Higher Education Research Council Fellowship
Boise State University
Final Report

Academic Year 2018-19

Donna Llewellyn, Executive Director, Institute for STEM & Diversity Initiatives
Catherine Bates, Assistant Director, Institute for STEM & Diversity Initiatives

BOISE STATE UNIVERSITY

Idaho State Board of Education

Introduction

The Institute for STEM & Diversity Initiatives administered the HERC Fellowship at Boise State University for Fall 2018, and Spring 2019. All STEM department chairs were notified of the HERC Research Fellowship application. The application was also disseminated to all STEM undergraduate students. We had 106 students apply for Fall 2018, Spring 2019 positions. Fall 2018, 8 students were awarded the HERC fellowship and 12 students were awarded the fellowship in the spring semester.

HERC Fellows from Boise State represented 12 different academic departments and were almost all first-time student researchers. We supported five students from traditionally underrepresented minority populations. HERC fellows primarily presented final research projects at either the Undergraduate Research Conference or the Idaho Conference of Undergraduate Research at Boise State University. Kelly Mazur presented her research at the 2019 Idaho Chapter of American Fisheries Society Annual Meeting, held in Boise, Idaho. Alex Schweitzer presented his research at the American Geophysical Union meeting in Washington DC. Nicole Clizzie presented at the 2019 Seismological Society of America Annual Meeting, held in Seattle, Washington. And finally, 10 students attended the Pacific Sociological Association annual conference in Oakland, CA. Students and faculty mentors are from a variety of disciplines (please see below).

A previous Boise State HERC Fellow, Melissa Roberts, was a co-author on a paper published in June 2019 in the peer-reviewed journal, *Scientific Reports*. Her work during her 2016 HERC fellowship appointment was included in this paper. The HERC Fellowship was also acknowledge in the paper. You can access her publication here: https://www.nature.com/articles/s41598-019-45310-z. Also, here is the press release of this accomplishment in Boise State's Campus Update: https://www.boisestate.edu/news/2019/06/26/researchers-cook-up-chemical-reactions-in-primordial-soup/

On behalf of the Institute for STEM and Diversity Initiatives, we thank the Higher Education Research Council for their generous support in helping build meaningful learning experiences for our undergraduate students.

HERC Funding:

The Higher Education Research Council provided $55,000 to support undergraduate students in their pursuit of faculty mentor supported undergraduate research experience. Please see table below of how stipends and travel awards were dispersed.

Stipends	**Amount**
Fall 2018 Research Stipends	$24,000
Spring 2018 Research Stipends	$26,000
Student Travel to Professional Conference	**Amount**
Pacific Sociological Assoc. Conference (10 students)	$5,000
Total	**$55,000**

Fall 2018, Spring 2019 Undergraduate Research Fellows and Discipline

Student Name	Gender	Ethnicity	Race	STEM Major	Type of Award
Linda Choi	F	Non Hispanic/Latino/a	Asian	Mechanical Engineering	Research
Nicole Clizzie	F	Non Hispanic/Latino/a	Native American	Geosciences	Research, Travel
Thomas Conrad	M	Non Hispanic/Latino/a	Caucasian	Health Sciences	Research
Kim Farrar	F	Non Hispanic/Latino/a	Caucasian	Chemistry	Research
Nathan Imonigie	M	Non Hispanic/Latino/a	African American	Biology	Research
Devan Karsann	M	Non Hispanic/Latino/a	Caucasian	Computer Science	Research
Lola Klamm	F	Non Hispanic/Latino/a	Caucasian	Biology	Research
Sandra Lira Ambriz	F	Hispanic/Latino/a	More than one race	Computer Science	Research
Danielle Marquette	F	Non Hispanic/Latino/a	Caucasian	Geosciences	Research
Kelly Mazur	F	Non Hispanic/Latino/a	Caucasian	Biology	Research
Elena Paz Munoz	F	Hispanic/Latino/a	More than one race	Chemistry	Research
Julie Ramirez	F	Hispanic/Latino/a	Caucasian	Environmental Studies	Research
Alex Schweitzer	M	Non Hispanic/Latino/a	Caucasian	Geosciences	Research
Joey Tuccinardi	M	Non Hispanic/Latino/a	Caucasian	Chemistry	Research
Malyk Walker	M	Non Hispanic/Latino/a	African American	Health Science, Pre-Med	Research
Ariel Weltner	F	Non Hispanic/Latino/a	Caucasian	Materials Science Engineering	Research
Donovan Wright	M	Non Hispanic/Latino/a	Caucasian	Computer Science	Research

Pacific Sociological Association (PSA) Conference Attendees—HERC Travel Award

Student Name	Discipline	Award Received
Alejandro Andonaegui	Psychology	Travel
Jeff Cates	Sociology	Travel
Michelle Fretwell	Sociology	Travel
Jessica Gaston	Psychology	Travel
Yasmine Goodman	Ethnic Studies	Travel
Allyssa Hernandez	Sociology	Travel
Ramona Hinrichs	Sociology	Travel
Aaron Lampe	Sociology	Travel
John Ropp	Communication	Travel
Patrick Wangoi	Sociology	Travel

Fall 2018 HERC Fellow Student Abstracts:

Sandra Ambriz
Faculty Mentor: Dr. Michael Ekstrand, Department of Computer Sciences
Research Title: Gender Bias in Word Embeddings

Common word embeddings, which allow words to be individually represented in vector form, have demonstrated to possess gender bias. In particular, the bias found in the Word2Vec and the GloVe word embeddings were explored. The Word2Vec and GloVe embeddings are commonly-used and their gender bias has been previously demonstrated to exist. Gender bias was argued to have been found in these embeddings by studying the cosine similarities of the vector word representations. Removing harmful word associations, while keeping desired word associations, from the word embeddings would eliminate gender bias. After loading the Word2Vec and GloVe data, the gender direction was defined, and a dataset of occupation words were projected onto that direction. The gender direction consisted of the words he and she (he-she) due the lack of multi-meaning associated with those specific gendered words. Given the gender direction and the projection of the occupation words, stereotypicality estimates were derived using word correlations. Using these techniques, gender bias was found to be present in both the Word2Vec and GloVe embeddings.

Linda Choi
Faculty Mentor: Dr. Zhanxian Deng, Department of Mechanical & Biomedical Engineering
Research Title: Flexible Piezoelectric Force Sensor Monitoring Pianist Performance

Piano beginners need to spend their first few months on properly pressing the keyboard.
Proper fingering and correct hand position ensure that notes are played with the same rhythm, flow and power. Without a professional teacher, this practice can be challenging. In this research project, a smart glove with a flexible and in-situ Polyvinylidene Fluoride (PVDF) sensor was designed to track the force on the piano students' finger tips in real time. Compared with existing resistive, capacitive, and semiconductor force sensors, PVDF sensors are superior in accuracy, sensitivity, mechanical robustness, lightweight, and corrosion resistance. The measurement range and frequency bandwidth of the new PVDF sensor were first calibrated by using a commercial piezoelectric force sensor. The calibrated PVDF sensor was then glued on a rubber glove and tested during actual piano playing. Due to the help of this smart glove, piano students can evaluate their own

performance by comparing the force measurement with the suggested data without a professional teacher. The same force sensing concept can be implemented as artificial skin of future robots.

Nicole Clizzie
Faculty Mentor: Dr. Lee Liberty, Department of Geosciences
Research Title: Shear-wave Velocity and Seismic Response Estimates From the Southern Isoseismal Region of the 1886 Charleston Earthquake: Results From a Seismic Land Streamer System
The 1886 M~7 earthquake damaged Charleston's infrastructure and killed more than 100 people. Today, ground amplification from a similar earthquake would devastate the region. For this fault mapping and site response study, we acquired 14 km of seismic data over five field days using a 72-channel, 90 m land streamer/accelerated weight drop system along city streets. The data collection was located within the southern isoseismal zone of the 1886 earthquake. We acquired shots every 2.5 m to obtain more than 5,000 dispersion curves and 360,000 first arrival picks. We estimate shear wave velocity (Vs) from phase velocity-frequency picks for the fundamental mode using a range of inversion approaches. We estimate p-wave velocity (Vp) by inverting first arrival picks. For our site response analysis, we assume a two-layer velocity model that represents Holocene sediments over older strata. Because Vp results are sensitive to water saturation that crosses lithologic boundaries, we rely on Vs to map Holocene layer thickness, to estimate resonant frequencies, and to estimate ground surface amplification. We compare our Vs results to mapped geology, layer thickness derived from auger holes, and to coincident seismic reflection results that we generated from the same dataset. We estimate Vs for Holocene sediments, late Pleistocene Wando Formation, middle Pleistocene Ten Mile Formation, and Tertiary Ashley Formation. We find the thickness of Holocene strata lies mostly at depths less than 30 m below the land surface. We suggest that this shallow boundary controls site amplification and that the seismic land streamer approach provides a rapid and effective high frequency site response tool for urban areas.

Thomas Conrad
Faculty Mentor: Dr. Don Warner, Department of Biological Sciences
Research Title: Synthesis of Small Molecule Inhibitors for Metastatic Breast Cancer Pathways

As of 2019, it is predicted that 268,600 women will be diagnosed with breast cancer in the United States and of those diagnosed, 41,760 will lose their lives. More specifically, the Surveillance, Epidemiology, and End Results Database (SEER) measured the 5-year survival rate of localized breast cancer to be 99% compared to a dismal 27% for distant breast cancer. It has been studied that inflammatory cytokines (IC) activate several pathways that have been found to play an active part in promoting the metastasis of breast cancer. This prompted the creation and evaluation of small molecule inhibitors (SMI) for the target IC. Previous work using enzyme-linked immunosorbent assays (ELISA) concluded the small molecule IC-SMI-10 inhibited one of the culpable pathways. The focus of this research is to design and synthesize second generation IC-SMI-10 analogs with greater proclivity for inhibiting the metastatic breast cancer pathway. The goal is to continue creating analogs of specifically IC-SMI-10B with a focus on determining to what degree hydrophobic and hydrophilic interactions are responsible for binding in the IC's active site. These developments are sought to be highly advantageous in preventing metastatic breast cancer.

Kim Farrar
Faculty Mentor: Dr. Michael P. Callahan, Department of Chemistry and Biochemistry
Research Title: Trace Analysis of Wine from 6000 BC

The Neolithic (10,000-3,500 BC) was the age of achievement and expansion. This period represented a transition where food-collecting cultures shifted to food-producing ones, which allowed people to establish year round settlements. Many plants were domesticated including the Eurasian grape, which is believed to be the first grape used to ferment wine. There is an ongoing archeological dig in the Republic of Georgia to investigate the earliest winemaking and the emergence of wine culture as part of the Gadachrili Gora Regional Archaeological Project Excavations (G.R.A.P.E.). Sherds of pottery jars excavated from the dig site, along with corresponding soil samples, were analyzed for the presence of four characteristic grape/wine acids (tartaric acid, citric acid, malic acid, and succinic acid) by high performance liquid chromatography-mass spectrometry. All four acids were detected in trace amounts in every sample; however, there was no significant difference in the amount of acids found in the sherd samples versus the soil samples. As a result, we could not verify the presence of wine in these particular archaeological sherds.

Nathan Imonigie
Faculty Mentor: Dr. Henry A. Charlier, Department of Chemistry and Biochemistry
Research Title: A Potential Role for Methionine-234 in Human Carbonyl Reductase Coenzyme Binding

Anthracyclines are among the most commonly used cancer chemotherapeutic agents; however, treatment is limited by cumulative-dose dependent cardiotoxicity. Human Carbonyl Reductase 1 (HCBR1) catalyzes the NADPH-dependent reduction of anthracyclines to alcohol metabolites that are thought to contribute to the cardiotoxicity. For this reason, HCBR1 is considered to be a potential therapeutic target for lowering the risk of anthracycline-induced cardiotoxicity. A methionine in the active-site of the enzyme, M234, was identified as having the potential to interact with the anthracyclines in a manner that limits the catalytic efficiency for them. To test this hypothesis, M234 was mutated to alanine (M234A). Earlier fluorescence quenching studies revealed M234 may actually impact NADPH binding as the M234A mutant showed lowered binding affinity for NADPH. This observation led to the hypothesis that the $NADP^+$ product may also have reduced binding affinity of M234A mutant. As expected, fluorescence quenching studies confirmed that the $NADP^+$ binding affinity of M234A was significantly lower than that of the native enzyme. This finding suggests that M234 might play a role in coenzyme binding by HCBR1 and have less direct impact on anthracycline binding and orientation than originally believed.

Devan Karsann
Faculty Mentor: Dr. Sole Pera, Department of Computer Science
Research Title: Featureless Approaches for Text Simplification Evaluation

Text simplification, which involves replacing or rephrasing (section of) a document while minimizing meaning loss in order to generate simplified, i.e., easier to understand, versions of said document, has attracted researchers from both natural language processing and information retrieval domains of study. Text simplification has a direct connection to a wide range of applications, from those that demand specific reading comprehension ease, e.g., ensuring legal or medical documents are easy to read and understand, to those focused on making reading materials further accessible for K-12 audiences or English language learners. Evaluating outcomes from existing text simplification techniques, in terms of pairwise correctness of label ranking predictions, is a difficult task because these techniques tend to depend upon domain specific indicators such as

lexical, syntactic, morpho-syntactic, and psycholinguistic features. Our hypothesis is that we can perform pair-wise text simplification ranking in a featureless fashion by relying on state-of-the-art learning architectures. . To answer our research question and manage scope, we will use sentences (not full documents) as a case study. Thereafter, we will explore diverse techniques from baselines like Naïve Bayes to well-known, state-of-the-art counterparts based on deep learning. We then will conduct an exhaustive empirical analysis on multiple datasets on feature-based and featureless strategies, in order to demonstrate the validity of our proposed approach.

Lola Klamm
Faculty Mentor: Dr. Marie-Anne de Graaff, Department of Biological Sciences
Research Title: The Effects of Bioenergy Crop Species on Microbial Functioning

With the threat of climate change, there is a growing incentive to reduce atmospheric carbon dioxide (CO2) levels. Soil is the largest sink of terrestrial carbon (C), and the natural processes of soil carbon sequestration could be harnessed to reduce atmospheric CO2. Grasses like switchgrass (*Panicum virgatum*) and big bluestem (*Andropogon gerardii*) have the potential to sequester C since they have extensive root systems, and their cultivation involves little disturbance to the soil. Research in our lab has shown that soil C accumulation differs among cultivars of switchgrass and big bluestem. Additionally, studies have indicated that the microbial community structure and functioning can affect soil C accumulation. However, whether variation among the microbial communities of big bluestem and switchgrass cultivars could be responsible for the observed differences in soil C accumulation is still unknown. This study seeks to understand how cultivars of switchgrass and big bluestem affect microbial functional diversity across a soil depth profile. We collected 30 cm soil cores split into 3 increments from a long-term field experiment in the Fermilab National Environmental Research Park, IL. Microbial functional diversity was analyzed for samples from cultivar monocultures by exposing them to different carbon substrates, incubating, and determining respired CO2.

Danielle Marquette
Faculty Mentor: Dr. Jim Browning, Department of Mechanical & Biomedical Engineering
Research Title: ENVI Classification of Multispectral Images to Track Alfalfa Bloom; Comparing Two Vegetation Indices

Alfalfa seed crop managers must coordinate the release of the crop's pollinators with peak alfalfa bloom to maximize seed yield. High resolution blue, green, and near infrared (NIR) imagery may provide useful information to track alfalfa blooms and better predict the optimal time to release the pollinators. This study used ENVI image analysis software classification methods to quantify blooms in NIR imagery. Two vegetation indices were applied to the images to increase the spectral separability of the flowers and to compare their accuracy. The vegetation indices are GNVI=*(Green-NIR)/(Green+NIR)* and FVI=*(Blue/Green)*(NIR/Green).* After applying the vegetation indices, regions of interest (ROI's) were selected and used as training data for ENVI's classification algorithms. Three ENVI classifications performed well at identifying and quantifying the blooms from the imagery. The classification methods are Constrained Energy Minimization, Maximum Likelihood, and Support Vector Machine. Constrained Energy Minimization with the FVI vegetation index had the highest accuracy of 98.35%.

Kelly Mazur
Faculty Mentor: Dr. David Pilliod, Department of Biological Sciences

Research Title: Examining Standard Environmental DNA Sample Extraction and Archival Methods

Use of environmental DNA (eDNA) methods for detecting rare and secretive species has become an important tool for biological research and monitoring. Given the recent development of the field and the novelty of the methods employed, however, empirical testing of methods is needed. The goal of our research was to evaluate the handling of filters (used to concentrate DNA during field filtration) prior to and during the DNA extraction process. A common DNA extraction procedure involves splitting a filter sample into equal halves, with one half processed and the other half archived by freezing (at -20C or -80C) in 200-proof molecular grade ethanol. Our first objective was to assess the assumption that eDNA is evenly distributed across both halves of a sample filter. This could have important implications for studies involving quantitative eDNA data. Our second objective assessed the effects freezing and storing the unextracted half of the filter on DNA yield. We tested both objectives using samples collected annually as part of another study dating back to 2012. Preliminary results of this study will be presented, including quantitative, statistical differences in DNA yield from the two halves of each filter within a year, as well as rates of degradation of DNA on stored filters across time (from 0 to 6 years). Results of this study could help improve eDNA laboratory methods and provide insight into proper sample archival procedures, helping to safeguard eDNA archives for future use.

Elena Paz Munoz
Faculty Mentor: Dr. Ken Cornell, Department of Chemistry and Biochemistry
Research Title: MTN Knockout Attenuates Vitamin Synthesis and Global Metabolism in E. coli O157:H7

The microbial enzyme 5'-methylthioadenosine/S-adenosylhomocysteine (MTA/SAH) nucleosidase (MTN) has three substrates MTA, SAH and 5'-deoxyadenosine (5'dADO). In each case, MTN cleaves the glycosidic linkage between the adenine ring and ribose sugar. MTN plays an essential part of methionine and purine salvage pathways, the activated methyl cycle, autoinducer-2 production, and radical S-adenosylmethionine (SAM) dependent reactions that are integral to vitamin synthesis. In this study, the impact of MTN activity on vitamin production and vitamin dependent metabolism were studied in E. coli strain O157:H7 wild type (WT) and MTN knock-out (KO) cells. Vitamins serve as cofactors for multiple pathways involved in bacterial metabolism. Proteomic studies comparing WT and KO strains have shown that the MTN KO strain expresses altered levels of enzymes involved in vitamin synthesis (thiamine, lipoate, biotin, etc.) and downstream enzymes that depend on these vitamins for activity. The results of our studies show that the activity of the biotin-containing enzyme acetyl-coA carboxylase (ACC) is reduced in the MTN KO strain. ACC is required for fatty acid biosynthesis. By biotin ELISA and western blot, we see a dramatic decrease in native biotinylation of ACC. Similarly, the activity of thiamine and lipoate dependent enzymes were also found to be reduced. We propose that loss of MTN activity leads to an accumulation of 5'dADO that in turn leads to product inhibition of radical SAM reactions, thus altering global metabolism through decreases in activity of vitamin dependent enzyme steps. Since MTN is only present in microbes, not humans, and central to metabolism, it may be a good target for antibiotic development. Our studies are useful in demonstrating potential mechanisms of action for such antibiotics.

Julie Ramirez
Faculty Mentor: Dr. Neil Carter, Department of Human Environment Systems

Research Title: Estimating Anthropogenic Influences on Species Occupancy at La Selva Biological Station, Costa Rica

The global network of nature reserves is intended to be refuges for wildlife species around the world. However, nature reserves are experiencing increasing amounts of human visitation each year, and it is critical to investigate how this influx in disturbance is influencing the space use, abundance, and richness of wildlife species in those reserves. We used camera trap data collected at La Selva Biological Station in Costa Rica, to understand how the presence of humans and other environmental factors are influencing the presence and distribution of various wildlife species. We deployed 9 cameras, in three blocks, on 9 different trails and accumulated 208 active camera nights in 2018. A total of 9,692 photos were obtained of 17 different animal species. We hypothesize that the occupancy rate of species will be primarily influenced by human presence on trails within the reserve. The most commonly detected species were Collared Peccaries (*Pecari tajacu*) with 0.837 average detections per day, Central American Agoutis (*Dasyprocta punctata*) with 0.409 average detections per day, and Great Curassows (*Crax rubra*) with 0.173 average detections per day across all camera sites. I will use the package "unmarked" in the program R to determine the influence of humans on species occupancy and richness.

Alex Schweitzer
Faculty Mentor: Dr. Dorsey Wanless, Department of Geosciences
Research Title: Formation of Lava Samples Collected by Three Alvin Submersible Dives at 14°N on the Mid-Atlantic Ridge

In 2018, a research cruise investigated the Mid-Atlantic Ridge at 14°N. During this expedition the seafloor was mapped using the AUV *Sentry* and basaltic lavas were collected using the HOV *Alvin*. To better understand the origin of these lavas, major element compositions of 40 basaltic glasses from three *Alvin* dives were measured using the BSU SXFive Electron Microprobe and trace element contents were measured on 33 samples using solution ICP-MS. Trace element ratios and patterns are important tools for investigating magmatic processes because they can be used to evaluate different magmatic processes; such as the amount of melting of the Earth's mantle that produces the magma and the extents of crystallization prior to eruption. Lavas collected on dives AL4953 and AL4954 have similar Rare Earth Element patterns, but variable elemental abundances, suggesting fractional crystallization was an important process in their formation. By contrast, lavas collected on dive AL4955 have variable trace element patterns and ratios, indicating a change in the extents of mantle melting. To further investigate the differences in these compositions, we will use numerical models to quantify the percent of mantle melting and extents of crystallization that led to the formation of lavas erupted in this region.

Joey Tuccinardi
Faculty Mentor: Dr. Don Warner, Department of Chemistry and Biochemistry
Research Title: Synthesis of Substituted Heterocycles to Inhibit a Pro-Metastatic Cytokine

While there have been significant advances in treatments for pre-metastatic breast cancer, the five-year survival rate post-metastasis remains an abysmal 27%. Systemic therapy continues to be the recommended course of treatment for patients diagnosed with metastatic breast cancer, but treatments that prevent distant metastases have yet to be discovered. Inflammatory cytokines (ICs) are small proteins involved in cell signaling that regulate inflammation and other important cellular processes. A certain IC binds to its main receptor to activate cell signaling pathways that are capable

of promoting the invasive potential of cancer cells during the preliminary stages of the metastatic cascade. This has led to an interest in the development of small molecule inhibitors (SMIs) that bind to and inhibit the IC responsible. Previously, an enzyme-linked immunosorbent assay (ELISA) demonstrated that IC-SMI-10 inhibited the expression of pSTAT3 to a significant extent, indicative of competitive inhibition of the IC binding to its main receptor. Structurally, IC-SMI-10 contains a furan core appended with two benzodioxole groups at positions 4 and 5, a nitro group at position 3, and a phenyl hydrazone moiety at position 2. The aim of this research is to optimize inhibitory activity by systematically investigating the role of each component. Thus far, the furan core has been converted to a thiophene, an N-H pyrrole, an N-Me pyrrole, and an N-PMB pyrrole to assess the importance of the heterocycle. Also, to investigate the aryl groups, Suzuki coupling reactions have been used to incorporate 3,4-alkoxy or phenol, indole, benzodioxane, and other heteroaromatic groups. Lastly, substitution of the phenyl hydrazone moiety with a carboxylic acid, α,β-unsaturated acids, amides, amines, and other groups has sought to explore the importance of substitution at this site. Preliminary ELISA and ITC experiments confirm molecular docking experiments that suggested the nitro group was not an important contributor to inhibition, while the length of the side chain at position 2 is significantly important, as shorter, non-conjugated chains exhibit little to no binding to the IC. Similarly, CSP-NMR experiments suggest IC-SMI-10 analogs bind to the IC appreciably. These and other results will be reported.

Malyk Walker
Faculty Mentor: Dr. Daniel Fologea, Department of Physics
Research Title: Influence of Voltage Rate on the Diffusion of Organic Ions through Bilayer Lipid Membranes

Tetraphenylphosphonium chloride(TPP) and Sodium Tetraphenylborate(TPB) are organic ions that are able to passively move across the membrane down the electrochemical gradient. To further investigate the transport of organic ions through the lipid partition of a membrane, we employed artificial planar bilayer membrane bathed by electrolyte solutions. The bilayer membrane integrity was assessed from capacitance and conductance measurements. Changes in membrane permeability upon organic ion addition were monitored by recording the ionic currents in response to variable voltage ramps. Besides expected changes in membrane permeability we observed that the linearity of the I-V plots is strongly influenced by the rate of the voltage change. This is a good indication that the transmembrane transport is a diffusion limited process. In conclusion, these ions are good experimental models for helping us understand similar ionic transport processes through biological membranes.

Ariel Weltner
Faculty Mentor: Dr. Paul Simmonds, Department of Physics, and Micron School of Materials Science and Engineering
Research Title: Analyzing the Effect of Gold Reflective Coatings on GaAs Quantum Dot Photoluminescence

Molecular Beam Epitaxy (MBE) is a method for making high purity, tensile-strained GaAs quantum dots (QDs) embedded in solid-state semiconductors. QDs, excited by electricity or lasers, emit photons characteristic of the QDs size and composition, which may be used in tunable optoelectronic devices such as LEDs, lasers and solar cells. Understanding the light emission properties of these QDs is essential for these applications, as well as for continued QD research. Photoluminescence (PL) is a laser-excitation technique used to determine these properties.

Occasionally, the PL signals from our samples are too low in intensity to be accurately detected. We will investigate whether the addition of gold coatings on the back of QD samples improves PL emission by reflecting additional photons into the detector. To apply these reflective coatings, we first prepare the samples using a chemical wet etch process and then deposit thin gold films via physical vapor deposition. We will analyze the difference in PL intensity between coated and noncoated samples and gauge the influence of gold deposition thickness.

Donovan Wright
Faculty Mentor: Dr. Clare Fitzpatrick, Department of Mechanical & Biomedical Engineering
Research Title: Using a Convolutional Neural Network to Segment the Knee

For this project, I will develop an algorithm to segment the knee which consists of the femur, tibia, and patella bones and their respective connected cartilage. The algorithm is based a convolutional neural network (CNN) which will be fed two different data sets. The first data set consists of 26 MRI images of patients who had reoccurring patellar dislocation. The second data set is from the Osteoarthritis Initiative (OAI) dataset which consists of 20 more patients. This combined total of 46 patient's MRI images will be segmented into sagittal slices with each MRI consisting of around 130 sagittal slices giving a total of 5980 sagittal slices. This number of sagittal slices will fluctuate depending on the resolution of the MR images and the type of scanner used. Once a working model is developed, I will validate and test it on more of the Osteoarthritis Initiative data set which consists of 4,796 patients. The overall objective of this project was to efficiently segment subject-specific knee structures, and then to later develop a way of transforming these CNN generated segmentations into a 3D model. These models will ultimately be used for subject-specific finite element simulations to evaluate joint mechanics.

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Final Report

Academic Year 2018-19

Donna Llewellyn, Executive Director, Institute for STEM & Diversity Initiatives
Catherine Bates, Assistant Director, Institute for STEM & Diversity Initiatives

Introduction

The Institute for STEM & Diversity Initiatives oversaw the HERC Undergraduate Research Supplemental Funding at Boise State University Fall 2018, and Spring 2019. These funds were used for four purposes: (1) We supported five students from the College of Western Idaho to have a research experience, (2) Three Boise State students were offered research opportunities, (3) We funded travel for two Boise State students to attend professional research conferences, and (4) We brought Dr. Carrie Cameron from the University of Texas MD Anderson Cancer Center to the Boise State Campus.

For the CWI research opportunities, Associate Professor of Biology Dusty Perkins, and Physics Instructor Stephanie Sevigny at the College of Western Idaho (CWI) created an application form. All STEM department chairs and faculty at CWI were notified of the HERC Research Fellowship application, and the application was also shared directly with CWI students through email and the Math and Science Hub (MASH), a cross-disciplinary student and mentor community at CWI that supports academic engagement and success among CWI students through sharing resources and experiences in science, research and collaboration. Thirty-three students applied for the fellowship, from which five were selected for funding. All five of these HERC fellows from CWI presented at the Idaho Conference of Undergraduate Research at Boise State University in July.

For the Boise State research and travel opportunities, we used the same process as reported on in our standard HERC Undergraduate Research final report.

Dr. Cameron visited with Boise State faculty, students, and administrators on February 26th, 2019. She held a one hour Science Communication Strategies Discussion with students. She also hosted a two-hour Science Communication Workshop for Faculty. Her workshops, and informal meetings provided Boise State students and faculty, a suite of tools and strategies for helping strengthen student's science communication skills. Here were just a few statements from Dr. Cameron's survey evaluations:

> "Carrie was an excellent facilitator, allowing the audience to engage."
> "This was so wonderful (& necessary!) Thank you for bringing her to Boise State."
> " I gained a lot of resources and knowledge of where to find other resources in the future for promoting student's science communication skills."

On behalf of the Institute for STEM and Diversity Initiatives, we thank the Higher Education Research Council for their generous support in helping build meaningful learning experiences for Idaho students and supporting faculty professional development.

HERC Funding:

The Higher Education Research Council provided $32,000 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	$10,000
College of Western Idaho Research Stipends	$15,000
Student Travel to Professional Conference	**Amount**
2019 Seismological Society of America Annual Meeting (1 student)	$1, 635.97
2019 Pacific Sociological Association Conference (1 student)	$1,000
Professional Development Workshop	**Amount**
Dr. Carrie Cameron Workshop & Travel Expense	$3906.46
Summer Research Community	**Amount**
Summer Research Community Supplies	$457.57
Total	**$32,000**

College of Western Idaho Undergraduate Research Fellows and Discipline

Student Name	Gender	Ethnicity	Race	STEM Major
Mia Cinello-Smith	F	NonHispanic/Latino/a	Caucasian	Biology – Natural Resources
David Maldonado	M	Hispanic/Latino/a	Caucasian	Biomedical Engineering
Casey Robinson	F	NonHispanic/Latino/a	Caucasian	Biology – Natural Resources
Antony Tuss	M	NonHispanic/Latino/a	Caucasian	Electrical Engineering
Zack Szymczycha	M	NonHispanic/Latino/a	Caucasian	Biology – Natural Resources

Boise State Research Fellows Undergraduate Research Fellows and Discipline

Student Name	Gender	Ethnicity	Race	STEM Major
Kyle Kramer	M	NonHispanic/Latino/a	Caucasian	Electrical and Computer Engineering
Jessica Mueller	F	Hispanic/Latino/a	Caucasian	Geosciences
Samantha Schauer	F	NonHispanic/Latino/a	Caucasian	Mechanical Engineering

Travel Awards

Student Name	Gender	Ethnicity	Race	STEM Major
Nicole Clizzie	F	NonHispanic/Latino/a	Native American	Geosciences
Bryant Hey	M	NonHispanic/Latino/a	Caucasian	Sociology

Dr. Carrie Cameron Workshop Agenda:

Monday, February, 25th		
Time	Description	Location
3:58 PM	Arrive in Boise (Catherine Bates will pick you up from the airport)	
4:30 PM	Check in at hotel	
5:30 PM	Dinner with Donna Llewelyn, Executive Director for Institute for STEM & Diversity Initiatives, and Catherine Bates	ALAVITA, 807 W Idaho St, Boise, ID 83702
Tuesday, February 26th		
8:30 to 9:00 AM	Coffee at Starbucks, Albertsons Library, Boise State University	
9:00 to 10:00 AM	Meet with Program Directors/Coordinators • Dr. Amy Ulappa, Clinical Assistant Professor, NSF Gateway Scholars Coordinator • Barb Jibben, Program Manager at Biomolecular Research Center • Dr. Cheryl Jorcyk, Professor of Biological Sciences, Director,	Albertsons Library 201C

	Clinical/Translation Research • Gregory Martinez, Director of Center for Multicultural Education Opportunities	
10:30 to 11:30 AM	Science Communication Strategies Discussion with Students	Riverfront Hall, 301
11:30 to 1:00 PM	Lunch with Students • Julie Ramirez • Jacob Tenorio • Jessica Mueller Sandra Ambriz	Madre, 1034 S La Pointe St, Boise, ID 83706
1:00 to 2:30 PM	Meet & Greet with College of Health Science Faculty • Dr. Bob Wood, Director School of Allied Health Sciences • Dr. Cara Gallegos, Assistant Professor • Dr. Joelle Powers, Associate Dean of COHS, Professor • Ella Christiansen, Director COHS Office of Research Dr. Stephanie Hall, Clinical Assistant Professor	MBEEB Building, 2302
3:00 to 5:00 PM	Science Communication Workshop for Faculty	MBEEB Building, 2302
5:00 to 6:30 PM	Dinner and Networking	Papa Joe's, 1301 S Capitol Blvd, Boise, ID 83706
Wednesday, February 27		
6:25 AM	Depart Boise	

HERC Fellow CWI Student Abstracts:

Mia Cinello-Smith
Faculty Mentor: Dusty Perkins MS, Department of Biology, College of Western Idaho
Research Title: **Phenological Variation Among Western Populations of Showy Milkweed (*Asclepias speciosa*)**

Western monarch butterflies (*Danaus plexippus*) have declined ~97% from historic abundances in the early 1980s and are being evaluated for listing under the Endangered Species Act. Habitat loss and fragmentation in wintering, migratory, and breeding areas are considered key causes. Since monarchs depend on milkweeds (*Asclepias sp.)* for reproduction, there is increased interest among conservationists to plant milkweeds as habitat restoration. Showy milkweed (*Aslceipias speciosa)* is the most common and abundant milkweed species in the Western US. Successful habitat restoration will require germplasm that is adapted for target restoration environments and seasonal phenology. Phenological traits are adaptive, easily observable, and shaped by climate; making them helpful in genecological applications for determining seed transfer zones. We evaluated phenological variation among 35 showy milkweed populations from across the Intermountain West to determine geographic patterns of adaptive traits and their relationships to local climates using a common garden approach. We used remotely sensed climate data in conjunction with growth and reproductive phenology data to identify variation in adaptive traits and correlate them to elevation and climate variation. Here we present the results of our analyses and their implications for defining seed transfer zones for showy milkweed in the context of monarch butterfly conservation.

David Maldonado
Faculty Mentor: Dr. Kristen Mitchell, Department of Biological Sciences, Boise State University
Research Title: RNA-seq Reveals Extracellular Matrix Remodeling Processes Mediated by AhR Activation

Non-alcoholic fatty liver disease (NAFLD) refers to the accumulation of liver fat in the absence of alcohol consumption. NAFLD risk factors include obesity, type II diabetes, and hypertension. In about 30% of NAFLD patients, disease progression includes inflammation and advanced fibrosis, which necessitate liver transplantation. Liver fibrosis occurs when activated hepatic stellate cells deposit collagen throughout the liver. We previously established a role for aryl hydrocarbon receptor (AhR) signaling in regulating stellate cell activation. In this study, we determined how AhR activation impacts NAFLD development and its risk factors. C57Bl/6 mice were treated with 1.0 mg/kg carbon tetrachloride (CCl_4) twice a week for 5 weeks. During the final week, 100 μg/kg of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) was administered to elicit AhR activation. Histological analysis revealed that CCl_4/TCDD co-treatment produced advanced NAFLD, based on the presence of hepatic steatosis, fibrosis and inflammation. CCl_4/TCDD co-treatment also modulated the hepatic expression of genes related to type II diabetes. Treatment with CCl_4 or TCDD alone failed to elicit NAFLD and had no impact on diabetes-related gene expression. We conclude that AhR activation may advance NAFLD progression by exacerbating liver injury and/or by increasing the development of risk factors (e.g. type II diabetes) associated with NAFLD progression.

Casey Robinson

Faculty Mentor: Dusty Perkins MS, Department of Biology, College of Western Idaho
Research Title: Variation in Adaptive Traits and Seed Zone Evaluation of Showy Milkweed (*Asclepias speciosa*)

Monarch butterfly (*Danuas plexippus*) populations are imperiled and in review for listing under the Endangered Species Act. Among many contributors to the decline is the loss of breeding, migratory, and overwintering habitat. Showy milkweed (*Asclepias speciosa*) and other obligate milkweeds are essential for monarch reproduction and have thus been cornerstones of monarch habitat restoration efforts in the Intermountain West. However, many potential restoration areas lack convenient seed sources to supply prospective efforts. Furthermore, because certain populations may be better adapted to specific local climates and selective pressures, the introduction of non-native, poorly adaptive genotypes may have negative consequences for restoration efforts and milkweed-dependent species. We used a genecological approach to identify adaptive traits among 35 showy milkweed populations from the Intermountain West to inform seed transfer zones for *A. speciosa.* We used morphological measures and plant growth data in conjunction with remotely sensed climate data to identify putative adaptive traits and determine how they relate to local climate variation. Here we present the results of our analyses and their implications for classifying showy milkweed seed transfer zones and maximizing restoration and conservation benefit for monarch butterflies.

Zack Szymczycha
Faculty Mentor: Dr. Sara Schulwitz, Director of the American Kestrel Partnership, The Peregrine Fund
Research Title: A Methodology for Systematic Mapping in Raptor Biology

Knowledge from peer-reviewed research in raptor biology is based primarily on a small handful of raptor species, while a large portion are virtually unstudied or understudied. With over 500 raptor species globally, this limited knowledge base is a chief impediment to conservation efforts. Here we introduce a systematic mapping protocol for raptor species that expedites the literature review process to better inform stakeholders of the current species-specific research. Using the RepOrting standards for Systematic Evidence Syntheses (ROSES) protocol guidelines, we constructed a methodology for systematic information mapping for raptor conservation that encompasses: stakeholder engagement; objective of the review; methods; searches; screening and inclusion criteria; critical appraisal; data extraction; data synthesis and presentation; and declarations. This method provides a comprehensive synthesis of objective evidence that features repeatable standards for information extraction that will ultimately contribute to a centralized raptor conservation database. Initial efforts involving the California condor (*Gymnogyps californianus*) as a conceptual model to demonstrate the methodology has identified 255 literature items of which 165 were extracted as PDFs, while the screening process remains ongoing.

Anthony Tuss
Faculty Mentor: Dr. Kurtis Cantley, Department of Electrical and Computer Engineering, Boise State University

Research Title: Advancements of Dielectrics and their Effects on Stabilizing the Electrical Grid
The modern world is more dependent on it's power than ever before, so much so that the stabilization of the electrical grid is of utmost importance. Thermal stresses, such as geomagnetic disturbance and running the grid transformers at a higher temperature are major concerns. The Idaho National Laboratory has subcontracted Boise State University to test and analyze data on

developed dielectric materials in the hopes that it will prove to be more reliable. The data that will be gathered includes, but is not limited to: resistivity, dielectric constant, breakdown voltage, and electrical reliability under heat stressors of the material.

HERC Fellow Boise State Student Abstracts:

Kyle Kramer
Faculty Mentor: Dr. Harish Subbaraman, Department of Electrical and Computer Engineering, Boise State University
Research Title: Understanding the Effects of Plasma Parameters on Plasma-Jet Printed Material Films

The demand for consistent additive manufacturing processes for biosensors that make use of flexible substrates is increasingly desired. Recent work has demonstrated a strong candidate for such processing is a plasma jet printing process. Optimization of the plasma jet printing process requires investigating the effects of different plasma conditions and flow rates, nanomaterial inks, and substrates on print quality and material properties. In this work, we examine the effects of using argon and nitrogen plasma sources on the conductivity and adhesion of four-point structures printed on polyamide substrates. The plasma source is a parallel plate discharge with a 0.5-1mm gap using two embedded metal electrodes. The source operates at 20 kHz and 2-3.5 kV. A new plasma source enclosure and mounting fixtures have been combined with an XY stage to print the inks. Print quality is verified through imaging the samples via scanning electron microscopy and examining the atomic spectra. Our future work involves the characterization of other nanoparticle inks and further demonstrating plasma jet printing as a cost effective, time efficient, and viable process. These results will be presented.
*This research is supported by a seed grant from the NASA Idaho Space Grant Consortium (ISGC).

Jessica Mueller
Faculty Mentor: Dr. Vicken Hillis, Department of Human Environment Systems, Boise State University
Research Title: Implications of Grazing Usage over Time and Space in the Thunder Basin Ecoregion
National grasslands are public lands that have diverse and critical uses. They serve as wildlife habitat, contain mineral resources, and are used recreationally. The Thunder Basin National Grassland, located in the Powder River Basin of Wyoming, spans more than 500,000 acres and local ranchers rely on that acreage to feed their cattle. Effective management of these grazing lands is challenging because agency managers have to balance multiple private and public objectives. Advancing rangeland policy requires an accurate understanding of previous grazing history. Even so, few long-term, quantitative records of grazing intensity on this land exist. To address this gap, we digitized physical records of four decades of grazing usage. We analyzed this data to examine variation in grazing intensity over time and space. We found that there was a steady increase in grazing intensity over time, but it fell dramatically in the early 2000s. This is an important observation that can help government agencies understand how various social and environmental factors impact grazing intensity. Application of this understanding can help create sustainable grassland policies.

Samantha Schauer

Faculty Mentor: Dr. Krishna Pakala, Department of Mechanical & Biomedical Engineering, Boise State University

Research Title: Living Learning Communities and Their Impact on First Year Engineering College Students

Office hours that happen in a virtual environment are called virtual office hours. A virtual environment can provide students and faculty with more flexibility in meeting times and locations, content delivery, and types of interaction. This type of student-faculty interaction can be easily hosted from a faculty computer/mobile device/tablet. With an invitation, students can login to the online session and join their instructor and peers in a virtual space. Using mobile technologies, students can join virtual office hours from a variety of locations including, the library, outdoors, on the commute ride home, while caring for children, eating dinner, and even while grocery shopping. Virtual office hours allow for more flexibility of student-faculty interaction. They are an alternative to traditional office hours. This type of student-faculty interaction helps increase students' trust in their teacher's care of their learning. This presentation describes the design and implementation of virtual office hours for courses in the thermal-fluid sciences (Thermodynamics, Fluid Mechanics and Heat Transfer). It also reports on students' learning experiences.