2019 HERC Fellow Boise State Student Abstracts:

Tessa Mei-lin Fong
Faculty Mentor: Dr. Zhangxian Deng, Department of Mechanical Engineering, Boise State University
Research Title: The Use Of Magnetostrictive Materials In Vibrational Energy Harvesting

Wireless devices have increased in the recent years. More technology means more products being charged. Recently, there has been a development of wireless charging because people need something convenient. Smart materials are being looked at, namely magnetostrictive materials. The energy harvester being designed will use mechanical energy (in the form of vibration) and convert that to electrical energy (in the form of voltage). This process can be used to create energy that can be applied to smart devices. The first objective was to develop a strong understanding of smart materials, especially magnetostrictive materials. The knowledge was then applied to learning about energy harvesting. This objective was met by reading and understanding research papers and reports from Dr. Zhangxian Deng. The two main reports included the "Review of magnetostrictive vibration energy harvesters" and "Magnetostrictive Devices", both by Dr. Zhangxian Deng and Marcelo J Dapino. [1], [2] The second objective was to develop skills in CAD and/or data acquisition software to allow a hands-on experience. This was done through the use of programs, such as SolidWorks and LabView. Hands-on experience was further demonstrated through the use of building the prototype. The last objective was to improve technical communication and writing. Technical communication of the problem was found with research papers provided by Dr. Zhangxian Deng, along with weekly meetings. Technical writing improved through the written final report due at the end of the corresponding semester. Fulfillment of these objectives helped the SMS Lab gain a system for future testing, along with a demonstration to model for those who may visit the SMS Lab.

Kate Grosswiler
Faculty Mentor: Dr. Mark Shmitz, Department of Geosciences, Boise State University

Research Title: Carbon Isotopic Analysis of Thaynes Formation Limestones: Using Global Carbon Cycle Perturbations to Explore the Temporal Correlation Between Early Triassic Ammonoid Biochronozones in North America and South China

The Permian-Triassic mass extinction, the most devastating mass extinction event in Earth history, was followed by a series of significant carbon cycle perturbations and climatic oscillations. Consequently, biotic diversity increased and decreased episodically. Because of their rapid speciation and preferential preservation, ammonoid fossils serve as key indicators of post-extinction marine faunal repopulation.

Previous work indicates Early Triassic ammonoid speciation was globally synchronous, yet radioisotopic age constraints on stratigraphic sections in Northeastern Nevada and South China that host identical ammonoid biochronozones exhibit a 1.5 Myr age offset. This age discrepancy illustrates the need for additional work to establish the temporal correlation between the North American and South China biochronozones.

We conducted carbon isotopic analyses on 63 limestone samples collected from the Early Triassic Thaynes formation in Southeastern Idaho and compared our results to carbon isotopic data from the Loulou formation in South China. Both formations host the same ammonoid biochronozones, making carbon isotope chemostratigraphy a useful calibration tool to determine whether the observed age incongruity is the result of erroneous biostratigraphic characterization or the result of flawed radioisotopic data from South China.

Ashley Leavell
Faculty Mentor: Dr. Marie-Anne de Graaff, Department of Biology, Boise State University
Research Title: TItle: Soil recovery after fire and invasion: implications for sagebrush reestablishment

The sagebrush steppe ecosystem has been heavily impacted by disturbance, including fires and the invasion of cheatgrass (*Bromus tectorum)*. Both fire and changes in the plant community can impact soil properties that reduce sagebrush (*Artemisia tridentata*) reestablishment success, but in the long-term, these soil properties may recover thus allowing for sagebrush re-establishment. With this study we ask: how do soil properties change in a recovering sagebrush ecosystem? To quantify soil properties and changes therein as succession progresses, I will investigate a 1983 fire on the Orchard Combat Training Center that is experiencing re-establishment of sagebrush. Soil samples have been collected from three areas: (1) areas of no sagebrush regrowth, (2) areas with sagebrush regrowth, and (3) unburned areas adjacent to the fire. I will measure physical, chemical, and biological soil properties that are critical to sagebrush re-establishment. These include soil structure, organic matter content, pH, nitrogen and carbon content, and microbial and arbuscular mycorrhizal fungi (AMF) communities. These results will allow us to evaluate the process of succession following fire and invasion, and the importance of recovery of soil properties in enabling this process.

Crystal Lundgren
Faculty Mentor: Dr. Michael Callahan, Department of Chemistry and Biochemistry, Boise State University.
Research Title: Synthesis and Characterization of Metallocyanides for Meteorite Analysis
Cyanide may have played an important role in prebiotic chemistry on early Earth including the synthesis of amino acids and nucleobases. Iron cyanocarbonyl complexes were recently discovered in meteorites (Smith *et al.*, Nature Communications 2019); however, the complete characterization and quantification of these compounds in meteorites has not yet been performed. We synthesized *trans*-$(PPh_4)_2[Fe(CN)_4(CO)_2]$ and $(PPN)_3[Fe(CN)_5(CO)]$ using procedures modified from Contakes *et al.* (Inorganic Chemistry 2002) and characterized these compounds by electrospray ionization mass spectrometry. Mass spectral peaks corresponding to distinct isotopologues were found to be identical to those measured in meteorites. Future work will involve accurate quantification of iron cyanocarbonyl complexes in meteorites using our synthesized compounds as reference materials.

Kendall Swainston
Faculty Mentor, Dr. Ken Cornell, Department Chemistry & Biochemistry, Boise State University
Research Title: Toxicity testing of anti-parasitic MTN inhibitors against mammalian cells

Giardia intestinalis (GI) is the most common protozoan parasite in the U.S. It is contracted by consumption of cysts that are passed in the feces of humans, domestic animals, and wildlife and frequently contaminate watersheds in Western states. The cysts pass through the stomach and excyst to the form trophozoites that infect the proximal small intestine, where they cause severe flatulence, diarrhea, abdominal cramps, nausea, vomiting, dehydration, and weight loss. Drugs like metronidazole (MTZ), tinidazole, and nitazoxanide are usually prescribed, but there are increasing cases of treatment failure. Our prior work has shown that the parasite enzyme 5' Methylthioadenosine nucleosidase (MTN) is an excellent target for drug development as it is unique to the parasite and absent from humans. *In silico* screening of allosteric drugs against crystallographic models of the parasite MTN has identified 36 potential MTN inhibitors, a number of which show *in vitro* anti-parasitic activity. In an effort to demonstrate that the compounds do not show undesired off target effects in humans, we have performed preliminary *in vitro* cytotoxicity screening of these compounds against cultured normal human fibroblasts and human fibrosarcoma cells. Our initial studies show that most of the compounds show little effect against human cells, even at high (100 μM) concentrations. The results of these initial studies will be presented.

Rebecca Torres
Faculty Mentor: Dr. Owen McDougal, Department of Chemistry and Biochemistry, Boise State University
Research Title: Detection of Acrylamide in Coffee Using Near Infrared Spectroscopy, Liquid Chromatography-Mass Spectrometry, and Gas Chromatography-Mass Spectrometry

Acrylamide is a suspected carcinogen required to be listed on food labels in California. Certain foods that are cooked at elevated levels convert amino acids, such as Arginine, Asparagine, and Lysine, into acrylamide through the Maillard reaction. Foods such as potato chips, french fries, breakfast cereals, and coffee are required by Proposition 65 to be labeled as containing a suspected carcinogen. Near Infrared (NIR) spectroscopy, as well as Liquid Chromatography-Mass Spectrometry (LC-MS) and Gas Chromatography-Mass Spectrometry (GC-MS) will be used to analyze acrylamide levels in light, medium, and dark roast coffee.

Ellie Woerner
Faculty Mentor: Dr. Krishna Pakala, Department of Mechanical Engineering, Boise State University
Research Title: Student Athletes in STEM

It is a rare combination for a Division 1 student-athlete to be pursuing a STEM degree owing to the rigor needed to pursue these degrees. Pursuing a STEM major is also very strenuous and often leaves limited time outside of their studies and has not been favored by athletes. Due to the rarity of this combination of individuals, there isn't a lot of information regarding how the experience of these student-athletes is during their college career. The study explores the support structures in place to help these student-athletes thrive both in the classroom and on the court, field, pool, or any other arena they are competing in. This study also reports on the skills that these individuals have that are enhanced through their sport and translate to the classroom to help them excel in their degrees. Finally, this study sheds light on how these individuals balance the roles of both student and athlete. The study results were obtained through surveys for the student-athletes and in-person interviews with staff in the athletic department, such as coaches and academic advisors.

Spring 2020 HERC Fellow Boise State Student Abstracts:

Holly Bossart
Faculty Mentor: Dr. Jaechoul Lee, Department of Mathematics, Boise State University
Research Title: Effective sample size calibrated multiple comparison methods for long memory US stock volatilities

Volatilities in stock prices often show long range dependence, representing significant autocorrelations even in large time lags. Multiple comparison methods can be used to identify different mean volatilities. However, the classical multiple comparison methods, including Fisher's least significant differences test, Tukey's honestly significant differences test, and Student-Newman-Keuls test, produce erroneously sensitive comparison results for long memory time series because these methods are developed for independent data. To accurately achieve the target significance level for long memory data, we propose using effective sample size (ESS) methods to calibrate these three popular multiple comparison tests. After using change point analysis to detect a sudden rise in mean stock volatilities of thirty prominent companies in January 2018, we analyze means before and after the changepoint using our ESS modified multiple comparison tests. With recent empirical evidence showing that low-volatility companies can outperform high-volatility companies, our methods help accurately identify which companies are low or high volatility.

Antone Chacartegui
Faculty Mentor: Dr. Donna Calhoun, Department of Mathematics, Boise State University
Research Title: Three Surprising Properties of Surface Curvature

Differential geometry is a branch of mathematics that studies local and global properties of curves and surfaces. Curvature plays a fundamental role in differential geometry. There are several different types of curvature described on a surface. For this research project, I investigated three surprising properties of *normal* curvature on smooth surfaces. The first property is a result of Euler's Theorem of principal curvature, which states that on any smooth surface, the principal curves at a point P are always orthogonal. The second property is the Mean Curvature theorem which states that, at a point P on a surface, the average curvature of all the normal curves passing through P is simply the arithmetic mean of the minimal and maximal curvature. The third property is that the mean curvature is related to the Laplacian.

How is it possible that the principal curves at a point P on a smooth surface are always orthogonal? Or that the average curvature is simply the arithmetic mean of the principal curvatures? How is the Laplacian operator, evaluated on the surface related to mean curvature? We will examine these questions and their answers.

Grace Coughlin
Faculty Mentor: Dr. Don Warner, Department of Chemistry and Biochemistry, Boise State University
Research Title: The Advancement of Breast Cancer Treatment by Developing Novel Cytokine Inhibitors

In the year 2020 the American Cancer Society estimates that 276,480 women will be diagnosed with invasive breast cancer and 42,170 women will die in the United States alone. The five-year survival rate plummets from 99% to 27% for metastatic breast cancer patients, making breast cancer the second leading cause of cancer deaths in women. An inflammatory cytokine (IC) plays a crucial role in activating cell signaling pathways that initiate the early stages of metastasis (i.e. detachment, migration, and intravasation), increasing the frequency of secondary tumors in vital organs. The aim of this research is to develop a small molecule inhibitor (SMI) that mediates IC-induced cell signaling. Previously, a high-throughput virtual screen of ~1.65 million compounds and a subsequent enzyme-linked immunosorbent assay (ELISA) identified SMI-26 as a lead compound. The three aryl groups of IC-SMI-26 have been synthetically modified to assess the steric, hydrophobic, and electrostatic interactions that contribute effective inhibition. Thus far, the incorporation of halogen substituents in aryl group 1, hydrophobic moieties in aryl group 2, and a strong electron withdrawing group in the para position of aryl group 3 increases SMI binding to the IC as determined by fluorescence quenching assays and ELISA experiments.

MJ Faris
Faculty Mentor: Dr. Karen Viskupic, Department of Geosciences, Boise State University
Research Title: Metacognitive Learning Strategies Used by Geoscience Students

Use of metacognitive learning strategies leads to better learning outcomes in college students (e.g. Dewey, 1933). This study sought to determine which metacognitive learning strategies are currently being used by geoscience students at Boise State University in order to see if students' metacognitive skills improve over time while in the geoscience program. Of the 43 students who completed the Learning Strategies portion of the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991), 11.6% were undergraduate underclassmen, 32.6% were undergraduate upperclassmen, and 55.8% were graduate students. Participants identified as 55.8% female and 44.2% male. Total scores ranged from 173-332 (M=247, SD=33.36) out of a possible 350. Students' use of metacognitive learning strategies is correlated with both age and class standing. Correlations between gender and learning strategy use were inconsistent and statistically insignificant. Participants, on average, reported high use of Effort Regulation strategies and low use of Peer Learning strategies. Specific metacognitive and peer learning strategies are recommended to the faculty of the Boise State University Geoscience Department in order to improve student use of metacognitive learning strategies which we hypothesize will improve student success.

Julio Gonzaelz Tempetla
Faculty Mentor: Dr. Pei-Lin Yu, Department of Anthropology, Boise State University
Research Title: Archaeological Predictive Model: Orchard Combat Training Center

The objective of this research is to help protect cultural heritage resources on Idaho National Guard lands that are protected by law and are significant to Idaho Native Americans and historically associated communities. By utilizing a predictive model previously developed by Michael Bishop, a Boise State University alumnus, with variables specific to the Idaho National Guard's Orchard Combat Training Center (OCTC), a map was successfully produced that identifies areas of high probability for encountering archaeological sites. Working from the variables in Bishop's predictive model, we used ArcGIS mapping software to select only those areas within the area of interest with a specific distance to hydrological features, elevation, and angle to hydrology. This map will be field-tested by conducting pedestrian survey and based on the results, the model will be refined to increase accuracy in future applications. We hope our research facilitates the management of cultural heritage resources within the OCTC and provides further research opportunities.

Maddelyn Jackson
Faculty Mentor: Dr. Daniel Fologea, Department of Physics, Boise State University

Research Title: Lysenin Channel Selectivity for Monovalent Metal Cations

The ability of transmembranes to selectively transport ions and molecules across biological membranes is paramount for all cells. The functionality of excitable cells, such as the excitability from the brain and muscles, is unequivocally determined by the ability of ion channels to discriminate between ionic solutes. Selectivity, along with high transport rate and regulation, is fundamental for all ion channels. Following this line of thinking, we asked whether other protein channels, with regulatory functions, have similar selectivity to ion channels. Our investigations were focused on lysenin, a protein that self-assembles into a regulated, large-conductance channel in both artificial and natural lipid membranes. The ionic selectivity of lysenin channels of monovalent metal cations was estimated through transmembrane voltages measured after chemical gradients were produced across the membrane through successive ionic additions. Our results clearly demonstrated that lysenin channels present cation selectivity. However, the estimated ionic permeabilities were different for Na^+, K^+, Li^+, and Cs^+. This unusual feature, commonly shared by ion channels, may be further explored for controlling the electrochemical gradients across natural and artificial cell membranes.

Dalton Miller
Faculty Mentor: Dr. Ken Cornell, Department of Chemistry and Biochemistry, Boise State University
Research Title: Demonstration of Cold Atmospheric Pressure Plasma Biofilm Removal Using Profilometry

The CDC estimates that 128,000 people are hospitalized due to food-borne illness each year in the United States. The presence of bacterial biofilms in food-processing settings is a concern for the spread of disease, and is responsible for a significant number of the outbreaks that result in hospitalizations and food recalls. Although food-processing plants can be sterilized to some degree, the current means of doing so uses harsh chemicals and requires production to be halted for extended periods of time. To that end, we have developed a novel cold atmospheric-pressure plasma (CAPP) device to combat these types of biofilms in a more cost effective manner that requires no harsh chemicals. This biofilm removal can be imaged using fluorescence microscopy and quantified by profilometry, which measures the height of the biofilm before and after CAPP treatment. Here we demonstrate that even short (e.g. 1 minute) CAPP treatments could etch away biofilms in a time-dose dependent fashion. Our findings provide a proof-of-concept that a CAPP device is a viable potential alternative to classic food processing decontamination methods that rely on harsh chemicals.

Sabrina Moores
Faculty Mentor: Dr. Zhangxian Deng, Department of Mechanical and Biomedical Engineering, Boise State University
Research title: 3D-pringed and Wireless Piezoelectric Tactile Sensors

This research investigates the use of inkjet printing to manufacture wireless and flexible piezoelectric force sensors. The PVDF-TrFE polymer exhibits high piezoelectric response that can be measured by sandwiching it between two conductive electrodes. By investigating polymer ink preparation, curing, and drying times, a PVDF-TrFE ink that is compatible with a commercial inkjet printer was synthesized. Further investigation of printer settings and substrate treatments has resulted in a thin piezoelectric film for flexible force sensing. The newly-developed sensor has potential to be used for health monitoring, soft robotics, and wearable tech.

Alyssa Romera
Faculty Mentor: Dr. Cynthia Curl, Department of Community and Environmental Health, Boise State University
Research Title: Methodology to Assess the Effect of Exposure to Environmental Toxins on Reproductive Health and Birth Outcomes

The environmental exposures that women experience before and during pregnancy can impact reproductive health and birth outcomes. Our lab's goal is to understand pesticide exposure levels during pregnancy and, ultimately, to evaluate the potential long-term effects of that exposure. We are currently recruiting 40 pregnant women during their first trimesters and collecting a series of 36 biological samples from each woman, which we will analyze for pesticides. As part of this work, I am recruiting, consenting, and enrolling participants, conducting interviews, collecting urine samples, and analyzing data. I am also conducting a literature review to understand how similar environmental exposure assessment methods have been used in other populations. Specifically, I am conducting a search of relevant, peer-reviewed literature using Google Scholar and Academic Search Premier to investigate the relationship between use of personal care items and reproductive health before and during pregnancy. My literature review focuses on personal care items that contain known carcinogens and that have been detected in biological samples in populations such as pregnant women. My work compares the epidemiological methodology of our study with other studies published to determine the impact of both herbicide and personal care items with the reproductive system and birth outcomes.

Kyra Schroeder
Faculty Mentor: Dr. Matt Kohn, Department of Geosciences, Boise State University
Research Title: Pressure-Temperature Record From the Eastern Alps, Austria, Reveals Dynamics of Plate Collision

Metamorphic rocks form and evolve in response to changes in Pressure (P) and Temperature (T). Application of thermodynamics to mineral compositions is commonly used to calculate P-T histories of metamorphic rocks. Geologists use this information to detail and interpret Earth's mountain building events. Here, we test the accuracy of the P-T paths for the eastern Alps constructed 35 years ago (Selverstone et al., 1984, Journal of Petrology, v25, 501-531) using improved thermodynamic calculations.

We first used optical petrography to identify minerals, textures, and metamorphic facies. We then used back-scattered electron imaging on Boise State's Electron Probe Microanalyzer (EPMA) to verify minerals and assess chemical zoning within minerals. Lastly, we used the EPMA to collect individual chemical analyses and applied thermodynamic software to constrain P-T conditions. Whereas Selverstone et al. (1984) report P-T conditions of 7 ± 1 kilobars (25 km depth) and 550 ± 25 degrees °C, our calculations show an indistinguishable pressure of 7 ± 1 kilobars, but a higher temperature of 635 ± 25°C. The higher temperature implies that tectonic plates were warmer than once inferred. Because rocks become less brittle with increasing temperature, brittle phenomena such as earthquakes in the past would have occurred at shallower depths.